Research Article

Detectability of Lesser Prairie-Chicken Leks: A Comparison of Surveys From Aircraft

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ABSTRACT Lesser prairie-chickens (Tympanuchus pallidicinctus) are traditionally monitored by spring road-based lek surveys and counts of males attending leks. Several weaknesses exist with ground-based monitoring methods such as the bias of restricting surveys to roads, unknown probability of lek detection, and man-hours required to survey large tracts of habitat. We evaluated aerial surveys to locate lesser prairie-chicken leks in Texas and New Mexico using a Cessna 172 airplane (C172), R-22 Beta II helicopter (R-22), and R-44 Raven II helicopter (R-44) during spring 2007–2008. We determined lek activity during surveys with remote cameras placed on leks and cross-referenced time on the photo frame to time on our Global Positioning System flight log. From remote cameras we found that 305 leks were available for detection during survey flights. We determined lek detectability was 32.7% (95% CI = 20.3–47.1%) in the C172, 72.3% (64.5–79.14%) in the R-22, and 89.8% (82.0–95.0%) in the R-44. We created 16 a priori logistic regression models incorporating aircraft platform, distance to lek, survey date, lek size, and lek type to explain lek detection from aerial surveys. Our top ranked model included platform, distance, and lek type (model weight; \( w_i = 0.288 \)). We had four competitive models and model averaged to draw inferences. Model averaging showed that detectability was generally greatest with the R-44, followed by the R-22, and lowest with the C172, with a slight deviation from this ranking at increased distances. Within our transect width, model averaging also suggested that detectability decreased as distance from the transect to the lek increased during helicopter surveys, and detectability increased as distance from the transect to the lek increased during C172 surveys. Furthermore, man-made leks were more likely to be detected than natural leks and large leks were more likely to be detected than medium or small leks. Aerial surveys effectively locate new leks and monitor lek density, and alleviate weaknesses associated with ground-based monitoring. We recommend using the R-44 to conduct lek surveys while flying at an altitude of 15 m at a speed of 60 km/hr on sunny mornings. © 2011 The Wildlife Society.

KEY WORDS aerial survey, detectability, fixed-wing aircraft, helicopter, lek, lesser prairie-chicken, New Mexico, Texas, Tympanuchus pallidicinctus.

Prairie grouse (Centrocercus spp. and Tympanuchus spp.) populations have declined over the past three decades and the need exists to clarify the conservation status of prairie grouse species (Silvy and Hagen 2004). Of particular concern is the lesser prairie-chicken (T. pallidicinctus), a species known to be vulnerable to anthropogenic impacts (Hammerstrom and Hammerstrom 1961, McRoberts et al. 2009, Pruett et al. 2009). Lesser prairie-chicken populations are estimated to have declined by 97% (Crawford 1980) with a 92% reduction in occupied range since the 1800s (Taylor and Guthery 1980). The decline of lesser prairie-chicken populations has been attributed to drought, mis-managed grazing of rangelands, conversion of native prairie to cropland, and habitat fragmentation (Lee 1950, Jackson and DeArment 1963, Crawford and Bolen 1976, Braun et al. 1994, Giesen 1998). In 1995, the United States Fish and Wildlife Service (USFWS) was petitioned to list the lesser prairie-chicken as threatened or endangered under the Endangered Species Act and, in 1998, the species was deemed, “warranted but precluded” for listing (USFWS 1998). The species remains a candidate species with its status reviewed annually (North American Bird Conservation Initiative 2009). In December 2008, the lesser prairie-chicken was elevated from a listing priority 8 to a listing priority 2, increasing the priority of conservation efforts for the species (USFWS 2008).

Managers have traditionally monitored prairie grouse with leks counts (D. M. Davis et al., Colorado Division of Wildlife, unpublished report; Schwartz 1945; Jackson and
DeArment 1963; Bibby et al. 2000) and road-based lek surveys (D. M. Davis et al., unpublished report; Best et al. 2003; Ripper et al. 2008). Lek counts provide an index of the number of lesser prairie-chickens attending a known lek during the spring breeding season. Road-based transect surveys are used to locate leks by driving a route in suspected prairie grouse habitat and stopping at intervals to look and listen for leks. Both methods are accepted as standards for monitoring prairie grouse population trends. However, weaknesses exist with traditional lek monitoring methods (Robel 1980, Cannon and Knopf 1981, Applegate 2000, Walsh et al. 2004). Weaknesses of lek attendance counts include missing counts on unknown lek locations that are inherently needed to calculate an index (Cannon and Knopf 1981). Weaknesses of road-based lek surveys include accessibility to survey areas, man-hours required to completely survey an area (Martin and Knopf 1981, Grensten 1987), and restricting surveys to roads (Applegate 2000, Anderson 2001). Research has indicated that lesser prairie-chickens avoid anthropogenic structures on the landscape (Pruett et al. 2009), intensifying the negative bias of conducting lek surveys from roads. Also of concern is the possibility of lesser prairie-chickens not calling during the ground-based listening period when investigators listen for booming, the unknown probability of hearing a lek as distance from the road increases, and differing environmental variables (e.g., topography, wind, background noise) confounding audibility. An assumption in road survey methods is that lesser prairie-chicken booming can be heard by surveyors within 1.6 km of a lek (D. M. Davis et al., unpublished report). However Butler et al. (2010) found that the sound intensity of booming lesser prairie-chickens at 1.6 km is that of a whisper. Furthermore, neither method is designed to estimate lek density in large tracts of contiguous habitat void of road networks. Applegate et al. (2004: 104) identified the “crucial need for a willingness to devise, test, and apply innovative ideas that are not normally considered in the management of grouse species, especially applying management to large areas within ecosystems.” Furthermore, Crawford (1980) identified the study of survey techniques as an important research need for lesser prairie-chicken management. The weaknesses, biases, and often haphazard approach to lesser prairie-chicken lek monitoring through road surveys created the need to test the applicability of aerial lek surveys.

Aerial surveys for prairie grouse leks are not a new concept. Eng (1955) flew surveys in a fixed-wing aircraft to successfully locate greater sage-grouse (C. urophasianus) leks in Montana. Lehmann and Mauermann (1963) surveyed for Attwater’s prairie-chicken (T. cupido attwateri) leks with both fixed-wing aircraft and helicopters. Martin and Knopf (1981) conducted surveys from fixed-wing aircraft for greater prairie chicken (T. cupido) leks and Schroeder et al. (1992) used helicopter surveys to estimate the number of greater prairie-chicken and lesser prairie-chicken leks in eastern Colorado. The objectives and scope of past prairie grouse aerial surveys were different, but a common conclusion among each study was that leks could be detected from aircraft. Our objectives were to 1) evaluate and develop line transect aerial survey methods for a fixed-wing aircraft and helicopters to detect leks, 2) quantify lek detectability from three aircraft platforms, and 3) create predictive models to explain lek detectability from aerial surveys. Our objectives are justified by the need to estimate lek density annually for population monitoring efforts, a valuable population parameter identified by Haukos and Smith (1999). Furthermore, determining lek locations from aerial surveys will be useful to initiate other management activities and determine lesser prairie-chicken occupied range.

**STUDY AREA**

We conducted aerial surveys at two sites in Texas and two sites in New Mexico. Study areas consisted of federal, state, and privately owned lands. We selected sites because specific lek locations were documented at each site, allowing us to estimate lek detectability. Lek densities ranged from 0.1 to 0.6 lek/km². Texas study sites were located in Hemphill and Yoakum counties. The Hemphill County site (5,007 ha) was dominated by Tivoli fine sand and Springer loamy fine sand soils (Natural Resources Conservation Service [NRCS] 2009). Average annual rainfall ranged from 38 to 64 cm and elevation in this region ranged from 670 to 1,465 m (Vodehnal and Hauffer 2008). The site was a short-mixed grass prairie ecosystem dominated by little bluestem (Schizachyrium scoparium) and sand sagebrush (Artemisia filifolia). The Yoakum County site (2,905 ha) was dominated by Brownfield fine sand and Brownfield–Circleback fine sand soils (NRCS 2009). The site was a xeric, sand dune ecosystem dominated by little bluestem and shinnery oak (Quercus havardii). New Mexico study sites were located in Chaves (3,961 ha) and Roosevelt (3,444 ha) counties. Both sites shared vegetative characteristics of the Yoakum County site and were dominated by Brownfield fine sand and Tivoli fine sand soil types (NRCS 2009). For the Yoakum, Chaves, and Roosevelt counties region, Vodehnal and Hauffer (2008) reported average annual rainfall of 33–56 cm and elevation of 795–1,585 m. All four sites received light to moderate grazing and either had active oil or gas wells or remnants of former wells.

**METHODS**

**Aerial Surveys**

We conducted aerial surveys from three aircraft platforms: Cessna 172 fixed-wing aircraft (Cessna Aircraft Co., Wichita, KS; hereon C172), R-22 Beta II helicopter (Robinson Helicopter Co., Torrance, CA; hereon R-22), and R-44 Raven II helicopter (Robinson Helicopter Co.; hereon R-44). The C172 held 3 observers (the pilot seated in the front left seat, an observer positioned in the front right seat, and another observer in the back left seat), the R-22 held 2 observers, and the R-44 held 4 observers, with the pilot serving as an observer in each platform. On average it cost US$ 135/hr to rent the C172, US$ 305/hr to rent the R-22, and US$ 520/hr to rent the R-44. We conducted flights between 8 March–17 May 2007 and 12 March–10 May 2009.
We based our flight methods on previous surveys for prairie grouse leks (Eng 1955, Lehmann and Mauermann 1963, Martin and Knopf 1981, Schroeder et al. 1992) and ptarmigan (Lagopus spp.; Pelletier and Krebs 1998). We surveyed at an altitude of 15 m for helicopters and 50 m for the fixed-wing aircraft. Our target flight speeds were 60 km/hr for the helicopters and 140 km/hr for the fixed-wing aircraft. Occasionally, we adjusted flight speed to maintain safe flying conditions during high winds (Pelletier and Krebs 1998). We did not fly during precipitation events or when forward visibility was <8 km. We began our initial test-flight survey at 0.5 hr before sunrise, but we adjusted subsequent flights to begin at sunrise. We completed surveys no later than 2.5 hr after sunrise. We conducted surveys in a north–south orientation in helicopters and in an east–west orientation in the C172. We started on the east side of survey areas to minimize time facing the sun during helicopter surveys.

We developed flight paths in ArcGIS® 9.2 (Environmental Systems Research Institute, Inc., Redlands, CA). We separated transects by 400 m and the starting point of transect 1 was randomly generated. We generated new transects for each flight and a lek was not covered by multiple transects during a survey. Length and number of transects varied with study area and ranged from 2.03 to 9.15 km and 10 to 23, respectively. We assigned waypoints used for navigation to both ends of transect lines. We programmed the consecutively numbered end-waypoints into a Garmin Model 60CSx Global Positioning System (GPS) unit and entered a route into the GPS unit from which the pilot navigated. We programmed the GPS unit to record a track of our flight path (position recorded in 1-s interval).

We alternated aerial observers (n = 23) and pilots (n = 5) to minimize detection bias associated with familiarity of lek locations within study areas. All aerial observers worked in the wildlife management field and received pre-flight instructions on lesser prairie-chicken and lek search image. Aerial observers focused their attention within a 200-m search distance on the side of the aircraft in which they were seated. When a lek was located, the observer gave the verbal command “mark” and the observer in the front of the aircraft marked the way-point GPS coordinates. We used one GPS unit to mark leks to avoid double-counts. The observer seated next to the pilot was responsible for recording leks spotted by the pilot.

Remote Cameras
We placed 1 or 2 programmable cameras (RECONYX Model RM30, RECONYX, Inc., Holmen, WI) on known lek locations (n = 40) within our survey boundaries. Remote cameras have been documented as an effective, non-intrusive method to monitor avian species (Cutler and Swann 1999) and have been used to monitor prairie grouse (Holloran and Anderson 2003, Behney 2009). We programmed cameras to take photographs during aerial surveys to determine lesser prairie-chicken presence on leks during the survey period, allowing us to determine which leks were available for detection when we flew near the lek. We classified a lek as available for detection if lesser prairie-chickens were visible in the photograph; photographs of displaying lesser prairie-chickens were not a requirement for classification as available for detection. We could not assume that because lesser prairie-chickens typically attended the lek that the lek was active and available for detection during our survey period. We included in our analysis only leks classified as active during each survey period. We attached cameras to a T-post 30 cm above ground. We used natural vegetation to camouflage cameras and make them inconspicuous to aerial observers. We set cameras to take a photograph at 1-min intervals during our survey period (a 1-min interval was the shortest interval possible for the RECONYX Model RM30). We referenced the time on the photograph with our GPS flight track to determine if the lek was active and available for detection during our survey.

Data Analysis
We created 16 a priori logistic regression models to evaluate variables influencing detectability (Table 1). We included aircraft platform in each model to meet our study objective and for management applicability. Beyond platform, we had a balanced model set including distance from the transect to the lek, survey date, lek type, lek size, and the platform × distance interaction as covariates. The platform × distance interaction was necessary because a strip approximately 100-m wide was not viewable directly below the fixed-wing aircraft causing a suspected difference in the slope of detection functions between the fixed-wing aircraft and the helicopters (Butler et al. 2007). We used SPSS® 16.0 (SPSS, Inc., Chicago, IL) to analyze the data and Akaike’s Information Criterion corrected for small sample size (AICc) to evaluate the model set. The response variable was lek detection with a binary classification of 1 for lek detected and 0 for missed lek detection. We only included leks confirmed as active and available for detection in our models. We evaluated fit of our global model using the Hosmer–Lemeshow test (Hosmer and Lemeshow 2000) and used AICc weights to assess evidence for each model. We model averaged our results to account for model selection uncertainty among competing models within our a priori set (Burnham and Anderson 2002, Anderson 2008). Model averaged beta estimates were conditional on the competitive models in which that parameter appeared.

We included lek size and type as categorical variables in our model set. We determined lek size by averaging the past 3 years of mid-April lek counts collected by site managers. We classified a lek as small if the average count was ≤10 birds, medium if the count was 11–20 birds, and large if the average count was >20 birds (P. McDaniel, The Nature Conservancy, personal communication). We adopted dummy coding for the lek size categories. Lek size was a categorical rather than continuous variable because accurate lek counts would be needed for each lek when the aircraft was on the adjacent transect and this count was unavailable. Lek type was also a categorical variable in our model set with a classification as either a natural or man-made lek (Taylor 2008).
Table 1. Ranking of candidate logistic regression models predicting detectability of lesser prairie-chicken leks from aerial surveys in Texas and New Mexico, USA, during spring 2007–2008.

<table>
<thead>
<tr>
<th>Model*</th>
<th>(-2LL)</th>
<th>(K)</th>
<th>AIC(_C)</th>
<th>(\Delta AIC_C)</th>
<th>(\omega_i)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLAT + DIST + PLAT × DIST + TYPE</td>
<td>288.240</td>
<td>7</td>
<td>302.617</td>
<td>0.000</td>
<td>0.287</td>
</tr>
<tr>
<td>PLAT + DIST + PLAT × DIST + SIZE + TYPE</td>
<td>284.727</td>
<td>9</td>
<td>303.337</td>
<td>0.720</td>
<td>0.201</td>
</tr>
<tr>
<td>PLAT + DIST + PLAT × DIST + DATE + TYPE</td>
<td>285.301</td>
<td>9</td>
<td>303.911</td>
<td>1.294</td>
<td>0.151</td>
</tr>
<tr>
<td>PLAT + DIST + PLAT × DIST + SIZE</td>
<td>288.080</td>
<td>8</td>
<td>304.567</td>
<td>1.949</td>
<td>0.108</td>
</tr>
<tr>
<td>PLAT + DIST + PLAT × DIST + DATE + SIZE + TYPE</td>
<td>282.380</td>
<td>11</td>
<td>305.281</td>
<td>2.664</td>
<td>0.076</td>
</tr>
<tr>
<td>PLAT + DIST + PLAT × DIST</td>
<td>293.108</td>
<td>6</td>
<td>305.390</td>
<td>2.772</td>
<td>0.072</td>
</tr>
<tr>
<td>PLAT + DIST + PLAT × DIST + DATE</td>
<td>285.590</td>
<td>8</td>
<td>306.026</td>
<td>3.409</td>
<td>0.052</td>
</tr>
<tr>
<td>PLAT + DIST + PLAT × DIST + DATE + SIZE</td>
<td>285.387</td>
<td>10</td>
<td>306.136</td>
<td>3.519</td>
<td>0.049</td>
</tr>
<tr>
<td>PLAT + SIZE + TYPE</td>
<td>300.615</td>
<td>6</td>
<td>312.897</td>
<td>10.279</td>
<td>0.002</td>
</tr>
<tr>
<td>PLAT + TYPE</td>
<td>306.565</td>
<td>4</td>
<td>314.699</td>
<td>12.081</td>
<td>0.001</td>
</tr>
<tr>
<td>PLAT + SIZE</td>
<td>305.240</td>
<td>5</td>
<td>315.441</td>
<td>12.823</td>
<td>0.000</td>
</tr>
<tr>
<td>PLAT + DATE + SIZE + TYPE</td>
<td>300.040</td>
<td>8</td>
<td>316.526</td>
<td>13.909</td>
<td>0.000</td>
</tr>
<tr>
<td>PLAT + DATE + TYPE</td>
<td>305.862</td>
<td>6</td>
<td>318.144</td>
<td>15.257</td>
<td>0.000</td>
</tr>
<tr>
<td>PLAT + DATE + SIZE</td>
<td>304.445</td>
<td>7</td>
<td>318.822</td>
<td>16.205</td>
<td>0.000</td>
</tr>
<tr>
<td>PLAT + DATE</td>
<td>313.371</td>
<td>3</td>
<td>319.451</td>
<td>16.834</td>
<td>0.000</td>
</tr>
<tr>
<td>PLAT</td>
<td>312.338</td>
<td>5</td>
<td>322.538</td>
<td>19.921</td>
<td>0.000</td>
</tr>
</tbody>
</table>

For each logistic regression model, we give \(-2 \times \log\text{-}likelihood (\(-2LL\)), number of parameters (\(K\)), second-order Akaike’s Information Criterion (AIC\(_C\)), difference in AIC\(_C\) compared to lowest AIC\(_C\) of the model set (\(\Delta AIC\_C\)), and AIC\(_C\) weight (\(\omega_i; i = 305\)).

*PLAT, aircraft platform; DIST, distance to lek; PLAT × DIST, platform × distance interaction; TYPE, lek type (man-made or natural); SIZE, lek size; DATE, survey date + survey date squared.

1979). Examples of man-made leks at our sites included abandoned oil pads, oil pipeline scars, and clearings around stock tanks. We adopted a binary classification for the lek type variable, assigning 1 for man-made leks and 0 for natural leks.

We included distance and date as continuous variables in our model set. We calculated precise perpendicular distance from the aircraft to the lek using the ArcGIS minimum-distance function. Calculating precise distances was possible because we surveyed areas with known coordinates at the center of each lek. In an applied setting, it would be necessary to use laser range-finders from helicopters or streamers on struts from fixed-wing aircraft to obtain distances to leks (Guenzel 1997; Butler et al. 2007, 2008). We generated a standardized survey date value by assigning the day of our earliest survey date, 8 March, as standardized date value zero and consecutively numbered until our latest survey date, 17 May, which received a value of 70. The standardized date allowed us to include a comparable date value for surveys conducted in 2007 and 2008. We included standardized date as a quadratic variable in our model set because lek attendance has a peak (Schroeder and Braun 1992, Johnsingard 2002).

RESULTS

We conducted 58 survey flights: 11 surveys in the C172, 28 in the R-22, and 19 in the R-44. Actual flight speeds were 135.5 ± 7.0 km/hr (± 95% CI) in the C172, 60.5 ± 3.0 km/hr in the R-22, and 58.1 ± 4.4 km/hr in the R-44. At these speeds we were able to survey 4,060.0 ± 99.2 ha/hr in the C172, 2,211.9 ± 127.3 ha/hr in the R-22, and 2,028.6 ± 184.7 ha/hr in the R-44. From the camera data, we determined that 305 leks were active and available for detection during aerial surveys, with 52 leks available during C172 surveys, 155 leks during R-22 surveys, and 98 during R-44 surveys. Lek detectability was 32.7% (95% CI = 20.3–47.1%) in the C172, 72.3% (64.5–79.1%) in the R-22, and 89.8% (82.0–95.0%) in the R-44. We pooled detections from the 3 aircraft platforms and found small leks had 59.4% (46.4–71.5%) detectability, medium leks had 70.3% (61.6–78.1%) detectability, and large leks had 78.8% (70.0–85.9%) detectability. We pooled detections from the 3 platforms and found man-made leks had 76.7% (69.8–82.6%) detectability and natural leks had 63.2% (54.1–71.7%) detectability.

Our global model fit the data (\(\chi^2_{df=8} = 4.188, P = 0.840\)). Of our 16 candidate models, the model with the greatest weight (\(\omega_i = 0.288\)) included aircraft platform, distance, platform × distance interaction, and lek type (Table 1). The interaction between platform and distance suggested the relationship between detectability and platform varied with distance (Fig. 1). At 0 m we found that lek detectability was 33.70 times greater from the R-22 (\(W_{df=1} = 23.071, P \leq 0.001\)) and 192.31 times greater from the R-44 (\(W_{df=1} = 22.675, P \leq 0.001\)) than the C172, and lek detectability was 5.71 times greater from the R-44 (\(W_{df=1} = 3.101, P = 0.078\)) compared to the R-22. As distance increased the odds ratio between the C172 and both helicopters decreased, yet the odds ratio between the R-22 and R-44 increased (Fig. 1). Lek detectability slightly increased with distance (odds ratio = 1.01; \(W_{df=1} = 2.419, P = 0.120\)) during C172 flights but decreased as distance increased in the R-22 (odds ratio = 0.98; \(W_{df=2} = 8.852, P = 0.003\)) and R-44 (odds ratio = 0.98; \(W_{df=2} = 6.638, P = 0.010\)). Additionally, we found that man-made leks were more likely to be detected (odds ratio = 1.92; \(W_{df=1} = 4.838, P = 0.028\)) than natural leks.

We had four competitive models (Table 2) and model averaging suggested that lek detection increased by using the R-22 (odds ratio = 33.54, SE = 0.746) or R-44 (odds ratio = 191.79, SE = 1.111) instead of the C172 at distance 0 m, but odds ratios among platforms varied as distance increased in the same manner as our top ranked model (Table 2). We found a slight increase in lek detectability...
as distance increased when we used the C172 (odds ratio = 1.01, SE = 0.005), but we found a decrease in lek detectability as distance increased in the R-22 (odds ratio = 0.98, SE = 0.006) and the R-44 (odds ratio = 0.98, 0.98, SE = 0.009). We found that man-made leks were more likely to be detected (odds ratio = 1.85, SE = 0.302) than natural leks and medium-sized leks (odds ratio = 1.47, SE = 0.385) and large-sized leks (odds ratio = 2.20, SE = 0.404) were more likely to be detected than small leks. Additionally, we found that detectability increased as the lekking season progressed (odds ratio = 1.03, SE = 0.039); however, we did not average the survey date variable because it only appeared in one of our competing models.

We applied hourly aircraft rental rates and calculated that the R-22 would cost 2.4 times the price of the C172, increasing lek detectability by 39.6%; the R-44 would cost 4.0 times the price of the C172, increasing lek detectability by 57.1%; and the R-44 would cost 1.7 times the price of the R-22, increasing lek detectability by 17.5%.

**DISCUSSION**

We estimated detectability to be 72.3% in the R-22. Schroeder et al. (1992) conducted two surveys for lesser prairie-chickens and three surveys for greater prairie-chickens from a Bell 47 Soloy 2-observer helicopter, with individual flight lek detectability reported at 86.7% and 46.7% for lesser prairie-chickens and 60.0%, 25.0%, and 20.0% for greater prairie-chickens. Schroeder et al. (1992) flew lesser prairie-chicken surveys during peak female attendance and again 2 weeks later and flew greater prairie-chicken surveys at peak female attendance and 2 and 3 weeks later. Our estimate of detectability was within the range of Schroeder et al. (1992) for lesser prairie-chicken surveys, yet the reported greater prairie-chicken lek detectability was below our estimate.

![Figure 1. Estimated probability of lesser prairie-chicken lek detection from aerial survey data collected in Texas and New Mexico, USA, during spring 2007–2008 using a Cessna 172 fixed-wing aircraft (C172), R-22 Beta II helicopter (R-22), and R-44 Raven II helicopter (R-44). Predictions and 95% confidence intervals (CI) based on the top ranked model (platform + distance + platform × distance interaction + lek type).](image)

![Figure 2. Estimated probability of man-made prairie-chicken lek detectability from aerial survey data collected in Texas and New Mexico, USA, during spring 2007–2008 using a Cessna 172 fixed-wing aircraft (C172), R-22 Beta II helicopter (R-22), and R-44 Raven II helicopter (R-44). Predictions and 95% confidence intervals (CI) based on the top ranked model (platform + distance + platform × distance interaction + lek type).](image)

**Table 2. Coefficients for top 4 logistic regression models and model averaged coefficients for detectability of lesser prairie-chicken leks in Texas and New Mexico, USA, during spring 2007–2008.**

<table>
<thead>
<tr>
<th>Model 1&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Model 2&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Model 3&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Model 4&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Model average</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>β</strong></td>
<td><strong>SE</strong></td>
<td><strong>β</strong></td>
<td><strong>SE</strong></td>
<td><strong>β</strong></td>
</tr>
<tr>
<td>Platform 1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.5176 0.7323</td>
<td>3.3969 0.7344</td>
<td>3.7264 0.7516</td>
<td>3.4171 0.7273</td>
</tr>
<tr>
<td>Platform 2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.2591 1.1044</td>
<td>5.2169 1.1081</td>
<td>5.4443 1.1239</td>
<td>5.0616 1.0736</td>
</tr>
<tr>
<td>Distance&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.0080 0.0052</td>
<td>0.0072 0.0052</td>
<td>0.0073 0.0052</td>
<td>0.0067 0.0051</td>
</tr>
<tr>
<td>Platform 1 × distance</td>
<td>-0.0179 0.0060</td>
<td>-0.0165 0.0061</td>
<td>-0.0186 0.0061</td>
<td>-0.0167 0.0060</td>
</tr>
<tr>
<td>Platform 2 × distance</td>
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<sup>a</sup> Model 1, platform + distance + platform × distance + lek type; Model 2, platform + distance + platform × distance + lek size + lek type; Model 3, platform + distance + platform × distance + survey date + lek type; Model 4, platform + distance + platform × distance + lek size.

<sup>b</sup> We used dummy variable coding where Cessna 172 airplane (C172) was the reference category. Platform 1, R-22 Beta II helicopter referenced against C172; Platform 2, R-44 Raven II helicopter referenced against C172.

<sup>c</sup> Distance to lek.

<sup>d</sup> Man-made or natural lek.

<sup>e</sup> We used dummy variable coding where small lek size was the reference category. Size 1, medium lek referenced against small lek; Size 2, large lek referenced against small lek.

<sup>f</sup> Survey date.
mate, which could be a result of a difference in species or in differences in vegetation types among the sites. Additionally, Schroeder et al. (1992) did not mention the pilot serving as an observer during survey flights which may explain the lower detectability estimate.

Martin and Knopf (1981) conducted survey flights for greater prairie-chickens with transects separated by 400 m in a C172 and reported maximum lek detection from a single survey flight of 52% in 1978 and 72% in 1979. Their detectability estimate was greater than the 32.7% we report and could be a result of pre-survey ground-based lek identification. Prior to surveys, Martin and Knopf (1981) conducted ground-based lek surveys to identify lek locations on eight study areas of 4,144 ha each. The lek locations Martin and Knopf (1981) detected from the ground were the same leks that would be surveyed from the C172. It appears aerial observers had prior knowledge of all lek locations, which could possibly result in a boost in aerial detectability. Another possibility is that large, conspicuous leks were more likely to be detected from ground-based surveys. We found that large leks were also more likely to be detected from aerial surveys. If known leks located from ground searches were biased towards larger leks, then aerial detectability could be biased high because the leks used to estimate detectability were more easily detected than small or medium sized leks. A third possibility to explain the difference in detectability is Martin and Knopf (1981) flew at an altitude of 25–50 m, whereas we flew our surveys at 50 m. Flying at a lower altitude within the 25–50 m range may cause an increase in detectability by searching more efficiently close to the transect, although significant safety concerns exist in flying at this low altitude. We found no detectability estimates to compare our results from R-44 surveys.

Our a priori model set contained four competitive models and we found it necessary to use model averaging to account for model selection uncertainty and provide inference about predictive variables. Choice of aircraft platform had the most influence on lek detectability. We believe differences in lek detectability between the C172 and both helicopter platforms were results of the inability to survey directly below the C172 and increased speed necessary to safely fly the C172. We believe that the difference in lek detectability between the R-22 and R-44 was a result of two additional observers present in the R-44. The interaction of platform and distance to the lek played an important role in lek detections. This interaction was caused by the inability to view beneath the C172 and caused the detection function for the C172 to have a positive slope, whereas lek detection functions for both helicopters had negative slopes. The C172 detection probability would likely peak at some distance beyond the 200-m search width and then decline. We found that lek detectability decreased as distance increased with both helicopter platforms. A possibility that warrants further investigation is surveying at an altitude >15 m to determine if detectability could increase with higher altitude.

Our results indicated that lek detectability was greater for man-made leks than natural leks. The greater detectability of man-made leks was likely due to the capability of targeting potential man-made lek sites on the landscape. Windmills, abandoned oil pads, and livestock watering tanks were all used as lek sites by lesser prairie-chickens and the absence of vegetation at these sites made lesser prairie-chickens easily detectable. We also found that lek detectability increased with lek size. Butler et al. (2007) reached a similar conclusion, reporting that flock size of wild turkeys (Meleagris gallopavo) played an important role in aerial survey detectability.

Survey date appeared in one of our competitive models and played a surprisingly small role in detectability. We restricted our surveys to mid-March through mid-May, with the center of our survey period at peak lek attendance (Crawford and Bolen 1975). Had we surveyed through the January–June period of male lesser prairie-chicken attendance on leks as suggested by Jones (1964), survey date would likely have had a greater impact on detectability by increasing probability of detection closer to peak lek attendance. The infrequency of survey date in our competitive model set did demonstrate that observers were not learning specific lek locations. We flew four sites, and although we alternated among sites with 23 observers, we had initial concerns that an observer would remember lek locations and detectability would increase during subsequent flights. Had this concern been valid, survey date would likely have played a greater role in our model set. The slight increase in lek detectability was likely a product of observer experience and the formulation of a search image for lesser prairie-chicken leks.

We were frequently challenged by inclement weather and were repeatedly grounded due to rain, fog, or high winds. If possible, surveys should be restricted to clear, sunny mornings. Martin and Knopf (1981) also stated that lek attendance drops during inclement weather. We also suggest restricting surveys to clear, sunny mornings because the white tail feathers of lesser prairie-chickens (visible during display behavior) reflected the sun and were easily visible. Contrary to previous studies on aerial surveys for leks, we recommend starting surveys for lesser prairie-chickens at sunrise, not 0.5 hr before sunrise as done by Schroeder et al. (1992) and Martin and Knopf (1981). We felt the amount of light at 0.5 hr before sunrise was inadequate, especially at distances approaching the 200-m search distance, to detect leks in lesser prairie-chicken habitats.

Lek density is important in estimating population trends. Aerial lek surveys are a more effective method to estimate lek density than traditional ground-based road surveys because of the ability to survey all potential habitat, not simply lek density adjacent to roads. It is also possible to calculate a confidence interval around the lek density estimate using our aerial survey lek detection estimates, which is currently not possible with ground-based survey methods. Our study areas have been monitored for lek locations for decades, yet we detected 4 new leks during our study period. We also conducted a survey in the R-44 on an additional area with 5 documented lek locations unknown to aerial observers. We detected each known lek and found 5 new leks during our aerial survey. Put simply, leks were not detected after years of
road surveys because a road did not exist near the lek, yet we promptly detected the leks with an aerial survey.

Lek counts have management applications, but it is important to attempt to account for all leks within a study area. If managers simply count males on stable, traditional leks a delay in identifying a population change is possible because attendance on stable, traditional leks would be the last to reflect the change (Haukos and Smith 1999). Satellite leks could remain undetected from ground survey because of remote locations or tendency to appear and disappear among seasons. In a 6-year study researching lek stability of greater prairie-chickens, it was found that an estimated 23% of leks disappeared between consecutive years (Schroeder and Braun 1992). Satellite leks are critical to population assessment because it is suspected that young birds typically form these leks (Schroeder and Braun 1992). A logistically practical method is needed to survey all habitat and we believe aerial survey is the most pragmatic way to detect satellite leks.

We understand that a direct comparison between aerial and ground-based road surveys would be of interest to managers. However, we do not believe this comparison would be valid because a lek detectability estimate does not exist for ground-based surveys. We have compared the 3 aerial survey platforms, but if the comparison was extend to ground-based surveys the principle objective of the survey, lek detection, would not be incorporated. The cost and time of aerial and ground surveys could be compared, but without estimates of lek detectability, the comparison would have no value. We believe that managers should implement aerial lek surveys because of the quantifiable factors that influence lek detection and the removal of biases, instead of attempting to justify ground-based lek surveys with hourly cost comparisons.

Lek counts and road-based surveys have been a population assessment tool for decades and have been diligently used to define management objectives. However, the status of prairie grouse populations still remains unclear (Silvy and Hagen 2004). Advancing technology has made it possible to evaluate the potential of aerial survey to locate leks. Although we cannot recommend counting the number of lesser prairie-chickens on a lek from aerial surveys, aerial surveys can be used to locate leks, and estimate lek density, which is superior to ground-based surveys. Additionally, managers will be able to conduct a more complete lek count index once lek locations within a study area are located. If managers are unaware of all lek locations then density estimates and indices have little value and trends are speculative at best.

MANAGEMENT IMPLICATIONS

The conservation status of the lesser prairie-chicken may require a rapid population survey only possible from aircraft. Aerial surveys allow for complete coverage of an area to estimate lek density and find new lek locations. Methods such as distance sampling and occupancy modeling could also be used in conjunction with our aerial survey methods. We recommend conducting surveys in the R-44 because of the greater detectability than the R-22 or C172. We do not recommend conducting lek surveys in the C172 because of safety concerns. However, other fixed-wing aircraft may have potential, and future research would be needed to address their applicability. We also suggest conducting surveys on clear mornings during peak lek activity because of the highly observable white tail feathers visible during display. At first glance aerial surveys are expensive, but it is our opinion that the cost is justified by the superior quality of data from aerial surveys by removing the biases and uncertainties associated with road-based surveys. It is the responsibility of wildlife managers to search for the most cost-effective management options, but a threshold of data quality must be met in cost-effective judgment and we do not feel current road-based lek survey methods reach such a threshold. If aerial lek surveys are implemented as a management practice, newly detected leks may be used for management activities such as estimating lek density, determining occupied range, trapping for radio-telemetry purposes, collecting genetic samples, and lek counts.

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