IMPROVING LESSER PRAIRIE-CHICKEN LEK SURVEYS ON PRIVATE LANDS

T-17-P
FINAL PERFORMANCE REPORT

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Lesser prairie-chicken numbers and distribution have significantly declined from historic levels. Since the 1800s, prairie chicken numbers have declined by 97% range-wide, and their distribution has suffered a 92% reduction (Litton 1978, Crawford 1980, Taylor and Guthery 1980). These declines were also evident in the Texas Panhandle, with a distribution reduction of 78% between 1963 and 1980 (Sullivan et al. 2000). Lesser prairie-chicken numbers in the Texas Panhandle are likely now at an all-time low (Wu et al. 2001, Whitlaw and DeMaso 2006). Reasons for lesser prairie-chicken declines are untested but may include: habitat loss and reduction of habitat quality as a result of over-grazing, wide-scale conversion of native prairies and rangelands to agriculture, habitat fragmentation, and drought (Crawford 1980, Taylor and Guthery 1980, Riley et al. 1993, Sullivan et al. 2000).

Declines in lesser prairie-chicken populations resulted in a petition to the U.S. Fish and Wildlife Service (Service) in 1995 to list the lesser prairie-chicken as threatened (Mote et al. 1999). In 1998 the Service determined that listing of the lesser prairie-chicken was warranted but precluded, which added them to the Service's candidate species list (Mote et al. 1999) and gave it a listing priority number of 8 on a scale from 1-12. The Service raised the listing priority number from 8 to 2 in 2008, increasing the probability of listing in the near future. Lesser prairie-chickens are a high-priority species for conservation efforts in the Texas Wildlife Action Plan (TWAP; Bender et al. 2005:26 and 737).

Lesser prairie-chickens in Texas primarily occur on private lands. Historically, lesser prairie-chicken populations on private lands have been monitored with ground-based surveys of known lek sites along road systems, using methods similar to those used on mourning dove surveys. Both the number of males attending lek sites and, less frequently, the total number of leks per area have been used to track population trends (Cannon and Knopf 1981, Applegate

2000). The Texas Parks and Wildlife Department (TPWD) has used these methods to monitor lesser prairie-chickens on private lands (TPWD 2004). In addition, TPWD uses these methods to find new lek locations. Ground-based listening survey methods are labor intensive and require good road access; they may also be affected by environmental conditions during survey periods (e.g., wind velocity, precipitation, topography, and vegetation). Applegate (2004) suggested that we must "think outside the box" and try new methods and alternatives in an effort to change downward trends in lesser prairie-chicken populations. He indicated that there is a crucial need for a willingness to devise, test, and apply innovative ideas that are not normally considered in the management of grouse species. In the same special section of *The Wildlife Society Bulletin* concerning prairie grouse, Hagen et al. (2004) stressed that survey methodologies needed to be standardized and improved.

Rusk et al. (2009) recently completed an evaluation and refinement of the morning covey-call survey methodology to estimate northern bobwhite quail (*Colinus virginianus*) abundance. One of their objectives was to obtain an estimate of the radius of audibility. Their concept and techniques of determining a radius of audibility is applicable and necessary for ground-based lesser prairie-chicken listening surveys. Currently, the general TPWD protocol for these surveys is to drive 1.6 km, then stop and listen for 5 minutes. The design is further described in Lionberger (2004), and summarized briefly in the Wildlife Management Institute's (WMI) comprehensive review of TPWD's science-based methods (WMI 2005). One of the underlying assumptions of this method is that booming lesser prairie-chickens can be heard by surveyors up to 1 mile from a lek. It is unlikely that this assumption is correct. This project evaluated how far surveying listeners can hear booming under varying environmental conditions to help TPWD and private landowners further streamline road-based lek surveys. This project also addressed TWAP priorities concerning improving understanding of population dynamics of species of concern, and improving survey techniques used to monitor high-priority species for conservation (Bender et al. 2005).

Study Area

This study was conducted on private lands in Cochran (SW), Gray (GR), and Yoakum (SW) counties, as well as private and public lands in Hemphill County. Hemphill County study sites were divided into 2 areas: those on private lands (NE) and those on the Gene Howe Wildlife Management Area (GH). All study sites were located within present lesser prairie-chicken range, and contain historically supported or currently known lesser prairie-chicken leks in the vicinity.

Sites in Cochran and Yoakum counties were in the High Plains Ecoregion (Bender et al. 2005). Sites in Hemphill County were in the Rolling Plains Ecoregion (Bender et al. 2005). The Gray County study site was located at the eastern edge of the Caprock Escarpment and had characteristics of both the High Plains and Rolling Plains ecoregions. Landscape in the study areas was a short-mixed grass prairie ecosystem dominated by little bluestem (*Schizachyrium scoparium*), sand sagebrush (*Artemisia filifolia*), and shinnery oak (*Quercus havardii*; Haukos and Smith 1999). Primary land uses were cattle ranching interspersed with oil and gas development and some Conservation Reserve Program lands, center-pivot agriculture, and dry-land agriculture (McRoberts 2009). Habitat types for the High Plains and Rolling Plains Ecoregions are described in detail in Bender et al. (2005).

Methods

We measured the intensity of booming male lesser prairie-chickens at active leks in Hemphill and Yoakum counties (Butler et al. 2010) during the breeding season 2009. The methods of measuring booming intensity of breeding male lesser prairie-chickens are described in detail in Butler et al. (2010). During observations to determine the booming intensity breeding male lesser prairie-chickens, we made digital recordings of vocalizations. We transferred these digital recordings to FoxPro digital game callers (FoxPro XR6 Digital Game Call; FoxPro, Inc., Lewiston, PA). The calls were calibrated to emit a digital recording of male lesser prairie-chickens booming at 106 dB at 10 cm which is equivalent to displaying male lesser prairie-chickens (Butler et al. 2010). We set the recording to play in a continuous loop. The game callers were positioned on wooden blocks 15 cm form the ground. This height is equivalent to a displaying male lesser prairie-chicken.

We established trial leks at randomly selected locations. A trial lek consisted of 2 game callers utilizing both speakers. The calls were positioned 10 m apart, with one call oriented north-south and the other oriented east-west. Listening posts were located along 3,200 m transects at 100 m intervals, with 4 transects oriented in the Cardinal directions at each trial lek when possible. Random selection of trial lek locations were constrained for several reasons (i.e., so transects do not go within 1 mile of known leks and remain on properties where we had permission to conduct work). Therefore some of the trials did not have all 4 transects while some transects were < 3,200 m. Table 1 lists trial leks by county, length and direction of transects.

Trial leks were established each morning at least 1 hour before sunrise. Each observer then located the farthest listening post on the transect (e.g., 3,200 m). Each observer conducted audibility trials on each transect. Observers did not simultaneously conduct trials at the same listening posts in order to avoid biasing each other's results. Observers simultaneously conducted trials on different transects. For trial leks that only had 1 transect, observers staggered their start times to avoid simultaneously conducting trials at the same listening posts. Trials were conducted on each transect twice, and each trial per transect was conducted by a different observer. Trials began 30 minutes before sunrise and continued until noon. Sunrise was determined from information available in GPS units (Garmin GPSMAP 76CSx; Garmin International, Inc., Olathe, KS). The observers listened for recorded booming lesser prairie-chickens at each listening post for 3 minutes, recorded data, then moved to the next listening post. At each listening post the observer recorded the following: time listening started and stopped; whether booming or calling was detected; total time booming or calling was detected (minutes and seconds); the direction of detected booming or calling (azimuth); whether background noise existed such as traffic, oil wells, drilling rigs, irrigation motors, or farm implements; wind speed (km/hr) and direction (wind direction is the azimuth from which the wind is blowing); ambient temperature (F°); and relative humidity (%). Wind speed was recorded as an average over the period of a minute. Audibility trials were not be conducted if wind speed was sustained at >32 km/hr (20 miles/hr) or if it was raining.

We modeled the probability of detection (i.e., the recorded booming or calling was heard during the trial) using logistical regression based on distance to the trial lek, wind speed, wind azimuth, ambient temperature, and relative humidity. The LOGISTIC procedure in SAS was utilized (version 9.2; Hosmer and Lemeshow 2000, SAS Institute, Inc. 2009). We used detection of recorded calls as a binary response variable and distance from trial lek, wind speed, wind direction, ambient temperature, and relative humidity as predictor variables. We assessed variable selection for each study site (northeast, Gene Howe Wildlife Management Area, Gray County, and southwest) and transect direction (north, south, east, and west) using stepwise selection. Since surveyors were always moving towards trial leks, we separated analyses by direction to control for wind direction. We separated analyses by study area to control for differences that may exist in topography and vegetation in the different ecoregions. Due to low sample size for wind direction predictor variables on the southwest study site, wind direction was not included in analyses from this site.

Results

Tables 2-17 display the results of each logistic regression analysis by location and transect direction. Distance to trial lek was the most important predictor of detection of recorded lesser prairie-chicken vocalizations. The predictor variable distance was present in all models for all study sites and transects directions. The beta parameter for the predictor variable was negative and the odds ratio was < 1 in all instances, indicating that probability of detection decreased as distance to the lek increased.

The predictor variable wind speed was present in 8 of 16 (50%) of the models. When the predictor variable wind speed was present, then beta parameter estimates were negative and the odds ratio was < 1, indicating that probability of detection decreased as wind speed increased. The odds ratios for wind speed ranged from 0.81 on the Gene Howe Wildlife Management Area to 0.96 on the southwest study site. The odds ratios for the southwest study site were higher (between 0.94 and 0.96) than for the Gray County site (between 0.88 and 0.910) followed by the northeast and Gene Howe Wildlife Management Area study sites (between 0.81 and 0.88).

The predictor variable relative humidity was present in 8 of 16 (50%) of the models. When the predictor variable relative humidity was present in all but one case, the beta parameter estimate was positive, and the odds ratio was > 1, essentially indicating that probability of detection increased as relative humidity increased. However, the odds ratios for relative humidity were very high when the beta parameter estimate was high, and in the instance when the beta parameter estimate was negative, the odds ratio was very close to zero.

The other predictor variables, wind direction and ambient temperature, were each present in only a few models. Wind direction was present in 3 of 12 (25%) of the models where this predictor variable was measured. Temperature was present in 5 of 16 (31%) of the models. Beta parameter estimates for these predictor variables were both < 1 and > 1.

Discussion

As would be intuitively expected, distance from the trial lek was the best predictor of detection of recorded vocalizations of displaying male lesser prairie-chickens. There was approximately a 1% decrease in the probability of detection with each 100 m increase in distance from the trial lek. Current lesser prairie-chicken protocols are to survey at 1.6 km intervals (Davis et al. 2008). Butler et al. (2009) found that the sound intensity of booming lesser prairie-chickens at that distant would be equivalent to a whisper and suggested that the influence of weather and vegetative conditions should be investigated.

This study found a relationship between wind speed and detection probability. On the southwest study site, there was a 4-6% decrease in detection probability for each 1 km/hr increase in wind speed. The southwest study site was entirely within the High Plains Ecoregion. Detection probability decreased between 9-12% for each 1 km/hr increase in wind speed on the Gray County site, which included transects located at the eastern edge of the Caprock Escarpment that had characteristics of both the High Plains and Rolling Plains Ecoregions. The northeast and Gene Howe Wildlife Management Area study sites were entirely within the Rolling Plains Ecoregion, where detection probability decreased between 12-19% for each 1 km/hr increase in wind speed.

Wind speed may have different effects on detection probability depending on the ecoregion in which surveys are conducted. This change may be due to different topography in these ecoregions. We did not conduct surveys of trial leks when sustained wind speeds were > 32 km/hr. Many of our surveys were conducted during calm wind conditions which could explain the lack of wind speed as a predictor variable in half of the models. There could be a threshold of wind speed that affects probability of detection, and that threshold may be less than the 32 km/hr used in this study, particularly in the Rolling Plains Ecoregion.

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Table 1. Randomly selected trial lek locations and corresponding transect lengths.

			Transect Length (m)			
Site	ID	County	North	East	South	West
GH	1	Hemphill	.	3200	.	.
GH	2	Hemphill	3200	.	.	.
GH	3	Hemphill	1500	3200	1800	2400
GH	4	Hemphill	.	3200	2400	.
GH	5	Hemphill	.	3200	2600	.
GH	6	Hemphill	.	3200	3100	.
GH	7	Hemphill	.	3200	.	3200
GH	8	Hemphill	.	2400	.	2800
GH	9	Hemphill	.	1600	.	3200
GH	10	Hemphill	.	.	.	3200
GH	11	Hemphill	.	.	.	3200
NE	1	Hemphill	3200	3200	.	.
NE	2	Hemphill	3200	.	.	3200
NE	3	Hemphill	3200	.	.	3200
NE	4	Hemphill	3200	.	3200	.
NE	5	Hemphill	.	.	3200	3000
NE	6	Hemphill	.	3200	.	3200

Table 1. Continued.

Site	ID	County	Transect Length (m)			
			North	East	South	West
NE	7	Hemphill	3000	3200	.	3200
NE	8	Hemphill	3100	.	.	3200
NE	9	Washita	1800	.	.	3200
NE	10	Hemphill	1500	.	1600	3200
NE	11	Hemphill	.	.	2500	3200
NE	12	Hemphill	.	3200	3000	.
NE	13	Hemphill	.	.	3200	.
NE	14	Hemphill	3000	.	.	1900
GR	1	Gray	.	3200	3200	.
GR	2	Gray	.	3200	3200	1700
GR	3	Gray	.	3200	3200	.
GR	4	Gray	1800	3200	3200	.
GR	5	Gray	3200	.	3200	.
GR	6	Gray	3200	3200	.	.
GR	7	Gray	3200	3200	2600	1900
GR	8	Gray	3200	3200	.	.
GR	9	Gray	3200	3100	.	.

Table 1. Continued.

Site	ID	County	Transect Length (m)			
			North	East	South	West
GR	10	Gray	.	.	.	3200
GR	11	Gray	3200	.	3200	3200
GR	12	Gray	3200	.	3200	3200
SW	1	Yoakum	3200	.	.	3200
SW	2	Yoakum	3200	3100	1500	1600
SW	3	Yoakum	3200	1800	2500	2900
SW	5	Yoakum	3200	3200	3200	3200
SW	6	Yoakum	3200	2700	3200	3200
SW	7	Yoakum	3200	3200	.	.
SW	8	Yoakum	3200	3200	3200	3200
SW	9	Yoakum	.	3200	3200	3000
SW	10	Yoakum	.	.	.	3200
SW	11	Yoakum	.	3200	.	.
SW	12	Yoakum	3200	.	3200	.
SW	13	Cochran	3200	.	3200	.
SW	14	Cochran	.	2300	3200	.

Table 2. Logistic regression analysis of north transects for lek audibility trials on Gene Howe Wildlife Management Area, Hemphill County, Texas

Predictor Variable		β	SE β	Wald's χ^2	*df*	*p*	Odds Ratio
Intercept		-10.642	4.3401	6.01	1	0.01	N/A
Distance		-0.013	0.0044	8.08	1	<0.01	0.996
Relative Humidity		31.013	11.5137	7.26	1	0.01	>1000
Test				χ^2	*df*	*p*	
Overall model evaluation							
	Likelihood ratio test			51.30	2	<0.01	
	Score test			22.65	2	<0.01	
	Wald test			8.39	2	0.02	
Goodness of fit test							
	Hosmer & Lemshow			0.62	5	0.99	

Predictor variables wind speed and wind direction did not meet $\alpha \leq 0.05$ to be included in model set

Predictor variable temperature did not improve model performance (Wald's $\chi^2 = 3.12$; $p = 0.08$) and was removed from the model

Table 3. Logistic regression analysis of south transects for lek audibility trials on Gene Howe Wildlife Management Area, Hemphill County, Texas

Predictor Variable	β	SE β	Wald's χ^2	*df*	*p*	Odds Ratio
Intercept	1.370	1.3829	0.98	1	0.32	N/A
Distance	-0.006	0.0011	28.31	1	<0.01	0.994
Temperature	-0.134	0.0291	21.08	1	<0.01	0.875
Relative Humidity	11.586	2.7447	17.82	1	<0.01	>1000

Test		χ^2	*df*	*p*
Overall model evaluation				
	Likelihood ratio test	116.76	3	<0.01
	Score test	66.24	3	<0.01
	Wald test	29.99	3	<0.01
Goodness of fit test				
	Hosmer & Lemshow	10.02	8	0.26

Predictor variables wind speed and wind direction did not meet $\alpha \leq 0.05$ to be included in model set

Table 4. Logistic regression analysis of east transects for lek audibility trials on Gene Howe Wildlife Management Area, Hemphill County, Texas

Predictor Variable	β	SE β	Wald's χ^2	*df*	*p*	Odds Ratio
Intercept	1.131	0.8484	1.78	1	0.18	N/A
Distance	-0.003	0.0005	61.21	1	<0.01	0.996
Wind Speed	-0.118	0.0308	14.73	1	<0.01	0.889
Wind Direction	0.009	0.0037	5.75	1	0.02	1.009

Test		χ^2	*df*	*p*
Overall model evaluation				
	Likelihood ratio test	194.21	3	<0.01
	Score test	132.22	3	<0.01
	Wald test	65.44	3	<0.01
Goodness of fit test				
	Hosmer & Lemshow	7.90	8	0.44

Predictor variables temperature and relative humidity did not meet $\alpha \leq 0.05$ to be included in model set

Table 5. Logistic regression analysis of west transects for lek audibility trials on Gene Howe Wildlife Management Area, Hemphill County, Texas

Predictor Variable	β	SE β	Wald's χ^2	*df*	*p*	Odds Ratio
Intercept	12.049	2.8826	17.47	1	<0.01	N/A
Distance	-0.004	0.0007	33.25	1	<0.01	0.996
Wind Speed	-0.202	0.0799	6.39	1	0.01	0.817
Temperature	-0.058	0.0146	16.68	1	<0.01	0.944
Relative Humidity	-8.026	2.9563	7.37	1	<0.01	<0.01

Test		χ^2	*df*	*p*
Overall model evaluation				
	Likelihood ratio test	136.93	4	<0.01
	Score test	100.586	4	<0.01
	Wald test	41.675	4	<0.01
Goodness of fit test				
	Hosmer & Lemshow	7.6841	8	0.4649

Predictor variable wind direction did not meet $\alpha \leq 0.05$ to be included in model set

Table 6. Logistic regression analysis of north transects for lek audibility trials on private lands on the northeast study site, Hemphill County, Texas

Predictor Variable	β	SE β	Wald's χ^2	*df*	*p*	Odds Ratio
Intercept	-7.675	1.7128	19.87	1	<0.01	N/A
Distance	-0.005	0.0008	46.10	1	<0.01	0.995
Temperature	0.105	0.0232	20.51	1	<0.01	1.111
Relative Humidity	9.307	2.0023	21.61	1	<0.01	>1000

Test		χ^2	*df*	*p*
Overall model evaluation				
	Likelihood ratio test	167.12	2	<0.01
	Score test	119.11	2	<0.01
	Wald test	54.94	2	<0.01
Goodness of fit test				
	Hosmer & Lemshow	1.30	8	1.00

Predictor variables wind speed and wind direction did not meet $\alpha \leq 0.05$ to be included in model set

Table 7. Logistic regression analysis of south transects for lek audibility trials on private lands on the northeast study site, Hemphill County, Texas

Predictor Variable		β	SE β	Wald's χ^2	*df*	*p*	Odds Ratio
Intercept		2.379	1.0638	5.00	1	0.02	N/A
Distance		-0.015	0.0048	9.15	1	<0.01	0.986
Test				χ^2	*df*	*p*	
Overall model evaluation							
	Likelihood ratio test			67.07	2	<0.01	
	Score test			30.23	2	<0.01	
	Wald test			6.41	2	0.04	
Goodness of fit test							
	Hosmer & Lemshow			0.57	3	0.90	

Predictor variables relative humidity, wind speed, and wind direction did not meet $\alpha \leq 0.05$ to be included in model set

Predictor variable tempreature did not improve model performance (Wald's $\chi^2 = 3.17$; $p = 0.08$) and was removed from the model

Table 8. Logistic regression analysis of east transects for lek audibility trials on private lands on the northeast study site, Hemphill County, Texas

Predictor Variable		β	SE β	Wald's χ^2	*df*	*p*	Odds Ratio
Intercept		0.439	2.5898	0.03	1	0.87	N/A
Distance		-0.040	0.0181	4.96	1	0.03	0.961
Wind Direction		0.059	0.0419	4.17	1	0.04	1.089
Test				χ^2	*df*	*p*	
Overall model evaluation							
	Likelihood ratio test			150.39	2	<0.01	
	Score test			72.50	2	<0.01	
	Wald test			5.25	2	0.07	
Goodness of fit test							
	Hosmer & Lemshow			0.03	2	0.98	

Predictor variables temperature, relative humidity, and wind speed did not meet $\alpha \leq 0.05$ to be included in model set

Table 9. Logistic regression analysis of west transects for lek audibility trials on private lands on the northeast study site, Hemphill County, Texas

Predictor Variable		β	SE β	Wald's χ^2	*df*	*p*	Odds Ratio
Intercept		2.379	1.0638	5.00	1	0.03	N/A
Distance		-0.015	0.0048	9.15	1	<0.01	0.986

Test		χ^2	*df*	*p*
Overall model evaluation				
	Likelihood ratio test	53.57	1	<0.01
	Score test	25.26	1	<0.01
	Wald test	9.15	1	<0.01
Goodness of fit test				
	Hosmer & Lemshow	0.57	3	0.90

Predictor variables relative humidity, wind speed, and wind direction did not meet $\alpha \leq 0.05$ to be included in model set

Predictor variable tempreature did not improve model performance (Wald's $\chi^2 = 3.17$; $p = 0.08$) and was removed from the model

Table 10. Logistic regression analysis of north transects for lek audibility trials on private lands on the Gray County study site, Texas

Predictor Variable	β	SE β	Wald's χ^2	*df*	*p*	Odds Ratio
Intercept	6.239	1.2673	24.24	1	<0.01	N/A
Distance	-0.003	0.0003	102.39	1	<0.01	0.997
Wind Speed	-0.123	0.0570	4.67	1	0.03	0.884
Wind Direction	-0.026	0.0034	58.58	1	<0.01	0.974
Relative Humidity	4.387	1.1681	14.10	1	<0.01	80.391

Test		χ^2	*df*	*p*
Overall model evaluation				
	Likelihood ratio test	296.55	4	<0.01
	Score test	216.42	4	<0.01
	Wald test	108.08	4	<0.01
Goodness of fit test				
	Hosmer & Lemshow	18.05	8	0.02

Predictor variable temperature did not meet $\alpha \leq 0.05$ to be included in model set

Table 11. Logistic regression analysis of south transects for lek audibility trials on private lands on the Gray County study site, Texas

Predictor Variable	β	SE β	Wald's χ^2	*df*	*p*	Odds Ratio
Intercept	-2.259	1.5041	2.26	1	0.13	N/A
Distance	-0.003	0.0004	62.49	1	<0.01	0.998
Wind Speed	-0.190	0.0543	12.30	1	<0.01	0.919
Temperature	0.070	0.0227	9.44	1	<0.01	1.121

Test		χ^2	*df*	*p*
Overall model evaluation				
	Likelihood ratio test	141.02	3	<0.01
	Score test	105.56	3	<0.01
	Wald test	63.76	3	<0.01
Goodness of fit test				
	Hosmer & Lemshow	10.57	8	0.23

Predictor variables relative humidity and wind direction did not meet $\alpha \leq 0.05$ to be included in model set

Table 12. Logistic regression analysis of east transects for lek audibility trials on private lands on the Gray County study site, Texas

Predictor Variable		β	SE β	Wald's χ^2	*df*	*p*	Odds Ratio
Intercept		-2.636	0.9821	7.20	1	<0.01	N/A
Distance		-0.002	0.0002	62.05	1	<0.01	0.998
Temperature		0.044	0.0136	10.69	1	<0.01	1.045
Test				χ^2	*df*	*p*	
Overall model evaluation							
	Likelihood ratio test			121.74	2	<0.01	
	Score test			103.20	2	<0.01	
	Wald test			70.01	2	<0.01	
Goodness of fit test							
	Hosmer & Lemshow			173.42	8	<0.01	

Predictor variables reltive humidity, wind speed, and wind direction did not meet $\alpha \leq 0.05$ to be included in model set

Table 13. Logistic regression analysis of west transects for lek audibility trials on private lands on the Gray County study site, Texas

Predictor Variable	β	SE β	Wald's χ^2	*df*	*p*	Odds Ratio
Intercept	-4.157	0.7839	28.12	1	<0.01	N/A
Distance	-0.003	0.0004	36.85	1	<0.01	0.997
Relative Humidity	9.008	1.5031	35.92	1	<0.01	>1000

Test		χ^2	*df*	*p*
Overall model evaluation				
	Likelihood ratio test	100.71	2	<0.01
	Score test	76.43	2	<0.01
	Wald test	45.39	2	<0.01
Goodness of fit test				
	Hosmer & Lemshow	4.86	8	0.77

Predictor variables temperature, wind speed, and wind direction did not meet $\alpha \leq 0.05$ to be included in model set

Table 14. Logistic regression analysis of north transects for lek audibility trials on private lands on the southwest study site, Yoakum and Cochran counties, Texas

Predictor Variable		β	SE β	Wald's χ^2	*df*	*p*	Odds Ratio
Intercept		2.303	0.5476	17.69	1	<0.01	N/A
Distance		-0.003	0.0003	80.01	1	<0.01	0.997
Wind Speed		-0.169	0.0374	20.52	1	<0.01	0.908
Relative Humidity		1.711	0.5585	9.39	1	<0.01	16.545
Test				χ^2	*df*	*p*	
Overall model evaluation							
	Likelihood ratio test			171.80	3	<0.01	
	Score test			126.83	3	<0.01	
	Wald test			82.46	3	<0.01	
Goodness of fit test							
	Hosmer & Lemshow			50.09	8	<0.01	

Predictor variable temperature did not meet $\alpha \leq 0.05$ to be included in model set

Table 15. Logistic regression analysis of south transects for lek audibility trials on private lands on the southwest study site, Yoakum and Cochran counties, Texas

Predictor Variable	β	SE β	Wald's χ^2	*df*	*p*	Odds Ratio
Intercept	0.856	0.5727	2.23	1	0.14	N/A
Distance	-0.003	0.0003	61.56	1	<0.01	0.997
Wind Speed	-0.102	0.0333	9.29	1	<0.01	0.964
Relative Humidity	2.383	0.7384	10.42	1	<0.01	46.072

Test		χ^2	*df*	*p*
Overall model evaluation				
	Likelihood ratio test	156.68	3	<0.01
	Score test	116.64	3	<0.01
	Wald test	67.80	3	<0.01
Goodness of fit test				
	Hosmer & Lemshow	6.30	8	0.61

Predictor variable temperature did not meet $\alpha \leq 0.05$ to be included in model set

Table 16. Logistic regression analysis of east transects for lek audibility trials on private lands on the southwest study site, Yoakum and Cochran counties, Texas

Predictor Variable		β	SE β	Wald's χ^2	*df*	*p*	Odds Ratio
Intercept		2.785	0.5168	28.48	1	<0.01	N/A
Distance		-0.004	0.0005	63.40	1	<0.01	0.996
Wind Speed		-0.143	0.0453	9.92	1	<0.01	0.948
Test				χ^2	*df*	*p*	
Overall model evaluation							
	Likelihood ratio test			179.14	2	<0.01	
	Score test			130.37	2	<0.01	
	Wald test			64.54	2	<0.01	
Goodness of fit test							
	Hosmer & Lemshow			99.84	8	<0.01	

Predictor variable relative humidity did not meet $\alpha \leq 0.05$ to be included in model set

Predictor variable temperature did not improve model performance (Wald's $\chi^2 = 3.80$; $p = 0.05$) and was removed from the model

Table 17. Logistic regression analysis of west transects for lek audibility trials on private lands on the southwest study site, Yoakum and Cochran counties, Texas

Predictor Variable	β	SE β	Wald's χ^2	*df*	*p*	Odds Ratio
Intercept	-1.057	0.5231	4.08	1	0.04	N/A
Distance	-0.003	0.0004	53.51	1	<0.01	0.997
Relative Humidity	3.958	0.7832	25.54	1	<0.01	52.346

Test		χ^2	*df*	*p*
Overall model evaluation				
	Likelihood ratio test	138.79	2	<0.01
	Score test	105.79	2	<0.01
	Wald test	58.37	2	<0.01
Goodness of fit test				
	Hosmer & Lemshow	117.83	8	<0.01

Predictor variables wind speed and wind direction did not meet $\alpha \leq 0.05$ to be included in model set

Predictor variable tempreature did not improve model performance (Wald's $\chi^2 = 3.12$; $p = 0.08$) and was removed from the model