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Original Article

Raptor Community Composition in the Texas Southern High Plains Lesser Prairie-Chicken Range

ADAM C. BEHNEY,[1] *Texas Cooperative Fish and Wildlife Research Unit, Department of Natural Resources Management, Texas Tech University, Lubbock, TX 79409, USA*

CLINT W. BOAL,[2] *United States Geological Survey, Texas Cooperative Fish and Wildlife Research Unit, Department of Natural Resources Management, Texas Tech University, Lubbock, TX 79409, USA*

HEATHER A. WHITLAW,[3] *Texas Parks and Wildlife Department, Lubbock, TX 79415, USA*

DUANE R. LUCIA,[3] *Texas Parks and Wildlife Department, Lubbock, TX 79415, USA*

ABSTRACT Predation can be a factor in preventing prey population growth and sustainability when prey populations are small and fragmented, and when predator density is unrelated to the density of the single prey species. We conducted monthly raptor surveys from February 2007 to May 2009 in adjacent areas of the Texas Southern High Plains (USA) that do and do not support lesser prairie-chickens (*Tympanuchus pallidicinctus*), a candidate for protection under the Endangered Species Act. During the summer period corresponding to prairie-chicken nesting and brood-rearing, Swainson's hawks (*Buteo swainsoni*) were the most abundant raptor. During the lekking and overwintering period, the raptor community was diverse, with northern harriers (*Circus cyaneus*) being the most abundant species. Raptor abundance peaked during the early autumn and was lowest during the spring. Utility poles were a significant predictor of raptor density at survey points and Swainson's hawks and all raptors, pooled, were found in greater densities in non-prairie-chicken habitat dominated by mesquite (*Prosopis glandulosa*). Avian predation risk on prairie-chickens, based on presence and abundance of raptors, appears to be greatest during winter when there is a more abundant and diverse raptor community, and in areas with utility poles. Published 2012. This article is a U.S. Government work and is in the public domain in the USA.

KEY WORDS anthropogenic features, community structure, conservation, lesser prairie-chicken, northern harrier, predation risk, raptor, Swainson's hawk, *Tympanuchus pallidicinctus*.

Like many prairie species, lesser prairie-chickens (*Tympanuchus pallidicinctus*) have experienced significant population declines throughout much of their historic range in the past century (Crawford and Bolen 1976, Hagen et al. 2004). Taylor and Guthery (1980) estimated that a decrease of ≥90% of the occupied lesser prairie-chicken range has occurred since the 1800s. Consequently, lesser prairie-chickens were designated a candidate species under the Endangered Species Act (USDI 2008) and today persist only in portions of their historic range in Kansas, Oklahoma, Texas, New Mexico, and Colorado in the United States (Hagen and Giesen 2005, Davis et al. 2008).

The decline of lesser prairie-chickens and other prairie grouse populations is thought to be a result of habitat loss, fragmentation, and degradation through poor range management, recurrent drought, conversion of native grasslands to croplands (Jackson and DeArment 1963, Crawford and Bolen 1976), oil and gas development, and other anthropogenic factors (Lyon and Anderson 2003, Robel et al. 2004, Pitman et al. 2005). Although these provide broad-scale hypotheses for the observed decline, few studies have examined how and why these habitat-level changes specifically affect prairie grouse and limit their population growth and sustainability. Identification of specific limiting factors of prairie-chicken populations is a key to successful conservation efforts.

Predation can be a limiting factor for a given prey species, especially where the species exists in small, fragmented populations (Macdonald et al. 1999) and when predator density is unrelated to the density of a single prey species (Thirgood et al. 2000*a*). As a component of conservation and management efforts, it is important to identify what predators may be influencing a declining species. Several raptor species have been suggested as predators of lesser prairie-chickens (Hagen and Giesen 2005). Hagen et al. (2007) found that raptor predation accounted for 11% of female lesser prairie-chicken mortality in Kansas. In Oklahoma and New Mexico, Wolfe et al. (2007) found that 33% and 45% of lesser prairie-chicken mortality was attributable to raptors. Within the

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[1]*Present address: Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale, IL 62901, USA.*
[2]*E-mail: clint.boal@ttu.edu*
[3]*Present address: United States Fish and Wildlife Service, Texas Tech University, Lubbock, TX 79409, USA.*

same study area, Behney et al. (2010) did not find any lesser prairie-chickens in the diet of nesting Swainson's hawks (*Buteo swainsoni*), nor were any raptor predation attempts successful during 650 hours of lek observations (Behney et al. 2011). However, Pirius (2011) found non-breeding season (Sep–Feb) mortality by raptors to be 18.9% in the same study area. Thirgood et al. (2000*b*) found that winter and summer mortality of red grouse (*Lagopus lagopus scotica*) were each about 30%, and raptors were responsible for about 70% and 90% of mortalities in winter and summer, respectively. The authors suggest that raptor predation was a limiting factor for red grouse based on a model predicting that if raptors were absent for 2 years, grouse densities would be up to 3.9 times greater than when raptors were present.

Haukos (1988) and Behney et al. (2011) reported that northern harriers (*Circus cyaneus*), Cooper's hawks (*Accipiter cooperii*), Swainson's hawks, red-tailed hawks (*B. jamaicensis*), rough-legged hawks (*B. lagopus*), ferruginous hawks (*B. regalis*), golden eagles (*Aquila chrysaetos*), peregrine falcons (*Falco peregrinus*), and prairie falcons (*F. mexicanus*) approached prairie-chickens at leks in shinnery oak (*Quercus havardii*) rangelands of the Texas Southern High Plains. However, raptors differ in their hunting strategies and ability to capture lesser prairie-chickens (Behney et al. 2011). Therefore, it is important to know what raptor species occur in the lesser prairie-chicken range, their relative abundance and densities, and the potential threat they may pose. Because many raptors forage from perches such as utility poles (Janes 1994), an assessment of raptor associations with manmade features may provide insights as to how anthropogenic development may alter the predator community and, in turn, influence lesser prairie-chicken populations.

We assessed the raptor community in 2 adjacent vegetation communities representing areas that were occupied and unoccupied by lesser prairie-chickens in the Southern High Plains of Texas. We also assessed the influence of utility pole density on raptor density.

STUDY AREA

Our study occurred on private lands in Cochran and Yoakum counties in the Texas Southern High Plains ecoregion (Llano Estacado). The topography was flat to gently undulating with small vegetated dunes. The dominant vegetation in most areas was shinnery oak intermixed with sand sagebrush (*Artemisia filifolia*) and grasses. The major land use in this area was agriculture, with a high proportion of land under intensive cultivation (cotton, wheat, sorghum) and cattle production. Oil extraction and drilling occurred throughout the study area.

METHODS

To assess the raptor community in the study area, we placed 38 raptor survey points at 1.6-km intervals along roads throughout the study area. This distance ensured that the study area was thoroughly surveyed while preventing overlapping of point survey areas. Surveys were conducted monthly over 2 consecutive days, from April 2007 to May 2009, with start and finish times between 30 minutes presunrise and 1100 hours, respectively. No surveys were conducted in May or June 2007. Originally, surveys were conducted within an unlimited radius in all directions of the survey point. Later, the survey radius was reduced to 500 m (area = 78.5 ha) because preliminary data review suggested detectability declined at greater distances. Raptors detected >500 m from points in unlimited-radius surveys were excluded from analyses. Surveys consisted of visiting each point and visually scanning for raptors for 5 minutes using binoculars. We recorded the species, age, and distance to all raptors detected using a rangefinder.

Initial surveys were conducted by one observer but we later switched to 2 observers with a double-observer sampling scheme to assess detection probability (Nichols et al. 2000). During double-observer surveys, each observer conducted an independent, simultaneous 5-minute survey at the same point. Observers positioned themselves on opposite sides of a vehicle to reduce bias of one observer on the other.

At each survey point, we visually estimated the percent cover of mesquite (*Prosopis glandulosa*), sand sagebrush, and shinnery oak communities within 500 m of each point. We then classified each point as either a suitable vegetation community (e.g., dominated by shinnery oak or sand sagebrush) or an unsuitable vegetation community (e.g., dominated by mesquite) for lesser prairie-chicken occupancy (Hagen and Giesen 2005). All points were almost entirely one vegetation type or the other; thus, classification was straightforward and objective and resulted in 22 points in mesquite and 16 points in shinnery oak or sand sagebrush. We also counted the number of utility poles within 300 m of each point to use as an index of utility-pole density at each point.

To examine temporal patterns of raptor abundance or presence in context of lesser prairie-chicken conservation, we grouped months into 3 "seasons" corresponding to the life-history patterns of lesser prairie-chickens. Lekking season consisted of surveys conducted during February–April, nesting and brood-rearing season consisted of surveys conducted during May–August, and the non-breeding season consisted of surveys conducted during September–January (Hagen and Giesen 2005).

We pooled similar raptor species in analyses to ensure adequate sample sizes. Prairie falcon, peregrine falcon, and unknown falcons were pooled into a "falcon" group; ferruginous hawks and red-tailed hawks were pooled into a "buteo" group. Northern harriers and Swainson's hawks were analyzed independently. We did not include American kestrels (*F. sparverius*) or burrowing owls (*Athene cunicularia*) in any analyses because they are too small to pose a threat to lesser prairie-chickens.

We used Program DOBSERV (Nichols et al. 2000) to estimate detection probability during double-observer sampling. We evaluated the following models of detection probability: 1) constant for all species and observers, 2) different estimates for each observer, 3) different estimates for each species or species group, 4) an interaction between each species and observer. Models of detection probability for species or species groups included "falcon group," "buteo group," Swainson's hawk, northern harrier, and other or unknown raptors. We took an information-theoretic approach, which consisted of using Akaike's Information Criterion corrected for small samples (AIC_c; Burnham and Anderson 2002) to estimate the best model of detection probability. We used the best model to derive parameter estimates of detection probability, which we used to adjust single-observer surveys, and we used the probability of at least one observer detecting a bird during double-observer surveys to adjust double-observer surveys. Adjustments were made by dividing raw counts by the detection probability (Nichols et al. 2000).

We examined the effects of season, vegetation type, and the number of utility poles within 300 m of survey points on raptor density using linear mixed-effects models (package nlme; Pinheiro et al. 2009, R Development Core Team 2010) for each of the most common species and species groups of raptors. We took an information-theoretic approach using AIC_c (Burnham and Anderson 2002) to evaluate performance of models. For each species and species group, we evaluated 10 models: 1) season, 2) vegetation type, 3) number of utility poles, 4) season + poles, 5) vegetation + poles, 6) season × vegetation (interaction), 7) vegetation × poles, 8) season × poles, 9) season × vegetation + poles, and 10) season × vegetation × poles. In all models, the dependent variable was raptor density and survey point was included as a random effect. We used Tukey's honestly significant difference method to compare densities among seasons. We used the Brillouin Index (Margalef 1958, Brillouin 1962) as a measure of raptor species diversity for each season as described in Krebs (1998).

To further examine relationships between raptor densities and utility poles, we used a simple linear regression model. The dependent variables were 1) the density of all raptors (raptors/100 ha), and 2) all raptors excluding northern harriers. We ran the model with 2 different dependent variables because northern harriers do not typically hunt from perches and we would not expect a relationship between perch density and harrier density. We used raptors/100 ha as dependent variables, so parameter estimates were larger. The independent variable was the number of utility poles within 300 m of the point. Statistical analysis was performed using Program R (R Development Core Team 2010). This research was conducted in accordance with Texas Tech University animal use protocol T06043-09.

RESULTS

We conducted 907 surveys at points between 11 April 2007 and 26 May 2009 and collected 433 raptor detections, 347 (80%) of which were ≤500 m from the survey point and used in analysis (Table 1). Overall raptor detections peaked during the autumn of each year and declined to a low during the spring (Fig. 1). Falcons were detected only during winter and early spring months. Northern harriers were detected all year with the exception of early summer. Red-tailed hawks and ferruginous hawks were only detected during autumn, winter, and early spring months. Swainson's hawks were detected in late spring through the summer. Brillouin diversity index values for raptor species diversity during lekking, nesting and brood-rearing, and non-breeding seasons were 0.61, 0.20, and 0.74, respectively, indicating a substantially more diverse raptor community during the prairie-chicken lekking and non-breeding seasons than during the nesting and brood-rearing season.

Double-observer surveys were conducted for 303 of the 907 surveys. The best model of detection probability had a constant detection probability between observers and all species (Table 2). The probability of either observer detecting a raptor during double-observer surveys was 0.95. However, the probability of the primary observer (ACB) detecting a raptor during double-observer surveys was 0.77 and this value was used to correct single-observer surveys.

The most parsimonious model of raptor densities included only an effect of season for each species and species group (Table 3). For the buteo group, the next most competitive models included an effect of utility poles ($\beta < 0.001$, $SE < 0.001$) and an additive effect of utility poles

Table 1. Raw counts of raptors detected from survey points in the Texas Southern High Plains (USA) during 2007–2009. Lekking season included surveys during February–April, nesting and brood-rearing season included surveys during May–August, and non-breeding season included surveys during September–January.

Species	Lekking	Nesting and brood-rearing	Non-breeding	Total
Swainson's hawk (*Buteo swainsoni*)	40	93	27	160
Northern harrier (*Circus cyaneus*)	22	5	52	79
Red-tailed hawk (*Buteo jamaicensis*)	13	0	50	63
Unknown raptor	5	17	31	53
Unknown buteo (*Buteo* spp.)	9	10	16	35
Ferruginous hawk (*Buteo regalis*)	1	0	14	15
Prairie falcon (*Falco mexicanus*)	0	0	10	10
Unknown falcon (*Falco* spp.)	1	0	5	6
Cooper's hawk (*Accipiter cooperii*)	2	0	3	5
Burrowing owl (*Athene cunicularia*)	0	2	0	2
Turkey vulture (*Cathartes aura*)	0	2	0	2
Great horned owl (*Bubo virginianus*)	0	1	0	1
Golden eagle (*Aquila chrysaetos*)	0	0	1	1
Peregrine falcon (*Falco peregrinus*)	0	0	1	1
Total	93	130	210	433

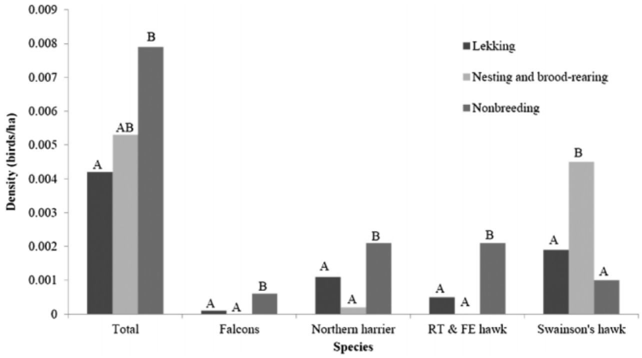

Figure 1. Densities of all raptors, falcons (peregrine and prairie falcon), northern harrier, red-tailed hawk and ferruginous hawk, and Swainson's hawk during the 3 seasons of lesser prairie-chicken life history in the Texas Southern High Plains, USA, 2007 through 2009. Letters denote significant differences (Tukey's honestly significant difference) in raptor densities among seasons within species and species group only ($P < 0.05$). No comparisons were made between species or species groups.

($\beta < 0.001$, SE < 0.001) with season (Table 3). Buteo densities were greater during the prairie-chicken non-breeding season than other seasons (Fig. 1). For northern harriers, the only competitive model after season was season + utility poles ($\beta < -0.001$, SE < 0.001; Table 3). Northern harriers were present in greater densities during the non-breeding season than the lekking or nesting and brood-rearing season (Fig. 1). For Swainson's hawks, the second-best model included season + utility poles ($\beta < 0.001$, SE $= 0.001$; Table 3) and was followed closely by vegetation type. Swainson's hawks were the only raptor present in greater densities during the nesting and brood-rearing season when compared with other seasons (Fig. 1) and were found more often in areas dominated by mesquite (0.003 ± 0.001 birds/ha) as opposed to shinnery oak and sand sagebrush (0.002 ± <0.001 birds/ha). The model of utility poles ($\beta < 0.001$, SE, 0.001) was also somewhat competitive (Table 3). In the falcon group, vegetation type was the second-best model with no other competitive models (Table 3). Falcon density was greatest during the prairie-chicken non-breeding season (Fig. 1) and falcon density was slightly greater in areas dominated by shinnery oak and sand sagebrush (<0.001 ± <0.001 birds/ha) than in areas dominated by mesquite (<0.001 ± <0.001 birds/ha). Vegetation was also the second-best model for all raptors pooled, followed closely by utility poles ($\beta < 0.001$, SE < 0.001; Table 3). Overall raptor density was greatest during the non-breeding season (Fig. 1) and in areas dominated by mesquite (0.007 ± <0.001 birds/ha) as opposed to shinnery oak and sand sagebrush (0.005 ± <0.001 birds/ha).

The number of utility structures was a significant predictor of raptor density in both simple linear-regression models of all raptors ($\beta = 0.012$, SE $= 0.005$, $P = 0.033$) and in the model excluding northern harriers ($\beta = 0.016$, SE $= 0.005$, $P = 0.004$).

Table 2. Models of detection probability of raptors during raptor surveys conducted from 2007 through 2009 in the Texas Southern High Plains (USA) lesser prairie-chicken range.

Model[a]	K	Deviance	AIC_c	ΔAIC_c	Wt
P(.,.)	1	35.66	37.70	0.00	0.64
P(.,I)	2	35.52	39.67	1.97	0.24
P(S,.)	5	30.46	41.22	3.52	0.11
P(S,I)	10	24.32	47.25	9.55	0.01

[a] Model components: . = constant detection probability, I = different estimate for each observer, S = different estimate for each species and/or species group.

DISCUSSION

The spring lekking season corresponded to the lowest observed densities of raptors in our study area. This was because wintering raptors migrated out of the area during the early stages of the prairie-chicken lekking season, but summer-resident Swainson's hawks did not arrive until late into or after the lekking season. With the exception of a few late or early migrant northern harriers, Swainson's hawks were the only diurnal raptor present during the prairie-chicken nesting and brood-rearing season in our study area; thus, it appears that Swainson's hawks pose the major diurnal raptor threat to prairie-chickens at that time. Prairie-chicken survival has been found to be lower during breeding periods than non-breeding periods (Hagen et al. 2007, Lyons et al. 2009) elsewhere, but Behney et al. (2010, 2011) did not find evidence of Swainson's hawks killing lesser prairie-chickens in our study area. In our study area, we suspect that predators such as mammals (predators of adults or chicks) or snakes (predators of chicks; Hagen and Giesen 2005) likely have a greater influence than do raptors on prairie-chicken mortality associated with breeding periods. This may not be the case in other areas with a more diverse suite of predatory birds.

In contrast to one raptor species during the nesting and brood-rearing stage, prairie-chickens contend with a more diverse and abundant suite of raptors in other seasons. There was a particularly high density of northern harriers (a species that, despite its relatively small size, is known to occasionally capture prairie-chickens; Haukos and Broda 1989). Despite occurring at lower numbers, the hunting behavior and size of other members of the wintering raptor community, such as large falcons and ferruginous hawks, likely pose a greater risk to prairie-chickens in our study area.

Most raptors in our study were migratory; therefore, it is not surprising that season was the primary factor influencing raptor density. Although the ΔAIC_c values for models other than season were sometimes large, we believe that these models are still valuable because of the large effect size of season. We found some evidence of vegetation community influencing the density of Swainson's hawks and all raptors pooled. We suspect that Swainson's hawks were found more often in mesquite-dominated areas due to availability of potential nesting structures and hunting perches that mesquite trees provide (as compared with low-growing shinnery oak). It appears that other buteos and northern harriers used the landscape ubiquitously, and were not drawn to any given area due to vegetation type. However, our results suggest that

Table 3. Linear mixed-effects models ($\Delta AIC_c < 10$ from second best model) describing the effect of lesser prairie-chicken life-history season, vegetation community type, and the number of utility poles, on raptor density in the Texas Southern High Plains, USA, 2007 through 2009.

Species	Model	K	Deviance	AIC_c	ΔAIC_c	Wt
Buteo group[a]	Season	5	−646.46	−635.91	0.00	0.85
	Poles	4	−639.64	−631.27	4.64	0.08
	Season + poles	6	−642.97	−630.18	5.72	0.05
	Vegetation	4	−636.46	−628.09	7.82	0.02
	Season × poles	8	−642.19	−624.82	11.09	0.00
Northern harrier	Season	5	−650.99	−640.44	0.00	1.00
	Season + poles	6	−639.52	−626.74	13.70	0.00
	Vegetation	4	−626.31	−617.94	22.49	0.00
Swainson's hawk	Season	5	−538.14	−527.59	0.00	0.99
	Season + poles	6	−529.19	−516.41	11.18	0.00
	Vegetation	4	−524.00	−515.63	11.96	0.00
	Poles	4	−522.56	−514.19	13.40	0.00
	Season × vegetation	8	−524.15	−506.78	20.81	0.00
Large falcon group[b]	Season	5	−813.90	−803.35	0.00	0.96
	Vegetation	4	−805.03	−796.66	6.69	0.03
	Poles	4	−799.67	−791.30	12.05	0.00
All raptors	Season	5	−486.20	−475.64	0.00	0.64
	Vegetation	4	−482.02	−473.65	1.99	0.24
	Poles	4	−480.56	−472.19	3.45	0.11
	Season + poles	6	−478.43	−465.65	9.99	0.00

[a] Red-tailed hawks and ferruginous hawks.
[b] Peregrine falcons and prairie falcons.

overall raptor density is higher in the mesquite-dominated areas primarily due to the seasonal abundance of Swainson's hawks.

As has been found in other studies (e.g., Janes 1984), the density of utility poles was a significant predictor of raptor density. Whether the presence of structures increases raptor density or only makes them more detectable remains an important question. In our study area, we suspect that structures do increase raptor density by providing hunting perches in an open landscape with few natural perches. Lesser prairie-chickens have been found to avoid vertical structures elsewhere (Pitman et al. 2005, Pruett et al. 2009). We have no overt evidence of vertical structure avoidance by lesser prairie-chickens in our study area. However, avoidance of such structures would result in a net reduction of otherwise suitable lesser prairie-chicken habitat. For conservation efforts, this may result in erroneous interpretations of available habitat, which is especially a concern in a landscape already subjected to extensive habitat fragmentation. Alternatively, if lesser prairie-chickens do not avoid vertical structures, they may be putting themselves at greater risk of predation due to increased raptor presence associated with the structures. Research efforts to assess avoidance of vertical structures in our study area would lead to an enhanced understanding of both habitat use and availability, and relative predation risk from raptors.

MANAGEMENT IMPLICATIONS

Raptors are more likely a predation risk for lesser prairie-chickens in the Southern High Plains during the non-breeding season compared with other periods. It has been established elsewhere that prairie-chickens avoid vertical structures, and we have found that raptors were associated with such structures regardless of vegetation community in our study area. As development occurs in areas of prairie-chicken habitat, it may therefore be prudent to minimize the need for utility poles and other tall structures or seek alternative means of energy conveyance, such as buried cables. Additionally, managers and landowners may want to consider removing old utility poles that are no longer needed or in service. Swainson's hawk and overall raptor densities were higher in areas dominated by mesquite; therefore, managers may want to consider reduction of mesquite cover. Such efforts would likely reduce the general presence of raptors plus potentially increase habitat suitability and occupiable space for lesser prairie-chickens.

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