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Effect of Energy Development and Human Activity on the Use of Sand Sagebrush Habitat by Lesser Prairie Chickens in Southwestern Kansas

Robert J. Robel
Kansas State University, Division of Biology
Manhattan

John A. Harrington, Jr.
Kansas State University, Department of Geography
Manhattan

Christian A. Hagen
Kansas State University, Division of Biology
Manhattan

James C. Pitman
Kansas State University, Division of Biology
Manhattan

Ryan R. Reker
Kansas State University, Department of Geography
Manhattan

Lesser prairie chickens (*Tympanuchus pallidicinctus*) occupy xeric grasslands dominated primarily by sand sagebrush (*Artemisia filifolia*) or shinnery oak (*Quercus harvardii*) in portions of southwestern Kansas, southeastern Colorado, western Oklahoma, northern Texas and eastern New Mexico (Giesen 1998), and their populations have declined rangewide since the 1800s (Braun et al. 1994). In southwestern Kansas, lesser prairie-chickens are most abundant in mixed- and short-grass prairies dominated by sand sagebrush south of the Arkansas River. Population indices (lek counts) suggest lesser prairie-chicken numbers have declined since the 1970s (Jensen et al. 2000). Generally the decline has been attributed to the deterioration of the sandsage habitat and the conversion of suitable habitat to intensive agriculture, primarily center-pivot irrigated corn. Even though most of the large-scale conversion of

sand sagebrush prairie to intensive agriculture ceased in the mid-1980s, lek indices to lesser prairie chicken populations continued to decline in southwestern Kansas (Jensen et al. 2000).

A 6-year study initiated in 1997 examined factors that may have contributed to the 1980 to 2000 decline in numbers of lesser prairie chickens in southwestern Kansas. Low nest success and poor chick survival were determined to be the most important factors contributing to the decline (Hagen 2003, Pitman 2003). The research was conducted in Finney County, an area of southwestern Kansas that historically supported a viable lesser prairie chicken population. Lek survey indices to prairie chicken populations in that county averaged 12.1 birds per square mile (4.7 birds/km^2) during the late 1960s (Church 1987). Between 1960 and 1975, approximately 60 percent of the native sand sagebrush prairie in Finney County was converted to intensive agriculture (Sexson 1980). That loss of habitat originally was thought to be the sole cause of the 33-percent decline (from 12.1 to 8.1 birds per square mile [4.7–3.1 birds/km^2]) in the lesser prairie chicken lek survey indices in Finney County during the 1980s and the 50 percent decrease (from 8.1 to 4.1 birds per square mile [3.1 to 1.6 birds/km^2]) in the 1990s. However, these declines occurred even though large expanses of sand sagebrush prairie existed in the county through the 1980s and 1990s. During Hagen's (2003) and Pitman's (2003) studies, radio telemetry data disclosed avoidance by lesser prairie chickens of what appeared to be suitable sand sagebrush habitat near anthropogenic features, e. g., roads, buildings, oil and gas wellheads, electric transmission lines and center-pivot irrigation fields.

The human population of Finney County increased by over 25 percent between 1980 and 2000 (U. S. Census Bureau 2003), coincidental with the construction of a coal-fired electric generating station and associated transmission lines, road improvements and an increased number of houses in rural settings. Petroleum exploration and production also increased in the county, and compressor stations were constructed to move natural gas through underground pipelines. These anthropogenic changes in Finney County coincided with declines in lek survey indices to lesser prairie chicken populations in the 1980s and 1990s.

We conducted this study to assess the magnitude of the impacts of anthropogenic factors on use of sand sagebrush habitat by lesser prairie chickens. We focused our efforts on the remaining sand sagebrush habitat in Finney, Kearny and Hamilton counties of southwestern Kansas, the three counties supporting 25 to 50 percent of the lesser prairie chicken population in Kansas during the early 2000s (assuming lek survey data are a realistic reflection of lesser prairie chicken numbers).

Methods and Procedures

Data used to determine use of sand sagebrush habitat by lesser prairie chickens were obtained from transmitter-equipped birds on two 12,500 acre (5,070 ha) study sites in Finney County during a 1997 to 2003 field study. Lesser prairie chickens were captured on leks using walk-in funnel traps (Haukos et al. 1990) primarily during March and April. Captured birds were fitted with less-than-0.4-ounce (11-g) transmitters (less than 2% of each bird's body mass) and released within 15 minutes at capture sites. Birds were located daily by triangulation using a truck-mounted, null-peak, twin-Yagi telemetry system. The influence of anthropogenic features on the use of sand sagebrush habitat was estimated from these data, and its impact was extrapolated to the remaining sand sagebrush habitat in Finney, Kearny and Hamilton counties during 2003 to 2004.

Study Area

The sand sagebrush prairies of Finney, Kearny and Hamilton counties exist primarily on undulating sand dunes south of the Arkansas River (Kuchler 1974). Two soil types are typical across the sand sagebrush vegetation complexes: Tivoli fine sand and Tivoli-Vona loamy fine sands (Harner et al. 1965). The long-term average annual precipitation for the area was 19 inches (48 cm) with 75 percent of it occurring between March and August; the mean annual temperature was 55° Fahrenheit (13°C), ranging from 21° Fahrenheit (-6°C) for January to 79° Fahrenheit (26°C) for July (U. S. Department of Commerce 2003).

Sand sagebrush dominated the vegetative community and was interspersed with grasses, including blue grama (*Bouteloua gracilis*), sand dropseed (*Sporobolus cryptandrus*), prairie sandreed (*Calamovilfa longifolia*), sand bluestem (*Andropogon halii*) and little bluestem (*Schizachyrium scoparium*). Other plants common on the area included western ragweed (*Ambrosia psilostachya*), annual erigonum (*Erigonum annum*), sunflowers (*Helianthus* spp.), plains yucca (*Yucca glauca*), prickly

pear (*Opuntia polyacantha*) and Russian thistle (*Salsola kali*). Kuchler (1974) presents a detailed description of the vegetation of the sand sagebrush prairie of the three counties. Over 90 percent of the sand sagebrush rangeland was grazed annually by cattle at various intensities resulting in highly variable vegetation structure across the study area.

Determining Coverage of Sand Sagebrush Prairie

The historical distribution of sand sagebrush habitat in Finney, Kearny and Hamilton counties was primarily defined by the extent of the Tivoli association soil complex and vegetation based landcover maps by Kuchler (1974). Defining natural habitat based on soil types has been successfully used in similar studies (Johnson et al. 1995). Two Landsat 1 multispectral scanner images (pixel resolution of 66 yards [60 m]) were used to identify sand sagebrush acreage in the three counties for 1973 whereas two Landsat 7 Enhanced Thematic Mapper (ETM+) images (pixel resolution of 36 yards [33 m]) and ground truthing were used for 2001 determinations.

Inventory of Anthropogenic Features in the Three Counties

Locations of anthropogenic features in the sand sagebrush habitat were entered into a GIS system for display and analysis. Road center lines from the U. S. Census Bureau were downloaded from the Kansas Data Access and Support Center. Point data for oil and oil/gas wellheads were downloaded from the Kansas Geological Survey Database. Locations of buildings (large houses, feedlots, ranch steads, compressor stations and the power plant) were identified on U. S. Geological Survey 1:24,000 topographic maps and Landsat 7 satellite imagery and a polygon layer of building sites was created by digitizing feature boundaries. Paper maps of electric transmission line routes were provided by the Sunflower Electric Corporation, georeferenced to Landsat 7 ETM+ satellite imagery, then digitized and uploaded into ArcInfo 8.1 to create a transmission line layer. Center-pivot fields were identified by their distinctive spectral and textural properties and classified in ERDAS Imagine 8.7 (Leica Geosystems 2003).

The scale of satellite images and course pixel resolution limited our ability to identify small anthropogenic features (minor roads and trails, individual houses, trailers and small outbuildings). Therefore, our assessment of the impacts of anthropogenic features on lesser prairie chickens in the sand sagebrush habitat of the three-county area must be interpreted as a conservative estimate.

Determining Areas Avoided by Nesting Lesser Prairie chickens

The movements of transmitter-equipped, female lesser prairie chickens were monitored daily during April through June. When a bird's location was unchanged for more than three days it was assumed to be nesting. The nesting bird was approached and the location of its nest recorded with a global positioning system. Nesting females were monitored daily by telemetry, but nest sites were not visited again until the female departed the site with a brood or the nest was depredated or abandoned. Vegetation structure was quantified at each nest site and at a paired, random point within 200 yards of the nest, within three days of hatching, depredation or abandonment. Vegetation measurements included height, visual obstruction readings and percent canopy cover of grass, sagebrush and forbs. Details of vegetation measurements are presented in Pitman (2003).

Locations of nests were incorporated into a geographic information system of the two study areas created in ArcView 3.1 (Environmental Systems Research Institute 1998) along with locations of wellheads, buildings, transmission lines, improved roads and unimproved roads and center-pivot irrigated fields (hereafter center-pivot field). Distances from each nest to the nearest wellhead, building, transmission line, roads and center-pivot field edge were calculated for each nest.

Wellheads were oil and oil/gas wells with pumping units powered primarily by diesel fuel. Buildings consisted of houses, gas compressor stations, and a 380 megawatts coal-fired electric generating station. Transmission lines primarily were 125, 138 and 345 kilovolts, double-circuit conductors distributing electricity from the generating station. Improved roads were graveled or paved and carried up to 486 vehicles per day (vpd) whereas unimproved roads were 2-lane pasture trails and ungraded service roads to wellheads with traffic less than 3 vpd. Center-pivot fields covered 160 acres (65 ha) with a water pump in the center and a 13- to 16-foot (4–5-m) high sprinkler boom extending from the center to the edge of the field. When in operation (generally from late April or early May through summer), the sprinkler boom irrigated the field by rotating circularly across the field on self-powered wheels.

We used Monte Carlo simulations (modified from Manly 1998) to determine if any of the six anthropogenic features were related to distances to locations of lesser prairie chicken nests. Because features far from nest sites were unlikely to impact nesting birds, we used only nests close to each feature (closest 10% of the nests) to assess the impacts of the six anthropogenic features.

Distances from each nest and the anthropogenic features were compared to distances of random points created by 1,000 draws in Monte Carlo simulations (details in Pitman 2003). This was done for each of the 10 percent closest nests to each of the anthropogenic features. Probability distributions were used to determine if nests were significantly (P = 0.05) farther than expected from a particular feature. If nests were significantly farther than expected from a feature, that feature was determined to negatively effect lesser prairie-chicken nest location. The mean distance of the closest 10 percent of the nests to a specific anthropogenic feature was determined, and that distance was used as the avoidance distance of nesting lesser prairie chickens for that feature.

Determining Areas Avoided by Adult Lesser Prairie chickens

We quantified use and nonuse areas of sand sagebrush habitat from telemetry locations of lesser prairie chickens. Use areas were defined using a 95 percent fixed kernel home range (Worton 1989) of bird locations. Because multiple locations at nest or lek sites may have underestimated the size of the kernel, we used only one lek or nest location per bird for kernel home range calculations. Sand sagebrush habitat not within the 95 percent fixed kernel home range was considered the nonuse area. Although we cannot be absolutely certain that lesser prairie chickens never used the nonuse areas, we never recorded transmitter-equipped or unmarked birds, or signs (droppings or feathers) of the birds in those areas during the six years of our field study.

Random location points were generated within use and nonuse areas in ArcView 3.1 (Environmental Systems Research Institute 1998) to serve as sampling points to characterize vegetation structure in those areas. At each point, diameters of individual sand sagebrush plants were measured, and a sampling quadrate was used to estimate the percent canopy cover of sand sagebrush, grass, forbs and litter. The vegetation structure of use and nonuse areas was compared using a fixed-model analysis of variance. Details of analytical procedures are in Hagen (2003).

Lesser prairie chicken location data from April to September, 2000 to 2002, were analyzed for impacts of four anthropogenic features (roads, buildings, wellheads and transmission lines) on their distribution on the two study areas. Locations of individual birds were stratified by month and year and were imported into ArcView 3.1 containing locations of the four anthropogenic features. Monthly home ranges (95% fixed kernel [Worton 1989]) were estimated for birds with more than 19 locations per month. A modified Monte Carlo simulation (Manly 1998) was used to test if the centroids of monthly home ranges were farther from the four anthropogenic features than expected at random. See Hagen (2003) for details of analytical procedures.

Quantifying the Acreage Impacted by Anthropogenic Features

Distance to anthropogenic features avoided by 90 percent of nesting and 95 percent of adult lesser prairie chickens were entered into an avoidance buffer database. Avoidance buffers around or along individual anthropogenic features were created in ArcInfo 8.1 (Environmental Systems Research Institute 2001) with the width of avoidance determined from previously described field data. Buffers around anthropogenic features often overlapped, e. g., transmission lines running adjacent to roads, wellheads lying within center-pivot fields. This overlap could result in overestimation of avoidance area. To eliminate bias associated with overlap, the merge and dissolve by attribute functions in ArcInfo 8.1 were used to create one comprehensive avoidance buffer that apportioned duplicated areas of impact among overlapping features.

Results and Discussion

Extent of Sand Sagebrush Prairie Habitat

Historically, an estimated 339,645 acres (137,556 ha) of sand sagebrush habitat existed in Finney, Kearny and Hamilton counties. By 1973, this acreage had been reduced to 298,806 acres (121,016 ha), primarily due to conversion of sand sagebrush habitat to center-pivot agriculture. Another 81,994 acres (33,208 ha) of sand sagebrush habitat was lost to center-pivot agriculture between 1973 and 2001. That loss and a commitment of 3,277 acres (1,327 ha) to urban development (residences, golf courses, etc.) left only 214,183 acres (86,744 ha) of sand sagebrush habitat in the three counties by 2001, approximately 63 percent of the historical acreage. Most of the loss of sand sagebrush habitat occurred in Finney County (74,154 of 142,132 acres [30,032 of 57,564 ha]; 52%) and in Kearny County (48,625 of 67,321 acres [19,693 of 27,265 ha]; 72%), and least in Hamilton County (2,004 of 130,192 acres [812 of 52,728 ha]; 2%).

Vegetation Structure and Nest Location

Vegetation structure around 174 nests of lesser prairie chickens were characterized during this study. Vegetation structure at nest sites differed