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**FINAL REPORT – PHASE I: Understanding the Ecology, Habitat Use, Phenology and Thermal Tolerance of Nesting Lesser Prairie-Chickens to Predict Population Level Influences of Climate Change**

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# FINAL REPORT – PHASE I: Understanding the Ecology, Habitat Use, Phenology and Thermal Tolerance of Nesting Lesser Prairie-Chickens to Predict Population Level Influences of Climate Change

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## EXECUTIVE SUMMARY

The region of the Great Plains Landscape Conservation Cooperative (GPLCC) is anticipated to experience increased maximum and minimum temperatures, reduced yet greater intensity precipitation events, and spring and the associated environmental phenology occurring earlier due to climate change. These changes and subsequent landscape management techniques may influence the Lesser Prairie-chicken (*Tympanuchus pallidicinctus*), a candidate for protection under the Endangered Species Act and a priority species under the GPLCC, in positive or negative ways. We have initiated a study funded by the GPLCC to 1) compile data on LEPC phenology and reproduction in Texas and New Mexico, 2) examine the thermal aspects of nesting LEPCs and parameters involved in nesting success, and 3) analyze a 10-yr data set of LEPC data in context of habitat management in New Mexico. We anticipated completing objectives 1 and 2 in FY 2010, and objective 3 in FY 2011. Unfortunately, due to the timing of the GPLCC funding and time to get contracts in place, many LEPC nesting attempts were completed before we could proceed with this study. Additionally, we did not have funding in place to purchase necessary equipment for several aspects of the study. We were able to make headway in the first two objectives and, indeed, gain useful information presented in this report, which we are presenting as a Final Report for Phase I of the study. Phase II will include additional analysis of objective 1 if data are provided by potential contributors, a substantial increase in data contributing to objective 2 and, therefore, requiring further analysis, and the complete analysis of objective 3. For this report, we note the scarcity of phenological data for LEPCs in general. We found that LEPC nests are maintained at temperatures and humidities that are consistent with wide swings in ambient conditions, and appear to be more associated with hen presence than nest location of vegetation. Nests are maintained at significantly warmer temperatures throughout most of the 24-hr period, but are kept significantly cooler than external temperatures when those temperatures are in the range that would result in increased potential for egg death. We also found that hens go into thermal stress due to more than just ambient temperatures, and suspect this may be due to direct exposure to solar radiation. This may have important implications for nesting cover that have not yet been addressed but are

directing us toward new directions with our research. This Phase I Final Report is the first documenting thermal aspects of LEPC nests, female behavior in response to thermal conditions, and calls to attention the need for more effort in collecting phenological data. We look forward to Phase II of this study.

## 1.0 INTRODUCTION

The Lesser Prairie-chicken is a species that has experienced as much as a 97% decline in population size (U.S. Fish and Wildlife Service 1997) and similar suspected declines in occupied area from historic levels. The species is currently a level 2 candidate for listing for protection under the Endangered Species Act due to ongoing and imminent threats (U.S. Fish and Wildlife Service 2008) and they are a priority species under the GPLCC. One of the primary science goals for the Landscape Conservation Cooperatives and the U.S. Geological Survey National Climate Change and Wildlife Science Center is to assess the vulnerability and risk of species and habitats to climate change. Furthermore, the issue of climate change as a challenge to bird conservation in arid and semi-arid regions was identified by Federal and State Fish and Wildlife Management Agencies as a high priority issue (http://nccw.usgs.gov/). The semi-arid region of the Southern Great Plains encompasses the entire distribution of the Lesser Prairie-chicken, which is considered the principal indicator species of the ecosystem. We are currently involved in studies of Lesser Prairie-chicken nesting and brood-rearing ecology, over-winter and breeding survival, and habitat use in west Texas and eastern New Mexico. Similar studies have been, and are being, conducted elsewhere across the species distribution. However, the influence of drought and climate change on Lesser Prairie-chickens has, to date, been largely overlooked. This is of concern, as Lesser Prairie-chickens appear to be particularly sensitive to landscape alterations (Hamerstrom and Hamerstrom 1961, Crawford 1980). Drought is suspected to negatively influence Lesser Prairie-chickens through reduced growth of vegetation that provides nesting, roosting, and escape cover and invertebrates that provide food (Merchant 1982, Peterson and Silvy 1994). Furthermore, there is evidence that home range sizes increase during drought years (Copelin 1963, Merchant 1982), and recruitment is lower after drought years (Merchant 1982, Giesen 1997). Home range size in particular during drought years may lead to localized abandonments, especially in fragmented landscapes. Landscape alterations and management (e.g., herbicide treatment of shrubs, grazing systems) appear to influence resource selection, survival, and reproductive success of Lesser Prairie-chicken population; however, specific (i.e., long-term) population parameters and vital rates necessary to development models of response to predicted climate change are lacking. Furthermore, despite substantial efforts to conserve LEPCs and their habitat, the thermal ecology of the species is unknown and virtually no information is available allowing predictive modeling of the role climate change may have on the nesting ecology of this species.

A key issue in conservation of Lesser Prairie-chickens in context of climate change is that the thermal ecology of the species, many specific vital rates, and long-term responses to habitat alterations are unknown. As such, virtually no information is available allowing predictive modeling of the role climate change may have on the species' reproductive ecology, resource selection, and seasonal survival. This is important in that the region of the Great Plains Landscape Conservation Cooperative (GPLCC) is anticipated to experience increased maximum and minimum temperatures, increased intensity of reduced occurrence of precipitation events, and spring and the associated environmental phenology occurring earlier. In particular, climate change forecasts indicate the Southern Great Plains will become drier with more frequent extreme heat events and decreased precipitation events (Karl et al. 2009). In addition, landscape habitat changes will occur and associated vegetation management techniques will likely become more intense. Furthermore, Lesser Prairie-chickens will be exposed to increased temperatures and decreased humidity that may exceed not only their own tolerance levels but that of their eggs. Increased surface and ambient temperature and reduced humidity may lead to egg death and/or nest abandonment. This may be exacerbated if nesting phenology shifts to later in the year due to low precipitation when temperatures are increased and humidity decreased.

There are many information needs for Lesser Prairie-chickens in west Texas and eastern New Mexico; therefore, our study has multiple goals. First was our objective of conducting a literature review of LEPC nesting phenology, clutch and brood sizes for west Texas and eastern New Mexico to provide a basis for analysis of these parameters in context of existing climate data. Second, was an in-field assessment of the thermal ecology of LEPCs derived by collection new data on thermal and humidity profiles at active nests and thermally associated behaviors of brooding Lesser Prairie-chickens. Our final goal was to conduct a complete analysis and assessment of a 10-year data set of LEPC response to herbicide and grazing treatments, including documentation of vegetation response to treatments and LEPC, reproductive success, and seasonal survival in response to the treatments. We will assess these parameters in context of projected climate change scenarios for the region. Admittedly, we recognize that this small, time-limited project will not answer all the questions regarding climate change and reproductive ecology, resource selection, and seasonal survival of Lesser Prairie-chickens. However, we believe it will provide a compilation and analysis of existing phenological data, new nest climate data, and an assessment of archived data that will be a valuable contribution toward development of predictive models of response to future climate change. Our results will provide an important tool for long-term conservation of this imperiled species by allowing simulations of spatial and temporal risk assessment for adaptive management options by conservation agencies.

Due to constraints associated with the funding cycle for the GPLCC grants and getting the contract in place, we have conducted this research in two phases. This is the final report for the first phase, which includes 1) the literature review of LEPC nesting phenology, clutch and brood sizes for west Texas and eastern New Mexico, and 2) an analysis of thermal data collected at LEPC nests during the 2010 breeding season, and influence of temperature on nesting success. With the contract now in place, we will be able to acquire the equipment that will allow us to more fully explore the thermal ecology of LEPCs during a second season of data collection, which will take place in 2011. The analysis of the 10-year data set is only now getting underway, as was proposed in the funded contract, the results of which will be provided in the Final Report: Phase II of the study.

## 2.0 STUDY AREA

Our study is on privately owned lands in Cochran, Hockley, Terry, and Yoakum counties in Texas and Roosevelt County in New Mexico (Fig. 1, 2). The soils in the area include Brownfield and Tivoli series; characterized by deep, loose, light colored, neutral sandy soils and deep, loose, light colored sands that occur as dunes that are two to five m high and have slopes as much as 30 percent, respectively (Newman 1964). The landscape is comprised of a matrix of rangeland, cropland, and gently undulating sandhills and is dominated by shinnery oak (*Quercus havardii*) and sand sagebrush (*Artemisia filifolia*) with mixed grasses and forbs. Common grasses include little bluestem (*Schizachyrium scoparium*), sand dropseed (*Sporobolus cryptandrus*), purple three-awn (*Aristida purpurea*), and sand paspalum (*Paspalum setaceum*) (Pettit 1979; Woodward et al. 2001). Common forbs include silverleaf nightshade (*Solanum elaeagnifolium*), spectacled pod (*Dimorphocarpa wislizenii*), Indian blanket (*Gaillardia pulchella*), wooly locoweed (*Astragalus ollissimus*), common sunflower (*Helianthus annuus*), scarlet gaura (*Gaura coccinea*), and halfshrub sundrop (*Calylophus serrulatus*). Pettit and Sullivan (1982) distinguished 3 community types within the shinnery oak community: 1) shin-oak/Harvard panicum (*Panicum havardii*)-giant dropseed (*Sporobolus giganteus*), with canopy cover usually less than 5%; 2) shin-oak/Harvard panicum-giant dropseed, with canopy cover from 10% to 50%; and 3) shin-oak/giant dropseed-Harvard panicum on more stable sand, with plant cover from 50% to 80% canopy cover. Additionally, Roebuck (1982) distinguished 2 subtypes within Pettit and Sullivan's type 2 in Cochran and Yoakum counties: 1) oak/grass, with an almost continuous cover of shin-oak to 76 cm tall, with three awn (*Aristida* spp.), sand dropseed, and seasonal abundance of false-buffalograss (*Monroa squarrosa*) and purple sandgrass (*Triplasis purpurea*), and 2) sand sagebrush/shin-oak, similar to shin-oak/grass but with more sandsage and slightly more grass and forbs. In other areas, mesquite (*Prosopis glandulosa*) is invasive and encroaching upon native grassland (Hagen et al. 2004; Behney 2007). Average precipitation is 45.9 cm in Texas and 31.5 cm in New Mexico (Smythe and Haukos 2009); with most precipitation falling from May to October (Newman 1964). Temperatures range from 44 to -33° C; July is hottest month with a mean temperature of 25 °C and January is the coldest month with a mean temperature of 2.4 °C (Newman 1964) in both states. The major land uses for this study are intensive agriculture and cattle production. In New Mexico, the study area is divided among several treatment blocks for a larger study on the effects of shrub control and grazing on LEPC habitat use (see Smythe and Haukos 2009 for more detailed description, Fig. 2). Common crops are cotton and grain sorghum (Crawford and Bolen 1976). Oil and natural gas production also occurs in this area.

## 3.0 METHODS

### 3.1 Literature review of LEPC nesting ecology

To examine historical patterns of LEPC nesting phenology, clutch sizes and nesting success, we did an intensive literature search to locate and review all published and unpublished reports and sought out voluntary contributions from collaborators of unpublished data. Initially, we had planned to examine detected patterns in context of different climate change scenarios. Unfortunately, the data were too sparse to do more with than compile and report the data for future opportunities for assessment.

### 3.2 In field assessment of thermal ecology of nesting LEPCs

This is the only field oriented component of the study. We will use several approaches to assess the thermal ecology of Lesser Prairie-chickens during the breeding season of 2010. The initial requirement was to capture and radio-tag LEPCs. We captured subadult and adult LEPCs on leks during late winter (February) and spring (March-April) using walk-in funnel traps, rocket-nets, and drop-nets. We determined sex by pinnate length, presence of eye comb, and other plumage characteristics (Copelin 1963). All LEPCs captured were banded with a uniquely-numbered aluminum blunt-end leg band and a nine gram necklace style radio-transmitter (American Wildlife Enterprises, Florida, USA) equipped with an eight-hour mortality censor. Each individual was subsequently released at the capture site.

We determined nest locations of radio-tagged hens by approaching the hen via homing when locations remained unchanged for ≥ 3 days (Pitman et al. 2006*a*). We counted the number of eggs in each nest (clutch size) and then marked nest locations with a hand held Garmin Etrex Vista global positioning unit.

<u>Nest Thermal Profiles</u>

We placed one Maxim Integrated Semiconductor (Maxim Integrated Products, Sunnyville, California, USA; hereafter "ibutton") inside the nest bowl and one ibutton outside of the nest bowl to record ambient air temperature and relative humidity (hereafter RH) at 10 minute intervals (categories hereafter are: nest temperature, nest RH, outside temperature, outside RH). All Temperatures are in °C and RH is defined as the ratio of water vapor mass per kilogram of dry air in a parcel of air (www.mesonet.ttu.edu, Accessed 17 August 2010). We placed the outside ibutton in the same vegetative substrate that constituted the nest bowl. For example, if the nest bowl was found in little bluestem, we put the outside ibutton on the perimeter of the nest bowl in the same plant. We collected the ibuttons within three days of nest failure or success.

We sorted the ibutton data by day and corresponding bird. We then calculated mean (and associated standard errors), maximum, and minimum values of nest temperature, nest RH, outside temperature, and outside RH for each nest and each day, respectively. We calculated mean, maximum, and minimum values in Proc MEANS in SAS version 9.2 (SAS Institute, Cary, NC, USA). Because nesting hens are more likely to be under thermal stress during the daylight hours, we calculated the mean nest temperature and mean outside temperature for the morning (0600-0900), midmorning (0901-1200), midday (1201-1500), afternoon (1501-1800), evening (1801-2100) and nighttime (2101-0559) hours. We compared these values by using a factorial analysis of variance (hereafter ANOVA) PROC GLM in SAS 9.2. We used temperature as the response variable and time period (morning, midmorning, midday, afternoon, evening, night) and location (nest/outside) as the factorial explanatory variables. We calculated the least square means for each combination using *lsmeans* in PROC GLM. We also used Cohen's *d* to determine the effect size (i.e., difference) between the two means based on the pooled standard deviation of those means; a *d* of 0.02 would be deemed small whereas a *d* of 0.8 or larger would be deemed a large effect (Cohen 1992). We also assessed if nest and outside temps and RHs differed throughout the duration of the nesting season on a weekly basis using a factorial ANOVA. We considered week 1 as 4 – 13 May, week 2 as 14 – 20 May, week 3 as 21 – 27 May, week 4 as 28 May to 3 June, week 5 as 4 – 10 June, week 6 as 11 – 17 June, week 7 as 18 – 21 June, and week 8 as 22 – 28 June. We used temperature as the response variable and week, location, and time period as the factorial explanatory variables. We calculated the least square means for each combination using *lsmeans* in PROC GLM.

We had anticipated assessing soil temperature at each nest with data loggers configured with two soil temperature probes with 2-m cable length. This would allow placing the data logger 2 m from the nest and burying the probe cable, with one probe being placed in the soil by the nest and one placed at the paired site. However, because the contract was not in place in time to purchase the necessary data loggers, we were unable to pursue this objective. We will pursue this during the 2011 breeding season and provide results in the Phase II report.

<u>Thermal Stress in LEPC Hens</u>

Gullar flutter is a method of thermoregulation among avian species. We assessed if a hen was exhibiting signs of thermal stress via gullar flutter by using video surveillance of hens at nests. To do this, we placed one GardenWatchCam (Brinno Incorporated, Palm City, Florida, USA; hereafter "nest-camera") at five nests. We set each nest-camera 1 meter from the nest bowl and each nest-camera was approximately 0.5 meters from the ground. We camouflaged the nest-camera with camouflage duct-tape and surrounding vegetation. We programmed each camera to record one photograph every five seconds and we collected the camera data within three days of nest failure or success.

We reviewed video data from each camera to monitor when hens engaged in gullar fluttering. We describing fluttering as: neck and head stretched out perpendicular to body (opposed to head and neck tucked into body) with bill gaping and "in and out" motions of the throat. At each ten minute interval we recorded: hen flutter (0= no, 1= yes), and the corresponding nest temperature, nest RH, outside temperature, outside RH from the ibutton data. We used ten minute intervals because the ibutton data restricted our observations to ten minute samples. For each hen we assess the number of flutter sequences (defined as when the hen starts flutters and continues until stopping) per day, the duration of each sequence, nest and outside temperatures when the flutter sequence begins and ends, and time spent off nest. We modeled the probability of hen going into gullar flutter based on outside nest temperature (ambient air temperature) using PROC LOGISTIC in SAS version 9.2. We used flutter as the binary response variable and outside nest temperature as explanatory variable.

<u>Nest Vegetation Surveys</u>

We quantified nest vegetation structure within three days of nest failure or success (Pitman et al. 2006*a*). We centered two perpendicular, eight meter transects on the nest bowl in a north-south and east-west orientations. We estimated percent canopy cover of shrubs, forbs, grasses, bare ground, and litter using a 60 x 60 cm Duabenmire frame (Daubenmire 1959) at the nest bowl and at four m intervals north, south, east, and west of the nest bowl. We estimated a visual obstruction reading (VOR) from a distance of four meters and a height of one meter using a Robel pole at the nest bowl (Robel et al. 1970). We measured the distance and height of the nearest shrub, forb, and grass from the center of the nest bowl (Pitman et al. 2006*a*) and measured litter depth from the center of the nest bowl out to four meters north, south, east, and west of the nest bowl at 0.5 m intervals (Davis et al. 1979).

Nest Survival Analysis

We developed 10 *a priori* models to assess nest survival. All candidate models are based on previous knowledge of LEPC behavior (Woodward et al. 2001, Hagen et al. 2004, Pitman et al. 2005, Pitman et al. 2006). We obtained weather data from the Sundown weather station (http://www.mesonet.ttu.edu/dailysummary.html; accessed August 2008) located in Cochran County, Texas. The weather station is located on the study site. We used Akaike's information criterion ($AIC_c$), changes in $AIC_c$ and $\Delta AIC_c$ values, and Akaike weights ($AIC_w$) to evaluate model performance and select the best approximating model (Anderson et al. 2000).

### 3.3 Analysis and compilation of 10-year response to habitat changes

During 1999 and 2000, grazed and tebuthiuron treated and associated control plots were established on a private ranch and adjacent State of New Mexico property. Over the course of the following 10 field seasons, female lesser prairie-chickens were radio-tagged each spring and followed until mortality occurred, the bird left the study area, or transmitter failure. Survival, nest site selection, nest success, and habitat use was recorded for >100 females during the course of the study. In addition, vegetation community response was recorded across treatment combinations. Species composition, cover, and richness were measured each year. Finally, invertebrate and small mammal composition and occurrence was also recorded. Synthesis and analysis of these data are the central component to Phase II of this study and will be addressed during FY 2010.

## 4.0 RESULTS

### 4.1 Literature review of LEPC nesting ecology

We conducted an extensive review and search for information on clutch initiation dates and brood sizes for LEPCs. Unfortunately, there is a dearth of information available on this data. We found data for 3 studies from Texas, 2 from New Mexico, two from Oklahoma and one from Kansas from which we could find data on some or all of the parameters of nest initiation dates and clutch sizes (Table 1). These reports averaged 3.6 years of data. Mean nest initiation ranged from as early as 25 April in 2005 in New Mexico (Davis 2009), to as late as 28 May in Oklahoma (Copelin 1963). However, Copelin's (1963) data must be interpreted cautiously, as they consist of only a small sample of 10 nests and include a wide time range (1920 to 1959). In general, mean initiation dates appear to be in early to mid-May (Table 1). However, all these data pooled both initial and renesting dates except Pitman et al. (2006). There was no correlation between date and clutch size for 7 data sets from 6 studies ($r = 0.282$, $p = 0.541$). The scarcity of data prevented examination of weather mediated influences on phenology at this time. We are attempting to obtain nest-specific initiation and brood size data for further analysis during Phase II of this study.

### 4.2 In field assessment of thermal ecology of nesting LEPCs

Nest Thermal Profiles

We collected 29,397 recordings of nest temperature, nest RH, outside temperature, and outside RH from 17 nesting hens (5 from Texas, 12 from New Mexico) in 2010. Outside temperatures and RH fluctuated widely with time of day whereas nest temperatures and RH were consistent within nests, suggesting they may be regulated by the nesting hen (Table 2, 3). In general, nests were warmer than external temperatures throughout the 24-hr period except for the afternoon and mid-day, during which nests were cooler (Table 2). Nests averaged 31.2°C with an average range of 28.5 – 33.5°C, whereas external temperatures averaged 27.6°C with a range of average from 20.3 to 35.0°C. However, these measures are as yet uncorrected for the number of hours within each time period. For example, we have not taken into account that the night time period is 9 hrs, whereas daylight periods range from 3 to 4 hrs. Relative humidity was similarly consistent among nests (mean 55.9, range 50.1 – 62.6) compared to external measures (mean 52.2, range 35.2 – 74.9), and was higher throughout the 24-hr period except during nighttime and early morning hours (Table 3). This relationship is illustrated for a representative hen in Fig. 3.

We collected 233 daily average recordings of nest temperature, nest RH, outside temperature, and outside RH for the daylight hours. Mean nest temperature ( $\bar{x}$ = 30.09, SE = 0.02) was significantly warmer than outside temperature ( $\bar{x}$ = 25.97, SE = 0.05; $t$ = 78.86, $df$ = 58754, $p$ = <0.001). The effect size ($d$ = 7.75) suggesting a large difference between the means. The mean nest RH ( $\bar{x}$ = 56.99, SE = 0.09) was more humid than outside RH ( $\bar{x}$ = 55.69, SE = 0.16; $t$ = 6.9, $df$ = 58754, $p$ = <0.001), with and effect size of $d$ = 0.681 suggesting a medium to large difference existed between the means. Nest temperatures were significantly different from outside nest temperatures as the nesting season progressed ($f$= 1011.81, $df$ = 13, $p$ = <0.001; Fig. 4). With the exception of week 7, nest temperatures were significantly warmer than outside temperatures. Additionally, outside temperatures increased throughout the nesting season (Fig. 4). Lastly, there was a significant interaction among week, time period, and location ($f$ = 761.62, $df$ = 83, $p$ = <0.001)

Thermal Stress in LEPC Hens

During the 2010 season, we were only able to place nest-cameras at 5 nests. We were only obtained usable footage from 4 (1 nest-camera was inadvertently blocked by vegetation). We also had to eliminate data for one hen due to faulty ibutton readings). Ultimately, we obtained only 3 complete flutter sequences from 2 birds. Each flutter sequence typically lasted for >5 hours, and once a hen began to flutter she did so continuously without breaks until she stopped. Table 4 outlines each flutter sequence from each complete observation. Hens typically left the nest twice a day, once in the early morning (05:00-08:00) and once in the early evening (18:00-20:30). Duration of off-nest events varied, but off-nest periods tended to last less than two hours (Table 5).When the hen was off nest, temperatures in the nest increased in the AM and decreased in the PM (Table 5).

We recorded 284 flutter observations from 3 nesting LEPC hens. According to our model, the relationship between ambient air temperature and gullar flutter is:

$$\text{flutter} = \frac{e^{0.1614(airtemp)-5.3095}}{1-e^{0.1614(airtemp)-5.3095}}$$

Ambient air temperature was not a good predictor of gullar flutter ($R^2$=0.24). Most importantly, the results indicate that a more complex model is needed to properly identify the relationship between gullar flutter and weather conditions (Hosmeer and Lemeshow; $\chi 2$ = 49.73, *df* = 8, *p* <0.0001; Table 6). We anticipate being able to build this model with the additional data we will collect in 2011 as part of Phase II of this study.

Nest Survival Analysis

We assessed nest success for 32 nests from 22 hens in 2008-2010 (14 in 2008; 8 in 2009; 9 in 2010). Three of 17 females did not initiate nests in 2008 and three of 11 females did not initiate nests in 2009 (conversely, nests may have been initiated but abandoned or depredated before being located). All females initiated nests in 2010. Twenty-two nests were found in shrubs (shinnery oak and sand sagebrush), seven nests were found in grasses, and two were located in yucca. In 2008, 7 of 14 nests hatched (46%), 2 of 9 (22%) nest hatched in 2009, and 7 of 10 hatched in 2010 (70%). Based on model selection criteria (Table 7), clutch size was the best predictor of nest survival. However, the model suggested weather effects were also an important factor in nest survival (Table 8). Based on the clutch model, nest survival was 0.56 (SE= 100) for 2008 - 2010**.** We suspect the SE is incorrect because there was over dispersion in the model, likely due to the disparity in hatch/fail rates among 2008, 2009, and 2010 in our study area. Unfortunately, MARK does not have a GOF test for the nest survival model.

### 4.3 Analysis and compilation of 10-year response to habitat changes

We are in the process of conducting this analysis. This will be the central component to Phase II of the study.

## 5.0 DISCUSSION

### 5.1 Literature review of LEPC nesting ecology

We have found there is a great lack of information on the phenological aspects of the nesting ecology of LEPCs. This is troubling in that it provides little opportunity to examine climate influences on phenology and clutch size, or make predictions as to the influence of climate change on the species. However, it also presents the opportunity for researchers to combine their efforts in collecting and compiling these data. Although we have obtained the summarized data from several studies, we now know whom to pursue for collaboration in providing their raw data for our examination of nesting parameters in context of weather conditions (to the extent available) local to the individual studies. The results of these efforts will be presented in the Phase II report.

### 5.2 In field assessment of thermal ecology of nesting LEPCs

<u>Nest Thermal Profiles</u>

We obtained thermal and RH data from the nests of 17 LEPCs. This number was reduced from what was possible due to the timing of the funding cycle for this project. We anticipate substantially increasing the number of nests from which we will collect thermal data in 2011. We had anticipated that nest temperatures would be cooler during the day and warmer at night than that external to the nests. We were correct in that night time nest temperatures were significantly greater than external temperatures, but had anticipated that daytime temperatures would be cooler than external temperatures. However, nest temperatures were cooler only during the afternoon and mid-day hours when external temperatures were at their highest. In relation to ambient conditions, however, nest temperatures and RH remained relatively consistent. Indeed, it was quite noticeable on the ibutton data when hen took temporary leave of nests. This suggests the hens play a critical role in regulating the thermal and humidity conditions within nests.

Nests averaged 31.2°C with an average range of 28.5 – 33.5°C. As noted previously, these measures are as yet uncorrected for the number of hours within each time period. The thermal tolerances of LEPCs is as yet undetermined, but thermal tolerance for 80% survivorship among Galliformes was estimated as 31° – 39° C (Webb 1987); if this holds for LEPCs, it appears current conditions may be pushing the threshold for egg survival. In general, Webb (1987) suggested most species could survive a range of 36° to 39° C for exposure of no more than a few hours.

Humidity may be an even greater issue for LEPC. Hermes (1995) recommended a relative humidity of 55% - 60% for captive incubation of bird eggs. Humidity in our study area averaged as low as 35.2% during some periods, but nest humidity averaged 55.9% and is consistent with the recommendations of Hermes (1994). It appears that hens can maintain nests in an acceptable humidity under current conditions; however, their ability to compensate for climate trends of hotter drier air is unknown. We also were not able to examine the role of soil temperature and moisture during the 2010 season. However, 2010 was a generally high humidity year in the study area. We hope to examine and report on this component in the Phase II report for the 2011 season.

<u>Thermal Stress in LEPC Hens</u>

The use of cameras in this study was experimental and the methods with which to optimize their use needed to be understood. After the 2010 season, we now have the experience to maximize our success in deploying cameras to monitor LEPC nests. Unfortunately, the fiscal constraints of the timing for funding contract being completed prevented us from purchase as many cameras as we had anticipated, and the lateness of the season reduced the number of active nests at which cameras could be placed. This limited the amount of data we were able to collect in 2010. However, our results are interesting. In essence, we found that once a hen commenced gullar flutter, she continued nonstop until the cooler temperatures of the afternoon. Indeed, flutter sequences ranged from 5 to over 6 hours. Gullar flutter, as an indicator of thermal stress, however, did not appear to be strongly associated with just ambient air temperature. We suspect we have overlooked another aspect of this behavior, as believe it may be related to direct solar exposure. Thus, it may be direct sunlight striking the hen rather than just temperature that leads to thermoregulation. We will explore this more fully in the 2011 season and present our result in the Phase II report.

Nest Survival Analysis

Based on model selection criteria, clutch size, related to nest age when found, was the best predictor of nest survival. However, our models also suggested weather effects were an important factor in nest survival. We suspect problems with our modeling efforts are associated with an over dispersion of our data, likely due to a high disparity in hatch/fail rates among LEPCs in our study area during the 2008, 2009, and 2010. We will explore approaches to account for this with our future modeling efforts.

### 5.3 Analysis and compilation of 10-year response to habitat changes

We are in the process of conducting this analysis. This will be the central component to Phase II of the study.

## 6.0 LITERATURE CITED

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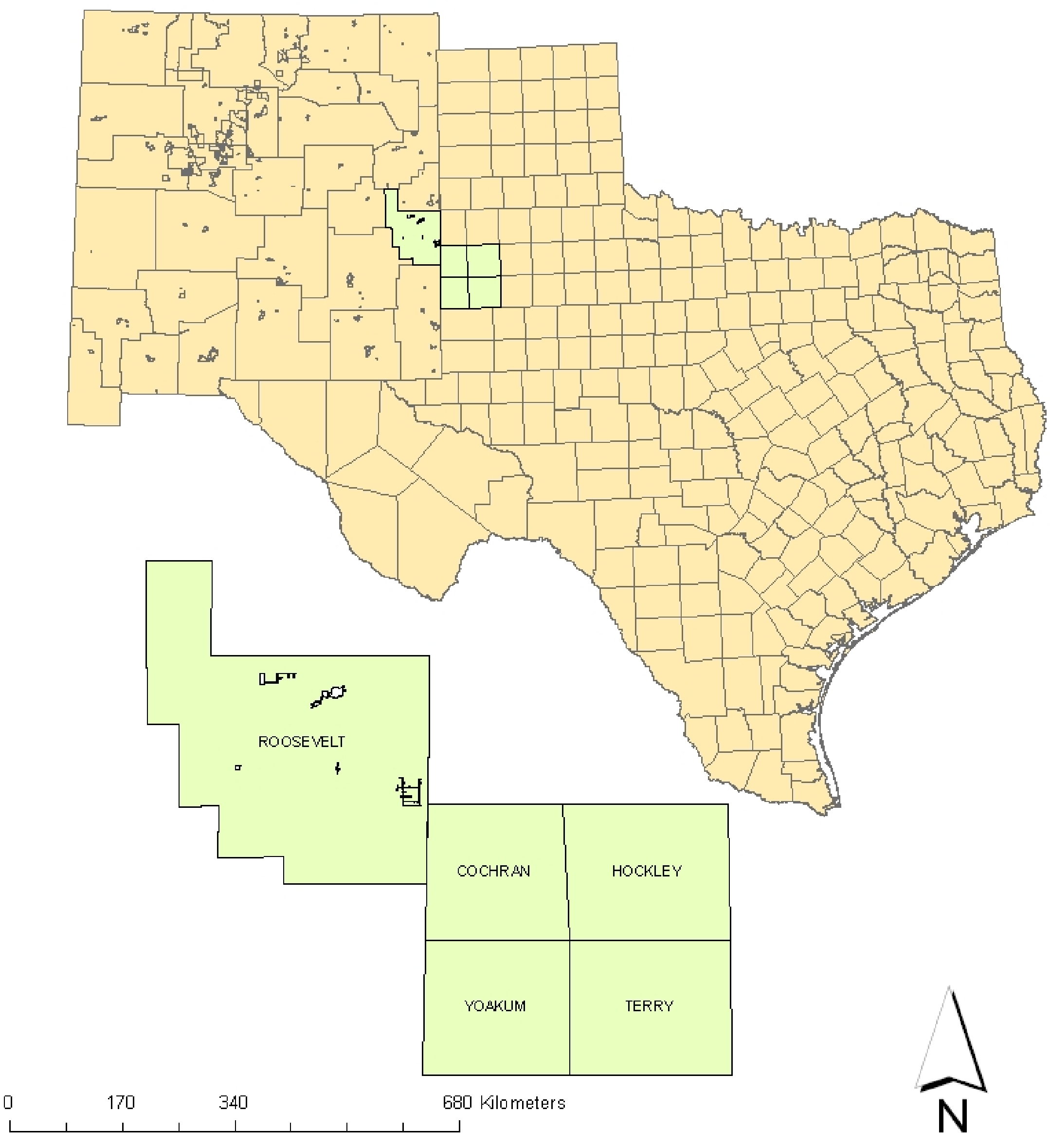



Figure 1. General outline of the New Mexico and Texas Lesser Prairie Chicken research study areas, Cochran, Hockley, Terry, and Yoakum counties, TX, USA, 2008-2010. Green boxes represent study area county boundaries.

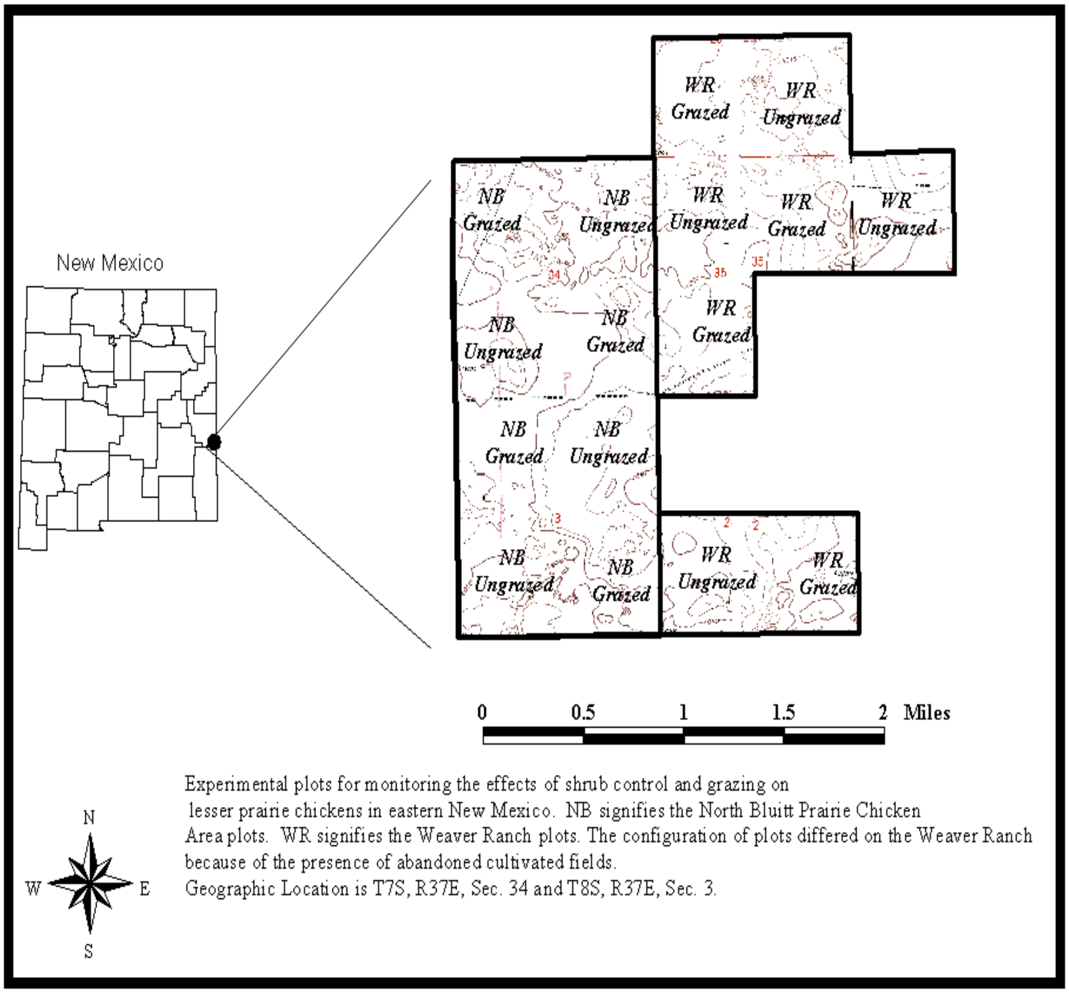
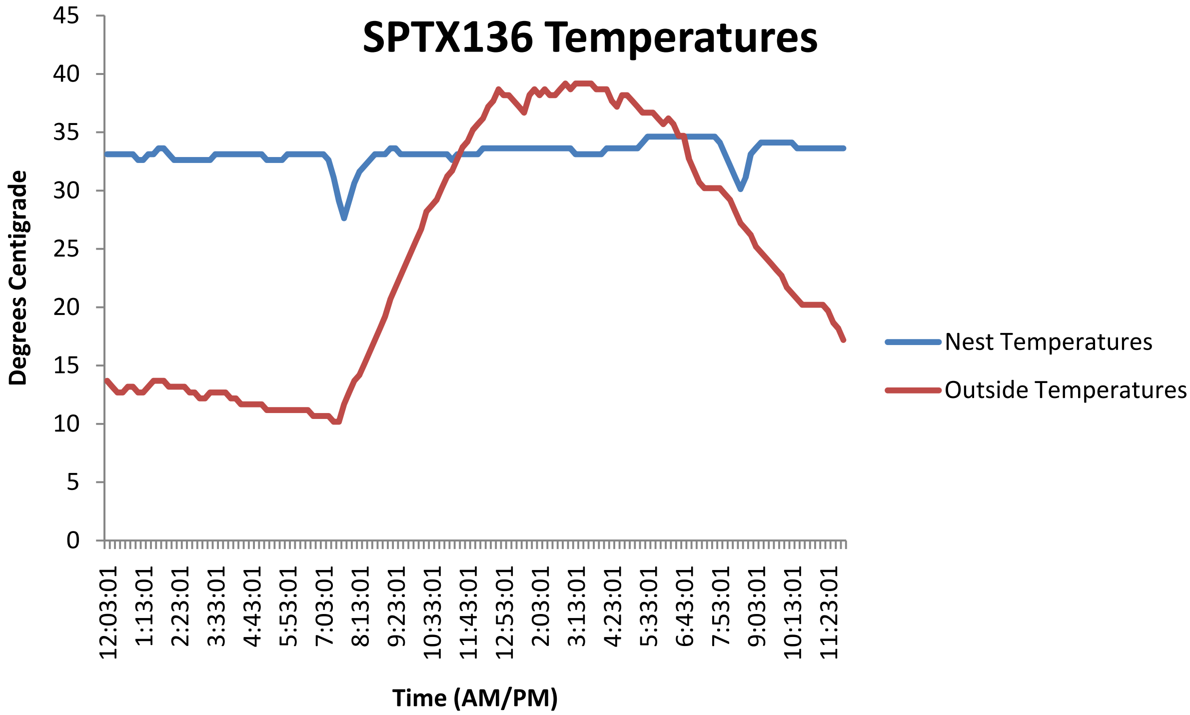



Figure 2. Experimental plots for monitoring the effects of shrub control and grazing on lesser prairie chickens in eastern New Mexico.



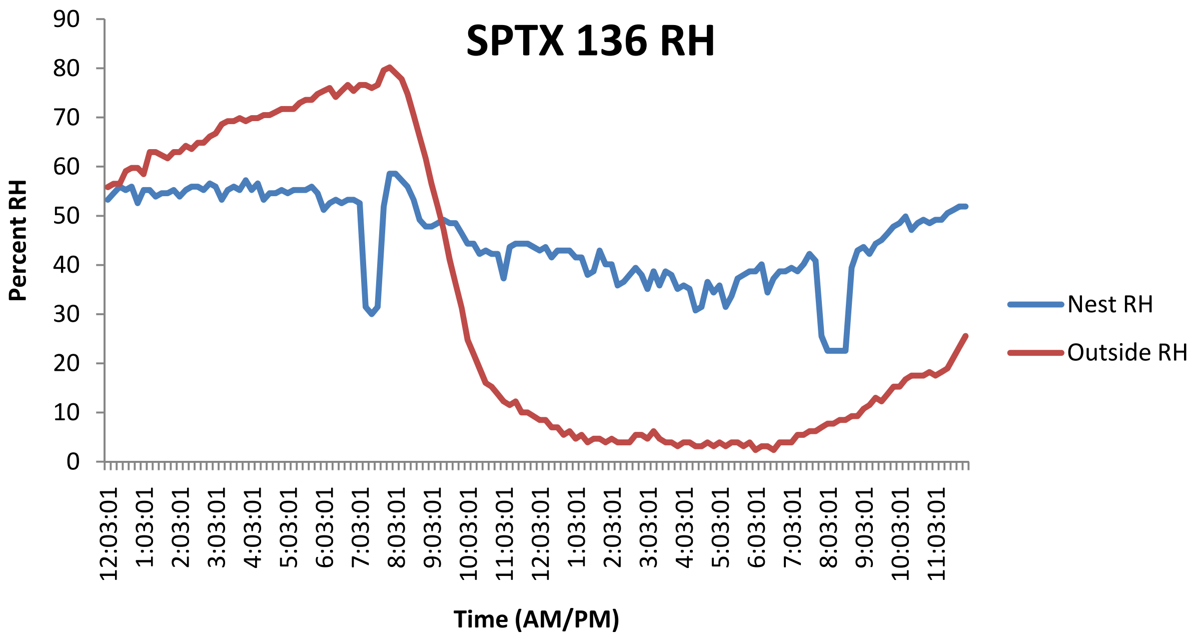
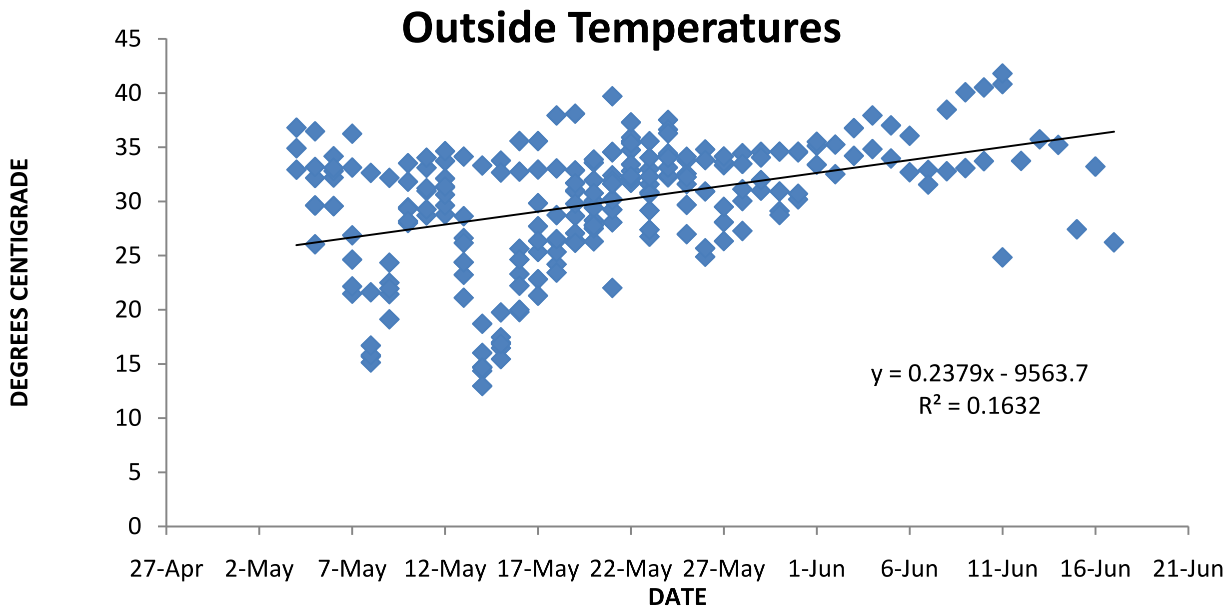




Figure 3. Nest and outside temperatures and RH for randomly selected bird (SPTX136) and date (6 May 2010).



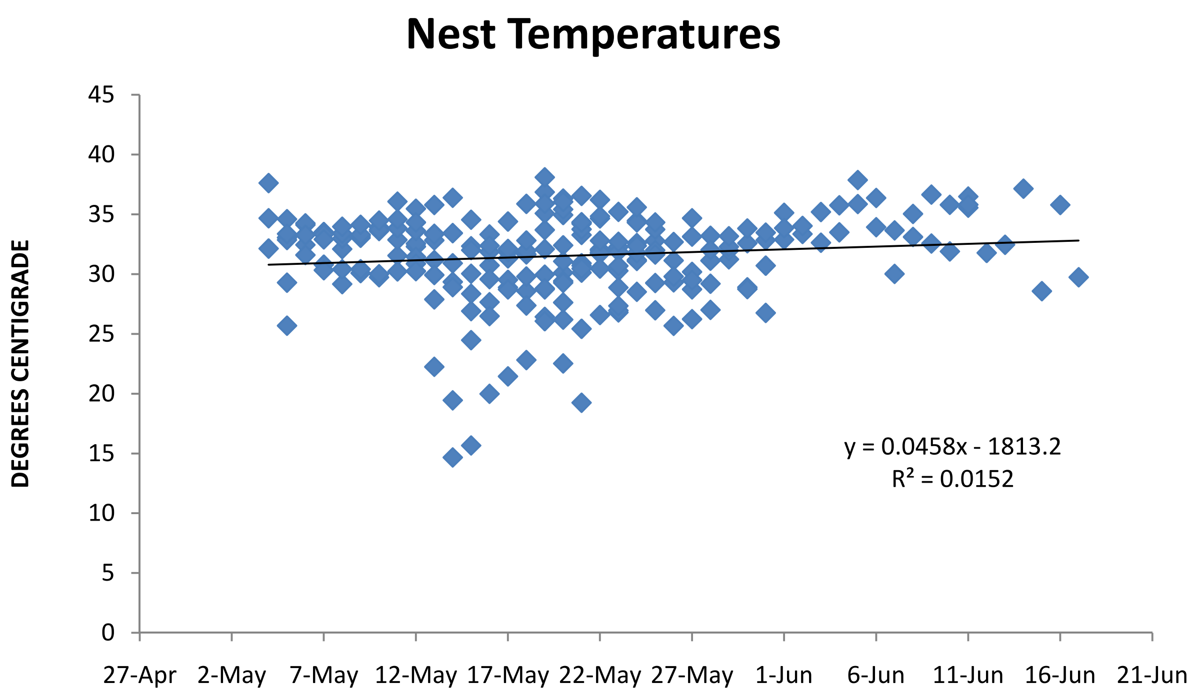




Figure 4. Mean daylight nest and outside temperatures by date from 17 LEPC nests in Cochran, Hockley, Terry, and Yoakum counties, TX, and Roosevelt county, NM, USA, 2008-2010.

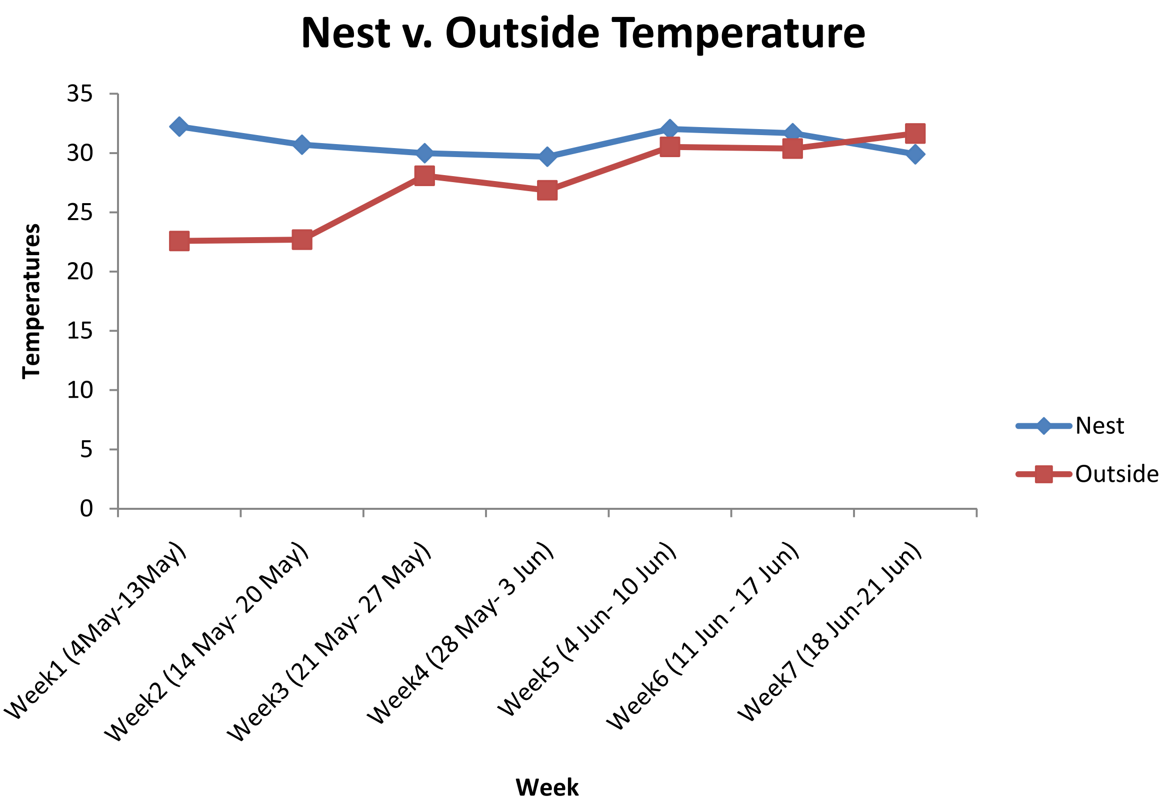



Figure 5. Mean nest and random temperatures by week for 17 nesting hens in Cochran, Hockley, Terry, and Yoakum counties, TX, and Roosevelt county, NM, USA, 2008-2010.

Table 1. Study locations, years, sample sizes, initiation dates and clutch sizes for studies of record reporting phonological and reproductive data for lesser prairie-chickens. * Parameter estimates for juvenile birds are in parentheses. ^No mean was indicated by authors. [a]Clutch size was not determined for every nest.

| Location | Year(s) | *n* | Mean Initiation Date | Mean Julian Date | Mean Clutch Size | Study |
|---|---|---|---|---|---|---|
| TX | 2008-2010 | 33 | 13-May | 133 | 7.48 | Grisham *et al.* (unpub.) |
| TX | 2008-2010 | 25 | 4-May | 124.2 | 9.84 | Holt *et al.* (unpub.) |
| TX | 1987-1988 | 13 | 13-May | 133 | 7.83 | Haukos (1988) |
| OK | 1920, 1956, 1959 | 10 | 28-May | 148 | 11.2 | Copelin (1963) |
| KA | 1997-2002 | 76(57)* | 7-May | 127.3 (127.4) | 12.3(11.8) | Pitman *et al.* (2006) |
| | | 15(13)* | 1-Jun | 152.9(153.9) | 7.3(8.2) | |
| NM | 2004 | 7 | 7-May | 127 | Range 6-12^ | Davis(2009) |
| | 2005 | 14 | 25-Apr | 115 | Range 6-12^ | |
| OK | 1999-2003 | *N/A* | *N/A* | *N/A* | 10.85 | Wolf *et al.* (2003) |
| NM | 2006-2010 | 93 | 18-May | 138 | 8.6 (43)[a] | Haukos *et al.* (unpub.) |

Table 2. Temperature means, standard errors, significance of differences, and direction of nest temperature relative to external temperature at lesser prairie-chicken nests in west Texas and eastern New Mexico, 2010.

| | Nest | | External | | | |
|---|---|---|---|---|---|---|
| Time | Mean | SE | Mean | SE | *P* | Nest temp |
| Morning | 28.5 | 0.11 | 20.3 | 0.11 | <0.0001 | ↑ |
| Mid-morning | 31.1 | 0.10 | 28.7 | 0.10 | <0.0001 | ↑ |
| Afternoon | 33.4 | 0.10 | 33.9 | 0.10 | 0.0517 | ≈ |
| Mid-day | 33.5 | 0.10 | 35.0 | 0.10 | <0.0001 | ↓ |
| Evening | 30.9 | 0.10 | 26.9 | 0.10 | <0.0001 | ↑ |
| Night | 30.0 | 0.06 | 20.9 | 0.06 | <0.0001 | ↑ |

Table 3. Relative humidity means, standard errors, significance of differences, and direction of relative humidity relative to external conditions at lesser prairie-chicken nests in west Texas and eastern New Mexico, 2010.

| | Nest | | External | | | |
|---|---|---|---|---|---|---|
| Time | Mean | SE | Mean | SE | *P* | Nest RH |
| Morning | 62.6 | 0.34 | 74.9 | 0.34 | <0.0001 | ↓ |
| Mid-morning | 58.2 | 0.33 | 53.7 | 0.33 | <0.0001 | ↑ |
| Afternoon | 50.1 | 0.33 | 35.2 | 0.33 | <0.0001 | ↑ |
| Mid-day | 52.2 | 0.33 | 37.5 | 0.33 | <0.0001 | ↑ |
| Evening | 52.1 | 0.33 | 45.0 | 0.33 | <0.0001 | ↑ |
| Night | 60.3 | 0.19 | 66.8 | 0.19 | <0.0001 | ↓ |

Table 4. Detailed description of each complete flutter sequence from 2 nesting LEPC hens in Cochran, Hockley, Terry, and Yoakum counties, TX, and Roosevelt county, NM, USA, 2008-2010.

| Bird ID | Day | Start Time | End Time | Duration | Nest Temp @ Start | Nest Temp @ Finish | Outside Temp @ Start | Outside Temp @ Finish |
|---|---|---|---|---|---|---|---|---|
| HEN127NM | 18-Jun-10 | 10:42 | 16:02 | 5:20 | 31.66 | 33.65 | 31.74 | 37.22 |
| | 19-Jun-10 | 10:52 | 15:52 | 5:00 | 32.65 | 34.65 | 31.74 | 35.73 |
| SPTX134 | 19-May-10 | 10:35 | 16:45 | 6:10 | 26.08 | 38.57 | 28.18 | 47.61 |

Table 5. Changes in nest temperature while LEPC hen was off nest. BeginningTemp is the temperature of the nest when the hen left nest and EndTemp is temperature is the temperature of the nest when the hen returned.

| Bird ID | Date | AM/PM | Duration off Nest | BeginningTemp | EndTemp | ΔNestTemp |
|---|---|---|---|---|---|---|
| SPTX134 | 19-May | PM | 1:20 | 39.06 | 34.08 | -4.98 |
| | 20-May | PM | 0:50 | 35.58 | 29.59 | -5.99 |
| | 6-Jun | AM | 1:20 | 24.17 | 26.17 | 2.00 |
| Hen127NM | 18-Jun | AM | 0:50 | 21.74 | 22.24 | 0.50 |
| | | PM | 0:50 | 34.23 | 29.47 | -4.76 |
| | 19-Jun | PM | 1:32 | 35.23 | 34.23 | -1.00 |

Table 6. Logistic regression model from 433 flutter observations of nesting LEPC hens from Cochran, Hockley, Terry, and Yoakum counties, TX, and Roosevelt county, NM, USA, 2008-2010.

| Predictor | $\beta$ | $SE^{\beta}$ | Wald's $\chi^2$ | *df* | *p* | $e^{\beta}$ |
|---|---|---|---|---|---|---|
| Intercept | -5.095 | 0.8684 | 37.3802 | 1 | <.0001 | N/A |
| RandomTemp | 0.1614 | 0.0298 | 0.0255 | 1 | <.0001 | 1.175 |

| Test | $\chi 2$ | *df* | *p* |
|---|---|---|---|
| Overall model evaluation | | | |
| Likelihood ratio test | 77.3323 | 1 | <.0001 |
| Score test | 62.9050 | 1 | <.0001 |
| Wald test | 39.9983 | 1 | <.0001 |
| Goodness-of-fit-test | | | |
| Hosmer&Lemeshow | 49.73 | 8 | <.0001 |

Table 7. *A priori* candidate models used to estimate nest survival rates for Lesser Prairie-Chicken nests in Cochran, Hockley, Terry, and Yoakum counties, TX, USA, 2008-2010.

| Model | Name | Parameters |
|---|---|---|
| $S_{RH}$ | Relative Humidity | Average Daily Humidity |
| $S_{Rain}$ | Rainfall | Daily Rainfall |
| $S_{Temp}$ | Temperature | Average Daily Temperature |
| $S_{Comp}$ | Nest Vegetation Composition | %shrub, grass, forb, litter, bare ground at nest |
| $S_{HenAge}$ | Hen Age | Juvenile, Adult |
| $S_{Clutch}$ | Clutch Size | # Eggs in Nest |
| $S_{T}$ | Linear Time Trend | *N/A* |
| $S_{TT}$ | Quadratic Time Trend | *N/A* |
| $S_{Daily}$ | Daily Survival | Day (27 Apr- 4Jul) |
| $S_{Weather+Comp}$ | Weather + Nest Vegetation Composition | Average Daily Humidity and Temperature, Daily Rainfall, %shrub, grass, forb, litter, bare ground at nest |

Table 8. Output from 10 *a priori* candidate models used to estimate nest survival rates for lesser prairie-chicken nests in Cochran, Hockley, Terry, and Yoakum counties, TX, 2008-2010.

| Model | QAIC | Delta $AIC_c$ | $AIC_C$ Weight | K | Deviance |
|---|---|---|---|---|---|
| {Clutch} | 144.4611 | 0.00 | 0.60 | 1.00 | 142.45 |
| {RH} | 146.6653 | 0.20 | 0.20 | 1.00 | 144.65 |
| {Weather} | 147.1336 | 0.15 | 0.15 | 3.00 | 141.09 |
| {Temp} | 151.8074 | 0.01 | 0.01 | 1.00 | 149.80 |
| {Group} | 151.9467 | 0.01 | 0.01 | 3.00 | 145.90 |
| {TT} | 375.86 | 0.00 | 0.00 | 2.00 | 371.85 |
| {T} | 375.86 | 0.00 | 0.00 | 2.00 | 374.76 |
| {HenAge} | 459.2609 | 0 | 0 | 1.00 | 457.25 |
| {Daily} | 472.1987 | 0 | 0 | 151.00 | 71.69 |
| {Rain} | 707.1792 | 0 | 0 | 2.00 | 703.15 |