The non-breeding season ecology of lesser prairie-chickens (*Tympanuchus pallidicinctus*) in the Southern High Plains of Texas

By

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ABSTRACT

Few studies have examined the non-breeding season ecology of the lesser prairie-chicken (*Tympanuchus pallidicinctus*; hereafter LEPC). The majority of research efforts have focused on breeding ecology. Given dramatic declines in LEPC populations (≥95% loss since the 1800's), a better understanding of the species' non-breeding ecology is important for conservation efforts. I used radio telemetry to examine gender-specific habitat use, home ranges, movements/movement patterns, and survival rates during the non-breeding seasons (1 September through 28 February) of 2008-2009, 2009-2010, and 2010-2011 in the Southern High Plains of Texas. Across the three non-breeding seasons, average home range did not differ between adult females (501 ha) and adult males (480 ha). LEPCs did not use each habitat proportional to availability within the study area (χ^2=1868.7, α=0.05). Grassland dominated areas with sand-shinnery oak (*Quercus havardii*) were used more than available. Sand-sage (*Artemisia filifolia*) dominated areas with bare ground, and sand-sage dominated areas with grassland were avoided. Four habitat types, mesquite (*Prosopis glandulosa*) savannah, reverted agriculture, sand-shinnery oak, and sand-shinnery oak dominated areas with grassland were used proportional to availability. I detected 13 mortalities (24.5%) among 53 radio tagged LEPCs. Mortalities were predominately males (77%) with the majority (6 adult male, 1 juvenile male, and 3 adult females) due to avian predation, wheras two mortalities were due to mammalian predation and one attributed to an unknown cause. Estimates of non-breeding season survival (180 days) were 84.6%, 82.7% and 57.2% for the 2008, 2009, and 2010 non-breeding seasons, respectively.

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CHAPTER I

HOME RANGE, HABITAT USE, MOVEMENTS AND SURVIVAL OF NON-BREEDING LESSER PRAIRIE-CHICKENS IN THE SOUTHERN HIGH PLAINS OF TEXAS

Introduction

The lesser prairie-chicken (*Tympanuchus pallidicinctus;* hereafter LEPC) has experienced severe declines in both population and range since the late 1800's (Taylor and Guthery 1980, Hagen et al. 2004). There are a suite of probable causes for the declines in both the population and distribution of LEPCs, among which are distribution-wide declines in native prairie due to conversion to croplands, degradation and fragmentation of existing habitat due to over grazing by livestock, oil and natural gas production, and fire suppression (Davis et al. 2008). Davis et al. (2008) suggested that 90% of the original range of LEPCs is no longer suitable for occupancy.

As of 2008, it was estimated that overall population of the LEPC ranged from 30,000 to 50,000 breeding birds (Davis et al. 2008). The current distribution of LEPCs is limited to areas of Colorado, Kansas, New Mexico, Oklahoma, and Texas (Davis et al. 2008) with the occupied range in Texas having declined by approximately 78% since 1940 (Sullivan et al. 2000). With evidence of long-term declines in population and historic range, the LEPC is currently a candidate for protection under the Endangered Species Act (USFWS 2008).

The reproductive ecology and brood rearing period for the LEPC has been the main focus of previous studies. Comparatively little research effort has addressed the non-breeding ecology of the species in terms of movements (Taylor and Guthery 1980), habitat use (Donaldson et al. 1969, Davis et al. 2008, Olawsky and Smith 1991), home range (Taylor and Guthery 1980, Jamison 2000, Toole 2005, Kukal 2010), or survival (Hagen et al. 2005, Pitman et al. 2006a, Hagen et al. 2007). Information on the non-breeding season ecology of the LEPC is limited in Texas as well as other areas across its range. My primary objectives were to assess sex-specific home range size, habitat use, and survival of LEPCs during the fall and winter on the Southern High Plains of Texas. The overarching goal of this project was to accumulate data on the non-breeding ecology of LEPCs that would facilitate information-based management and conservation decisions for the LEPC and the study area.

Study Area

The study site was located on private lands in Cochran, Hockley, Terry, and Yoakum counties of the Southern High Plains of Texas. The study site consisted of primarily flat terrain with intermixed sand dunes. The site was dominated by sand-shinnery oak (*Quercus havardii*) and sand sagebrush (*Artemisia filifolia*) with grasses such as sand bluestem (*Andropogon hallii*), little bluestem (*Schizachyrium scoparium*), sand dropseed (*Sporobolis cryptandrus*), purple three-awn (*Artistida purpurea*), blue grama (*Bouteloua gracilis*), buffalo grass (*Buchloe dactyloides*), and various forbs (Crawford and Bolen 1976). The area surrounding the study site was dominated by mesquite (*Prosopis glandulosa*), grassland pastures, and agricultural fields of cotton (*Gossypium* spp.), grain sorghum (*Sorghum* spp.), sunflower (*Helianthus* spp.), and peanuts (*Arachis* spp.). The dominant soil type was a Brownfield fine sand, which is defined by ≥50 cm of fine sand on top of a sandy loam that exhibits a water infiltration rate at approximately 70 cm/hr (Pettit 1979).

Located on my study site was the Sundown, Texas Mesonet weather recording station (West Texas Mesonet 2011). Average annual precipitation for 2002 through 2010 was 45.3 cm (West Texas Mesonet 2011). Annual precipitation for 2008 through 2010 was 38.8 cm, 34.4 cm, and 58.2 cm respectively (West Texas Mesonet 2011). Average non-breeding season precipitation for 2002 through 2010 was 16.7 cm (West Texas Mesonet 2011). The non-breeding period (September through February) average rainfall for the 2008-2009, 2009-2010, and 2010-2011 seasons was 19.6 cm, 18.5 cm, and 12.2 cm (West Texas Mesonet 2011).

Cattle grazing and crop production were the primary uses of the study area as well as substantial amounts of oil production. As of 2006, Yoakum County had ≥ 6500 oil wells (Railroad Commission of Texas 2006). There were few active oil wells located on the study site; however, abandoned oil pads were still present and, occasionally, used as leks.

CHAPTER II

METHODS

Capture and Radio Tagging

I captured lesser prairie-chickens in the spring (early March to Late April) and fall (early September to mid October) with walk-in funnel traps (Haukos et al. 1989). Upon capture, I recorded sex based on tail pattern, pinnae length and presence of an eye comb (Copelin 1963). White spotting within 2.5 cm of the feather tip of the 9th and 10th primary flight feathers indicated a juvenile, whereas the absence of white spotting within 2.5 cm indicated an adult (Copelin 1963). I also measured body mass, tarsus length, and an unflattened wing cord. I collected 6-8 breast feathers and a blood sample from each bird for contribution to a separate study examining the genetic diversity of LEPCs in Texas; I drew blood (a 2-3 microliter tube, and two 1-microliter tubes) from the brachial vein using a 20-gauge needle. I equipped each bird with an aluminum TPWD blunt end leg band and 3 separate color bands, which corresponded to the lek of capture and allowed visual identification of individual birds. Following guidelines by Warner and Etter (1983) radio transmitter weights should fall below 2.3% of total body mass so as to not decrease survival. On my study site LEPCs weighed ~600-800g, for which transmitter weights should range from 13.8g to 18.4g. Conservatively, I equipped each captured LEPC with a 9 g American Wildlife Enterprise “necklace” style VHF radio transmitter (American Wildlife Enterprises, Monticello, Florida, USA), which was set with an 8-hour mortality sensor.

Radio-Telemetry

I located LEPCs via triangulation using an Advanced Telemetry System R-2000 Receiver (Advanced Telemetry Systems, Isanti, Minnesota, USA) and a hand-held 3-element Yagi antenna. I located each LEPC by triangulating (Cochran and Lord 1963) 3 to 4 bearings from fixed locations

2 to 3 times per week. I rotated relocation events among 3 diurnal periods of 0600-1000, 1001-1400, and 1401-1900 to obtain even amounts of locations per period per individual across the non-breeding period. I recorded the bearings within 15-minute intervals to limit error due to movements by birds between acquisition of bearings. I used program LOAS 4.0 (location of a signal) (Ecological Software Solutions) to obtain the Universal Transverse Mercator (UTM) coordinates derived from triangulated bearings for each location. I discarded locations from analysis if error polygons were greater than fifteen thousand square meters (e.g., ~122m x 122m) due to the high error associated with the locations. UTM coordinates were then transferred into ArcMap 10 (ArcInfo, Environmental Research Institute, Redlands, CA) and plotted as a point layer over the map of the study site.

When a mortality signal occurred, I located the transmitter via homing (Mech 1983). Upon finding a transmitter with a mortality signal, I collected all available data to determine if a mortality had occurred or if a transmitter had come unattached from a LEPC. When I confirmed a mortality, I took photographs of the mortality location and collected information such as condition of the transmitter, all available tracks and scat, and all feathers to facilitate the identification for cause of mortality.

Vegetation Cover Type Determination

I imported NAIP (National Aerial Imagery Program) aerial imagery at 1-m resolution (2008 imagery) into Arcmap 10. I described 11 different vegetation cover types based on visual interpretation of the aerial imagery (Table 1.1). I predetermined cover types based on past and current habitat management practices, and to be comparable to previous studies (Fuhlendorf et al. 2002, Kukal 2010) to accurately describe the diversity of vegetation cover types on the study site. I used ArcGis to digitize boundaries of each cover type to create a layer of vegetation cover type patches.

To confirm the delineations from aerial imagery, I ground-truthed 259 points which were located using a hand held GPS (CS60x, Garmin International Inc., Olathe, KS). The points were systematically placed at 400m intervals along roads and ATV trails across my study area. I limited data collection to a single observer to avoid observer bias. At each point, I recorded ocular estimates of percent shrub (typically sand sage brush), sand-shinnery oak, grass, and bare ground out to 100m in each of the four inter-cardinal directions (NW, NE, SW, and SE). All pastures within the study site were represented with 7-8 points to ensure accuracy of the cover type classification and delineation. I conducted ground-truthing in early spring (March and April) when the sand-shinnery oak and sand sage brush were beginning to bud (Vermeire and Wester 2001) so that I could accurately assess non-breeding season cover types.

Table 1.1. Land cover types used for determining habitat types in the Southern High Plains of Texas during the non-breeding seasons of 2008-2010.

Cover type	Classification	Description
1	Agriculture (AGRI)	Cultivated field. Typically winter wheat (*Triticum aestivum*) or common sunflower (*Helianthus annuus*).
2	CRP Grasslands (CRPG)	Monoculture of weeping love grass (*Eragrostis curvula*).
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	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.
6	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).
7	Sand-shinnery oak (SHIN)	Areas dominated by sand-shinnery oak (≥70%), with 20-30% sand-sage brush, and <10% native grasslands.
8	Sand-shinnery oak dominated, with grassland (SHIDG)	≥70% Sand-shinnery oak with ≤30% native grassland and sand-sage brush intermixed within.
9	Sand-sage brush dominated, with bare ground (SHRDB)	≥70% Sand-sage brush with ≤30% bare ground.

Table 1.1 Continued.

Cover type	Classification	Description
10	Sand-sage brush dominated, with grassland (SHRDG)	≥70% Sand-sage brush with ≤30% native grassland and sand-shinnery oak intermixed within.

CHAPTER III

ANALYSIS

Home Range and Movement Analysis

To compute the 95% fixed kernel home range polygons (Worton 1989), I used the adehabitat package (Calenge 2006) in Program R. I used the fixed kernel method over the Minimum Convex Polygon (MCP) as the MCP can be sensitive to outliers and number of locations (Seaman et al. 1999). Although Seaman et al. (1999) recommended a minimum of 30 locations for this method, sample size restrictions necessitated that I use 25 locations as a minimum number of relocations. I used a *t*-test to determine if gender-specific differences in home range size occurred. I plotted locations and computed home ranges as layers in Arcmap 10 for use in habitat analyses described below.

To assess movement patterns across the non-breeding season, I calculated minimum weekly distances between locations on a 7 day time frame. I averaged minimum weekly movements across all birds for each year. I plotted the average weekly movements for the 2009-2010 and 2010-2011 seasons against time. To assess areas of use, based on Taylor and Guthery (1980), I split the distance groups into 5 buffer sets: ≤0.8, 0.8-1.7, 1.7-3.2, 3.2-4.8, and ≥4.8 km. Within these buffers, I evaluated proportions of locations to three potentially important features: lek of capture, nearest known lek, and nearest known useable water source. I defined useable water as surface water in a man-made stock tank that was constantly available throughout the year. The tank must have water at a distance of ≤10 cm from the top of the rim or an on-ground runoff area.

Habitat Analysis

I used a Baileys Confidence interval (Bailey 1980) method to assess use vs. availability of vegetation cover types (Neu et al. 1974, Cherry 1996, Boal et al. 2005). To be more precise for this analysis, locations with error polygons greater than ten thousand square meters (~113 m x 113 m) were discarded due to high error. I used a reduced number to truncate, ten thousand square meters versus fifteen thousand square meters, to limit any habitat types falsely occurring within a given home range. I used the calculated 95% Fixed Kernel estimated home ranges to determine “available” habitat. I classified “use” by taking the locations by an individual within its home range and assessed cover type to each particular point. For this analysis, I removed three cover types (agriculture, CRP grasslands, and grassland dominated areas with mesquite) that were not detected within any LEPC calculated home range or buffer points. To avoid any overlapping habitat types, areas that had been previously treated with the herbicide tebuthiuron for control of sand-shinnery oak, were placed into the cover type with which they best correspond. I used the chi-square “goodness-of-fit” technique to assess the hypothesis that LEPCs utilize habitat types in proportion to what is available across the study area (Neu et al. 1974).

Survival Analysis

I conducted the survival analysis with the PROC PHREG in Statistical Analysis Software (SAS; v. 9.2, SAS Institute, Cary, NC). Individuals were censored based on 3 events: emigration off the study site, mortality, or survival beyond the end of the non-breeding season (28 February each year). Cause-specific mortality was assessed based on criteria described in Warner and Etter (1983). I constructed 3 *a priori* models with the categorical variables of gender, season (2008, 2009, and 2010 seasons), and overall survival rate (pooled across gender and season). I calculated model weights (ω_i) based on Akaike’s Information Criteria (AIC) which were corrected for low sample size (AICc). Cause specific mortality was pooled across season and gender.

CHAPTER IV

RESULTS

I obtained 1219 telemetry based relocations for 53 adult LEPCs (29 male and 24 female) through the 2008, 2009, and 2010 non-breeding seasons. However, I only obtained sufficient relocations to calculate home range sizes for 23 individuals (17 male and 6 female). Low sample size for home range analysis in the 2008-2009 non-breeding season (n=1) allowed comparisons only between the 2009-2010 and 2010-2011 non-breeding seasons. Home range size between seasons for male ($t=0.08_{df=1}$, P=0.95) and female ($t=0.02_{df=2}$, P=0.86) did not differ so estimates of home range for each gender were pooled across years for further analysis (Table 1.2). Pooled home range size averaged 503.5 ha (±34.9 ha) for adult females(n=5) and a slightly smaller 489.1 ha (±34.9 ha) for adult males(n=17). Overall female and male home range sizes did not differ ($t=0.05_{df=2}$, P=0.96).

Across three non-breeding seasons, I found that 97.2 % of locations of both male and female LEPCs were within 3.2 km of the lek of capture while very few locations (<5.0%) were recorded between 3.2 and 4.8 km of lek of capture (Fig 1.1). Only 2.8% of locations were beyond the 3.2-4.8 km buffer; all of these locations were attributed to movements of one adult female in September of 2008. I found 96.8% of all locations to be within 1.7 km of a known lek (Fig. 1.2) and 99.9% of all locations were within 3.2 km of an available water source (Fig. 1.3). Minimum weekly movements did not differ between seasons for male ($t=0.66_{df=15}$, P=0.52) and female ($t=0.39_{df=3}$, P=0.70) LEPCs. Similarly, when genders were pooled there was no detectable difference in minimum weekly movements (Table 1.2) between the 2009-2010 and 2010-2011 seasons ($t=0.41_{df=18}$, P=0.69).

Three of the 11 classified vegetation cover types (Table 1.1) were excluded from analysis due to lack of occurrence in any of the estimated home ranges. Cover types were not used proportional to occurrence within the home ranges (χ^2=1868.7, α=0.05). One cover type (grassland dominated areas with sand-shinnery) was used more than available (Table 1.4). Sand-sage dominated with grassland, and sand-sage dominated with bare ground were both used less than available (Table 1.4). There was no difference between use and availability of the four remaining habitat types (mesquite savannah, reverted agriculture, sand-shinnery oak, and sand-shinnery dominated oak with grassland) (Table 1.4).

During the 2008 season, I estimated the non-breeding season survival rate for 12 individuals (1 male and 11 female) at 0.846 (SE 0.141). The 2009 non-breeding season survival estimate (0.827± 0.092) for 21 individuals (13 male and 8 female) was similar to that in 2008. The non-breeding season survival estimate for 20 individuals (15 male and 5 female) in 2010 (0.572± 0.136) was markedly lower compared to previous years. The overall non-breeding season survival estimate for LEPCs on the study site was 0.721 (SE 0.0763). Based on posterior model probabilities, 46% of the model weight was supported by overall survival while season (year)and gender was supported by 37% and 17% of the weights, respectively (Table 1.5). However, all models were plausible based on delta AIC ≤2. During the 3 year study, I recorded 13 mortalities of which 10 were attributed to avian predation, 2 were mammalian, and 1 was an unknown cause (Fig 1.4).

Table 1.2. Estimated home ranges (ha) based on 95% fixed kernel estimator (HR), minimum weekly movements (MWM), minimum distance to lek-of-capture (DLC) for male and female lesser prairie-chickens in the Southern High Plains of Texas in the 2008-2009, 2009-2010, and 2010-2011 non-breeding seasons. Home ranges are reported in square meters and all distances are reported in meters.

	HR			MWM			DLC		
Season	n	Mean	SE	n	Mean	SE	n	Mean	SE
2008-2009	1	939.7	0	1	706.9	101.3	1	2512.3	184.7
2009-2010	12	430.3	28.7	12	676.0	116.8	12	965.2	189.8
2010-2011	10	506.4	57.3	10	661.9	158.6	10	1060.6	272.4

Table 1.3. Estimated minimum distance to nearest known leks (DNL), and minimum distance to nearest available water source (DH_2O) for male and female lesser prairie-chickens in the Southern High Plains of Texas in the 2008-2009, 2009-2010, and 2010-2011 non-breeding seasons. All distances are reported in meters.

	DNL			DH_2O		
Season	n	Mean	SE	n	Mean	SE
2008-2009	1	645.9	46.2	1	1542.3	74.8
2009-2010	12	729.5	118.7	12	889.6	115.8
2010-2011	10	605.8	131.8	10	1301.0	176.4

Table 1.4. Non-breeding season habitat use relative to availability of lesser prairie-chickens in the Southern High Plains of Texas from 1 September through 28 February for 2008-2009, 2009-2010, and 2010-2011. The data are based on 95% Baileys confidence intervals comparing habitat types at telemetry relocation points to available habitat types within lesser prairie-chicken home ranges.

Habitat Type[a]	Lower	Upper	Mean Proportion Availability	Use vs. Available[b]
GRDS	54.175	61.055	38.640	more
MESA	0.042	2.130	1.478	no difference
REAG	0.081	4.437	4.008	no difference
SHRDB	0.003	1.703	2.164	less
SHIDG	17.884	28.734	23.973	no difference
SHRDG	0.399	3.773	8.970	less
SHIN	5.515	12.863	11.59	no difference

[a] Habitat types as classified in table 1.1. Three habitat categories (AGRI, CRPG, and GRDM) were removed from analysis due to failure to appear in any home ranges.
[b] If mean proportion availability falls below or above the lower and upper limits of the CI, the habitat type is used more or less than available. If the mean proportion availability falls within the calculated CI, it is determined to have no difference.

Table 1.5. Ranking of *a priori* candidate models predicting survival for lesser-prairie chickens in the Southern High Plains of Texas from 1 September through 28 February for 2008-2009, 2009-2010, and 2010-2011, respectively. For each model, I display the second order Akaike Information Criterion (AICc) value, the ΔAIC value representing the difference between the models AICc value and the lowest value ofAICc, -2log likelihood, and model probability (ω_i).

Model	k	AICc	ΔAIC	-2log likelihood	ω_i
S.	1	70.92	0.00	68.84	0.46
Year	2	71.35	0.42	68.67	0.37
Gender	2	72.93	2.00	67.09	0.17

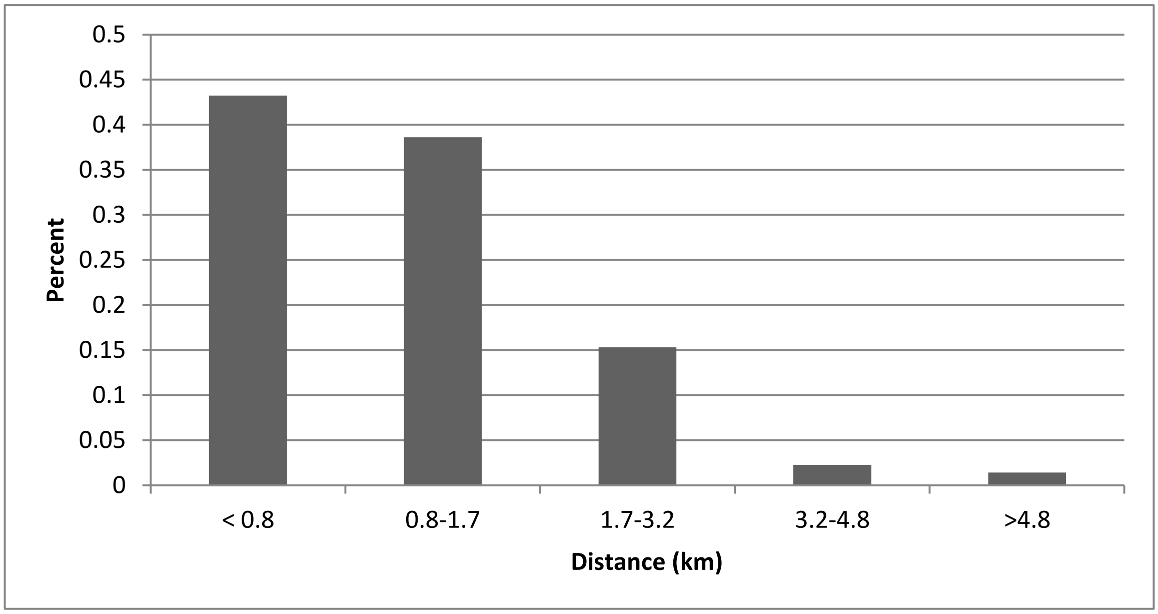

Figure 1.1. Percent of locations from lek of capture for lesser prairie-chickens in the Southern High Plains of Texas from 1 September through 28 February 2008-2009, 2009-2010, and 2010-2011.

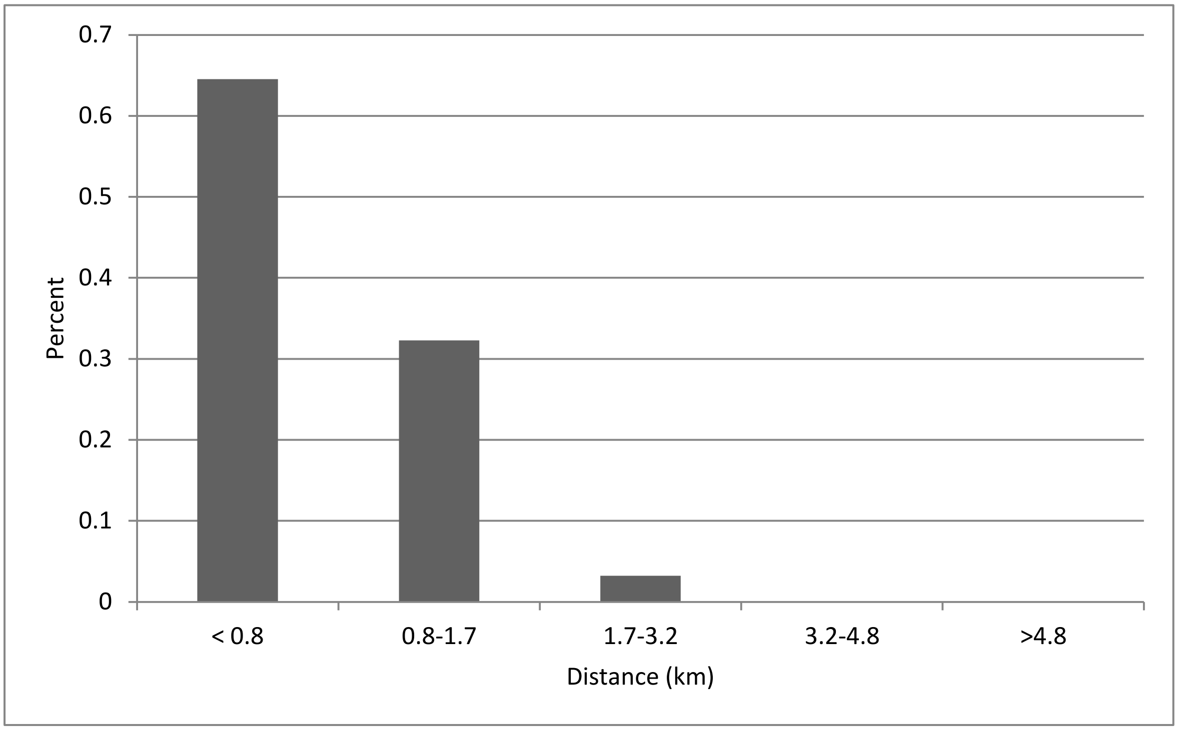

Figure 1.2. Percent of locations from nearest known lek for lesser prairie-chickens in the Southern High Plains of Texas from 1 September through 28 February 2008-2009, 2009-2010, and 2010-2011.

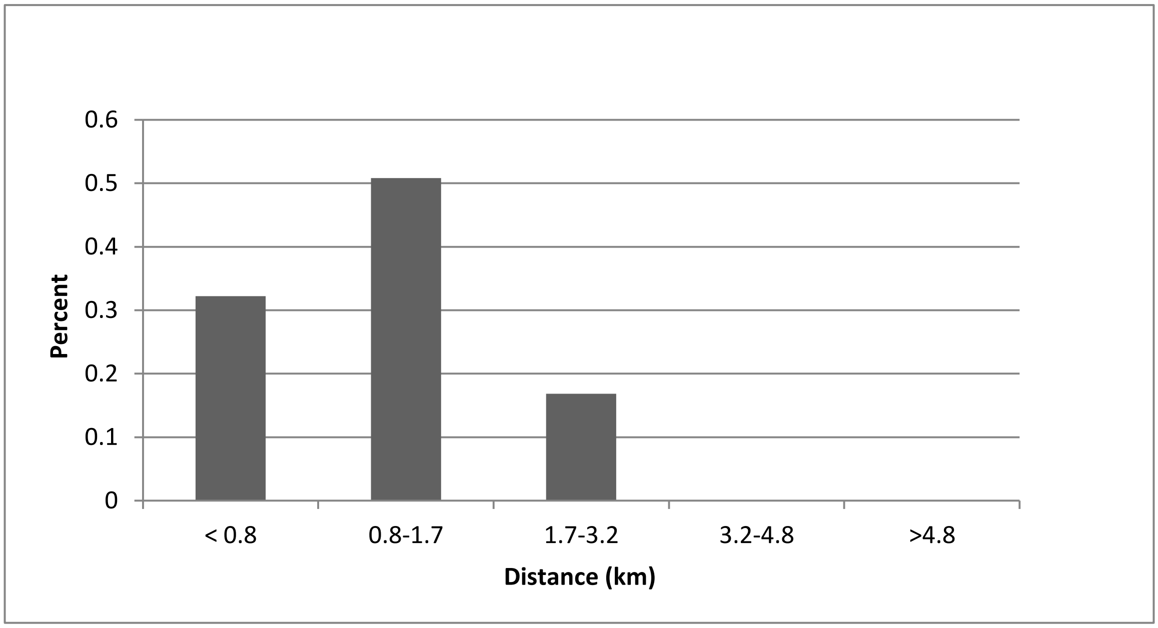

Figure 1.3. Percent of locations from estimated telemetry location point to nearest water for lesser prairie-chickens in the Southern High Plains of Texas from 1 September through 28 February 2008-2009, 2009-2010, and 2010-2011.

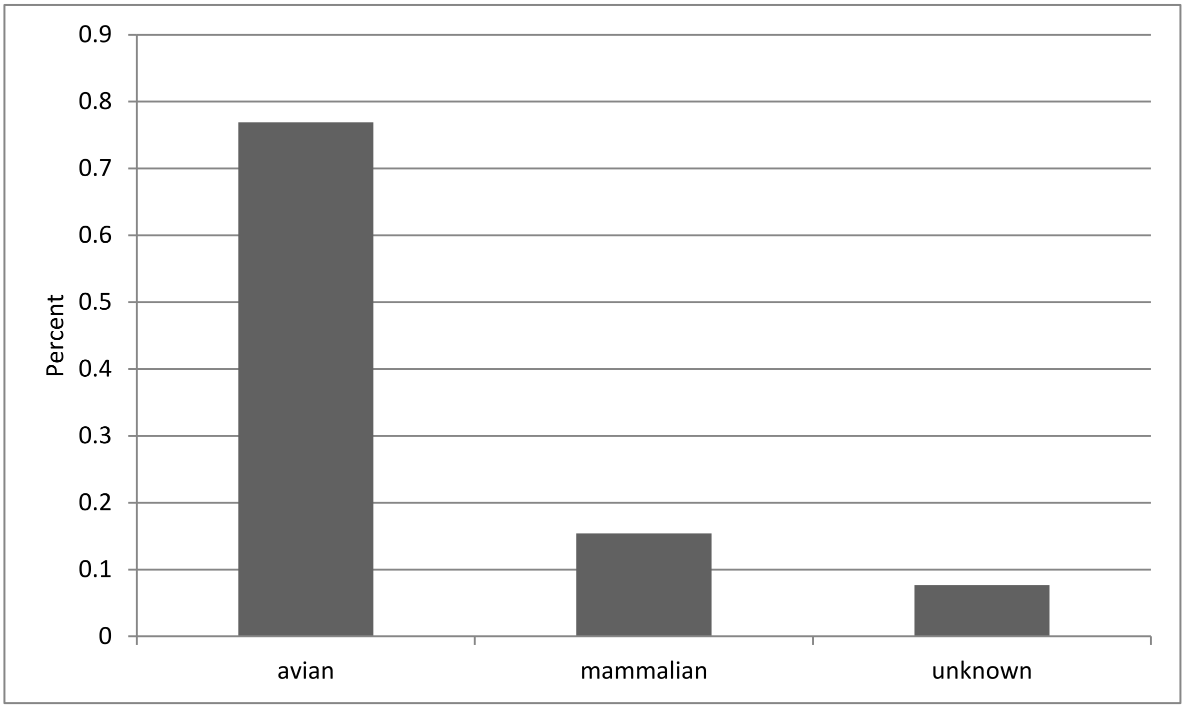

Figure 1.4. Cause specific mortality of lesser prairie-chickens in the Southern High Plains of Texas from 1 September through 28 February 2008-2009, 2009-2010, and 2010-2011.

CHAPTER V

DISCUSSION

Information-based management is pivotal for monitoring and conserving imperiled species. The ability to assess and estimate home range, movements, habitat use, and survival is important not only for understanding the basic ecology of a species but also to aid wildlife managers in making informed decisions (Heisey and Fuller 1985, Pollock et al. 1989, Murray 2006).

The observed home range estimates for adult male and adult female LEPCs were not outside other reported values. It is difficult however to directly compare our results to many other studies conducted on LEPCs. Other studies provided results using other methodology (e.g., minimum convex polygon home range estimator), different seasonal time periods and attempted to split the non-breeding seasons into autumn (1 September- 31 November) and winter (1 December-28 February). While splitting home range size into two distinct seasons may provide managers with additional information, my collected data did not support this action for three reasons. First, other studies were able to report information on juveniles. Juvenile home ranges are highly influenced by dispersal movements observed in the brood break up period (October through early January) (Taylor and Guthery 1980, Pitman et al. 2006a). Difficulties capturing juveniles in the late summer and the fall lekking period made for too small of a sample size (n=1) to analyze fall and winter movements. Second, when comparing movements with home ranges, other than one individual female dispersing 14 km in one week in January, there were no atypical movements. Third, of the 23 LEPCs in my study for which I estimated home ranges, the minimum number of locations used had to be liberalized for 5 individuals due to sample size restrictions. Splitting the available data into two distinct seasons would have weakened the home range estimates.

Movements to seek sources of food, cover, or water may increase home range sizes. Additionally, LEPCs are also known to form large flocks over the winter months; Taylor and Guthery (1980) found flocks with up to 100 LEPCs feeding in a grain field. Davis et al. (2008) also suggested that LEPCs originally may have benefited from small amounts of conversion of native grassland to cropland. I did not observe any movements to agricultural fields as previously reported in the literature (Jones 1964, Crawford and Bolen 1976, Taylor and Guthery 1980), nor did I observe any flocks ≥10 individuals at any point of the non-breeding period outside of fall lekking males. The observed groups, both through radio-collared individuals and a separate camera study, were of both single sex and both sex groups. There are various explanations that can be drawn from this information. Dry-land cotton in the Southern High Plains of Texas currently numbers 1.1 million ha and was rapidly increasing with the former Boll Weevil eradication program and the conversion of the CRP program back to row cropping (Ralston 2005). With approximately 97% of suitable habitat for LEPCs now gone (Davis et al. 2008) habitat isolation (Mader 1984) or the island effect (MacArthur and Wilson 1967) may be yielding smaller home ranges and movements.

Previous research has shown non-breeding LEPCs to remain within 4.8km of the lek of capture (Taylor and Guthery 1980, Kukal 2010). Taylor and Guthery (1980) speculated that during the fall months when sand-shinnery oak leaves drop, LEPCs will seek sources of greater cover. The opposite was reported by Donaldson (1969) who found that LEPCs used the sand-shinnery oak (*Quercus havardii*) habitat during the fall and winter months. The one cover type that was used greater than available in my study area contained sand-shinnery oak but also had a grass component. Jones (1964) found that the half-shrub type, sand-sage brush (*Artemisia filifolia*), was preferred after the loss of cover in the sand-shinnery oak dominated habitat. The sand-sage dominated habitat types were used less than available or proportional to available on my study area. The habitat types that lacked or had low percentages of grassland cover were either used proportional to, or less than, available. A grassland component mixed with the sand-shinnery cover types was preferred during the non-breeding season on my study site. However, a larger proportion of non-native weeping lovegrass (CRP grasslands) was avoided which may indicate that a mixture of sand-shinnery oak and grassland be a suitable cover type for the non-breeding season which would coincide with results found within the literature (Taylor and Guthery 1980, Olawsky and Smith 1991). Approximately 75% of the entire study site contained at least some portions of sand-shinnery oak. However, approximately 35% of the entire study site fell into the preferred grassland dominated with sand-shinnery oak habitat type. With roughly 40% of the study site falling into the other sand-shinnery oak categories (sand-shinnery oak, and sand-shinnery oak dominated with bareground), habitat improvement, increasing the grassland component within these areas through tebuthiuron treatment and/or grazing management, may be warranted.

My results suggest that LEPCs remain within 3.2 km of the lek of capture as previously reported in the literature (Taylor and Guthery 1980, Jamison et al. 2002, Kukal 2010). My results also show that LEPCs remain within 3.2 km of nearest known lek and within 3.2 km of the nearest available water. If large-scale management efforts are attainable, habitat within 4.8 km of known leks, consisting of sand-shinnery oak or grassland dominated areas with sand-shinnery oak should receive highest conservation priority. However, if resources are limited my results indicate that areas within 3.2 km of a waterhole or waterhole should be of highest priority.

Survival estimation is important when monitoring imperiled populations. Survival estimates for my study area are among the highest reported for the non-breeding period. Previously reported survival estimates range from 44% to 64% for males (Pitman et al. 2006b) and 43% to 70% for females (Hagen et al. 2007). My study found that the overall non-breeding season survival estimate of 72.1% was higher than previously reported in the literature for LEPCs. Furthermore, the survival rate estimates of 83.3% in 2008-2009 and 82.2% in 2009-2010 were greater than any reported in the prairie grouse literature for similar time frames which would suggest that non-breeding season survival may not be a limiting factor in my study area. However, I could not report juvenile ecology and my sample size, especially for females, was very low. Future research towards fine scale habitat preference and survival of female and juvenile LEPCs during the non-breeding season may provide improved understanding for development of sound conservation strategies.

Knowledge of cause-specific mortality is essential to understanding a portion of the LEPCs ecology. Over three non-breeding seasons I was able to assess cause specific mortality for 13 LEPCs. I recorded avian predation at 18.9% (10 individuals), mammalian predation (2 individuals) at 3.8%, while 1.9% (1 individual) was of an unknown cause. Previous research (Wolfe et al. 2007) has classified fence collisions as a substantive cause of mortality among LEPCs; I found no evidence of LEPC mortality due to fence collisions during the three non-breeding seasons on my study site.

CHAPTER VI

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