# Vegetative Characteristics of Active and Abandoned Leks of Lesser Prairie-Chickens (*Tympanuchus pallidicinctus*) in Southeastern New Mexico

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# VEGETATIVE CHARACTERISTICS OF ACTIVE AND ABANDONED LEKS OF LESSER PRAIRIE-CHICKENS (*TYMPANUCHUS PALLIDICINCTUS*) IN SOUTHEASTERN NEW MEXICO

JOHN L. HUNT* AND TROY L. BEST

*Department of Biological Sciences and Alabama Agricultural Experiment Station, 331 Funchess Hall, Auburn University, AL 36849*

*Present address of JLH: School of Mathematical and Natural Sciences, 397 University Drive, University of Arkansas–Monticello, Monticello, AR 71656*

**Correspondent: huntj@uamont.edu*

ABSTRACT—Populations of lesser prairie-chickens (*Tympanuchus pallidicinctus*) have declined sharply across the range of the species, including southeastern New Mexico. Several possible causes for this decline have been suggested, including overgrazing by livestock. To test this hypothesis, vegetative composition of active and abandoned leks of lesser prairie-chickens and the pastures in which they were located was measured using the line-point sampling method. Vegetative composition of active leks and the pastures in which they were located was significantly different from those of abandoned leks and surrounding pastures in all 3 years of the study. Active leks and surrounding pastures had significantly more bluestem (*Andropogon*) and less dropseed (*Sporobolus*) than did abandoned leks and surrounding pastures. Abandoned leks were closer to honey mesquites (*Prosopis glandulosa*) >60 cm in height than were active leks. Results are symptomatic of overgrazing, which is detrimental to populations of lesser prairie-chickens.

RESUMEN—Las poblaciones del gallo chico de las praderas (*Tympanuchus pallidicinctus*) han disminuido bruscamente a través de la distribución geográfica de la especie, incluyendo el sureste de Nuevo México. Varias posibles causas de esta disminución han sido sugeridas, incluyendo el sobrepastoreo del ganado. Para probar esta hipótesis, la composición vegetal de áreas comunales de despliegue (leks) activos y abandonados del gallo chico de las praderas y la de los pastizales cercados en donde se quedaron fue medida usando el método de muestreo línea-punto. La composición vegetal de las áreas comunales de despliegue activas y pastizales en donde fueron localizados fue significativamente diferente de la de las áreas comunales de despliegue abandonadas y pastizales cercados durante los 3 años del estudio. Las áreas comunales de despliegue activas y pastizales cercados tuvieron significativamente más pasto tallo azul (*Andropogon*) y menos zacate de arena (*Sporobolus*) que las áreas comunales de despliegue abandonadas y pastizales cercados. Las áreas comunales de despliegue abandonadas estuvieron más cerca a mezquites de miel (*Prosopis glandulosa*) >60 cm de altura que las áreas comunales de despliegue activas. Los resultados son sintomáticos de sobrepastoreo, que es perjudicial para las poblaciones del gallo chico de las praderas.

Because of their largely herbivorous diets, the relationship between grouse and vegetation in their habitats is especially close (De Juana, 1994). For example, the lesser prairie-chicken (*Tympanuchus pallidicinctus*) occurs primarily in habitat that contains shinnery oak (*Quercus havardii*) or sand sagebrush (*Artemisia filifolia*; Giesen, 1998). It depends on shrubs, forbs, and grasses, especially bluestem (*Andropogon*), for food, shelter, cover to avoid predators, and camouflage and shelter for nests (Copelin, 1963; Hagen et al., 2004; Pitman et al., 2005; C. A. Davis et al., in litt.). Change in composition and structure of plant communities has negative impacts on many species of birds (Cox, 1997), and because of the close relationship between lesser prairie-chickens and associated plants, such change might have negative effects on populations of lesser prairie-chickens.

Range-wide declines in populations of lesser prairie-chickens have been well documented. Populations have declined up to 97% since the

1800s (Taylor and Guthery, 1980*a*). The lesser prairie-chicken originally inhabited rangelands of Texas, New Mexico, Oklahoma, Kansas, Colorado, and Nebraska. Although fragmented populations still exist in all of these states except Nebraska, the area occupied by the species has been reduced by 92% (Giesen, 1998). A similar decline in populations has occurred in southeastern New Mexico. Surveys in the 1980s and 1990s suggested that the lesser prairie-chicken had nearly disappeared from central Eddy and Lea counties, New Mexico. These populations persisted into the mid-1990s (K. Johnson and H. Smith, in litt.). Reasons for declines in populations of lesser prairie-chickens are not well understood. Suggested causes include drought, conversion of habitat to agricultural use, improper grazing management, chemical control of shinnery oak, hunting, and disturbance caused by petroleum development (Giesen, 1998; Peterson and Boyd, 1998; Silvy et al., 2004; K. Johnson and H. Smith, in litt.; New Mexico Department of Game and Fish, in litt.).

Conversion of suitable habitat to cropland has been implicated in the decline of several species of grouse in North America (Schroeder and Robb, 1993; De Juana, 1994; Westemeier et al., 1998), including the lesser prairie-chicken (Giesen, 1998; Johnsgard, 2002; Silvy et al., 2004). However, broad-scale land-use patterns within the habitat of lesser prairie-chickens in southeastern New Mexico have remained relatively stable (New Mexico Department of Game and Fish, in litt.). Perhaps of greater importance to populations in southeastern New Mexico are changes in habitat associated with grazing by livestock. Anecdotal evidence indicates that abandoned breeding display areas, or leks, east of Carlsbad seemed to be associated with areas of overgrazing (K. Johnson and H. Smith, in litt.). Overgrazing by livestock has detrimental impacts upon rangelands by altering species composition, vegetative structure, and overall density of plants (Fleischner, 1994; Heady and Child, 1994). Lesser prairie-chickens have greater nesting success in areas with taller cover of grasses (Riley et al., 1992), suggesting that overgrazing by livestock may be detrimental to populations of lesser prairie-chickens. Effects of grazing on breeding behavior are not known. Males return to the same lek year after year (Copelin, 1963; Campbell, 1972), so that modification of vegetative composition of lek sites or the surrounding pastures by livestock could lead to smaller populations of lesser prairie-chickens if reproductive success is affected or if there is greater exposure to predators.

Habitat of the lesser prairie-chicken in southeastern New Mexico consists of a combination of shinnery oak, sand sage, sand dropseed (*Sporobolus cryptandrus*), sand bluestem (*Andropogon hallii*), little bluestem (*A. scorparium*), a variety of forbs, including spectacle pod (*Dithyrea wislizenii*) and annual buckwheat (*Eriogonum annuum*), and in some cases, honey mesquite (*Prosopis glandulosa*) and broom snakeweed (*Gutierrezia sarothrae*; Taylor, 1978; Sell, 1979; Taylor and Guthery, 1980*a*, 1980*b*; Giesen, 1998; Peterson and Boyd, 1998; C. A. Davis et al., in litt.). This habitat has been used for grazing by livestock since the mid-1800s (Beck, 1962).

An indirect effect of grazing by livestock is destruction of shinnery oak. Shinnery oak is sometimes toxic to livestock (Peterson and Boyd, 1998). Since 1974, large tracts of shinnery oak in New Mexico have been treated with tebuthiuron, which kills shinnery oak after 2–3 years (Jones and Petit, 1984). Shinnery oak communities are a favored habitat of lesser prairie-chickens (Giesen, 1998). Although diversity of grasses increases after removal of shinnery oak, body mass (Peterson and Boyd, 1998) and size of populations of lesser prairie-chickens may decline (Martin, 1990).

Honey mesquite may be an indicator of overgrazing by livestock (Clements, 1920; Bahre, 1995; Brown and Archer, 1999; Van Auken, 2000). Invasion by shrubs has been cited as a possible cause for declines in populations of Attwater's prairie-chicken (*Tympanuchus cupido attwateri*) and lesser prairie-chickens (New Mexico Department of Game and Fish, in litt.). Shrubs may act as perches or camouflage for predators, and cause abandonment of leks. It is possible that a similar situation could occur with lesser prairie-chickens (N. J. Silvy, pers. comm.).

Lesser prairie-chickens use a breeding system in which males display at leks for females. Females come to leks to choose a male with which to mate, then build a nest usually within 1.2–3.4 km of the lek (Giesen, 1998), although some females travel much farther to nest (Pitman et al., 2006). Individual males usually return to the same lek year after year, so lek sites are fairly permanent (Copelin, 1963). Females raise broods usually within 2 km of the lek


FIG. 1—Current distribution (gray) of the lesser-prairie chicken (*Tympanuchus pallidicintus*) and location of the study area (black) in southeastern New Mexico.

(Ahlborn, 1980; Giesen, 1994). Location of lek sites is based on proximity to nesting areas (Bergerud and Gratson, 1988), so that a change in vegetation that decreases quality of nesting habitat might cause abandonment of leks.

Objectives of this study were to compare composition of vegetation, including shinnery oak and honey mesquite, at historically and currently active leks and in the pastures that contain them. Differences in vegetation that correspond to overgrazing may be evidence that populations of lesser prairie-chickens have been negatively impacted by overgrazing.

MATERIALS AND METHODS—The study site was located in Eddy, Lea, Chaves, and Roosevelt counties in southeastern New Mexico (Fig. 1), and contains about 303,750 ha of shinnery oak, which is a primary habitat component of the lesser prairie-chicken (Peterson and Boyd, 1998). With the exception of some refuges specifically set aside for lesser prairie-chickens, most of the shinnery oak community is grazed by livestock throughout the year under a variety of grazing-management schemes. Some of the area has been treated with tebuthiuron to control shinnery oak. Oil and gas development is scattered throughout the shinnery oak community, with some areas of high concentration of development. The study area contains areas where lesser prairie-chickens have remained present with some fluctuation in size of populations, and other areas in which populations have disappeared (Best et al., 2003; K. Johnson and H. Smith, in litt.; H. Smith et al., in litt.).

In 2001, 60 active or previously active leks were selected and located with assistance of personnel from the Bureau of Land Management and New Mexico Department of Game and Fish. We determined status of leks as active or abandoned through extensive surveys of leks during each of 3 years of the study. We categorized leks determined to be active during any of the 3 years as active.

Because vegetative characteristics may change from year to year (Heady and Child, 1994), we took measurements each year (2001–2003) during January–March. We measured vegetative cover at 32 active and 28 abandoned leks in 2001, and at 33 active and 27 abandoned leks in 2002 and 2003, using the line-point sampling method described by Bonham (1989) and K. Johnson and H. Smith (in litt.). Because activity of lesser prairie-chickens conceivably could have an effect on vegetative characteristics, we also sampled the pasture in which each lek was located, 300 m from the center of the lek (hereafter referred to as pasture sites). At the center of each lek ($n$ = 60) and pasture site ($n$ = 60), we conducted four 100-m transects in the four cardinal directions. At 1-m intervals along each transect, vegetation was identified to genus and recorded. We computed percentage cover of each genus of plant, bare ground, and plant litter. Because percentage data are non-independent, percentages were transformed into log-ratios by taking natural logarithm of the percentage divided by percentage of *Artemisia* (Aitchison, 1986; Aebischer and Robertson, 1992). *Artemisia* was selected because of its low occurrence in most surveys of leks. We compared percentages of *Artemisia* using Student's *t*-tests (Green et al., 1997) to ensure that use as a divisor would not impact results of statistical procedures, and no significant difference was found in any year between leks and pasture sites or between active and abandoned leks, or between pasture sites of active and abandoned leks (all $P \geq 0.173$). We compared vegetative cover at active and historically active leks, and at pasture sites, using discriminant-function analyses with included ANOVAs. Structure matrices and ANOVAs associated with the discriminant-function analyses were used to evaluate relative importance of individual plant genera in determination of differences revealed by analyses. In discriminant-function analyses, we used ≤12 variables to maintain the minimum recommended 5:1 ratio of observations to variables (Hair et al., 1998). Discriminant-function analyses were cross-validated using the leave-one-out protocol of SPSS 10.0 (SPSS, Chicago, Illinois; Green et al., 1997). We recorded presence or absence of honey mesquite >60 cm in height within 200 m of the center of each lek, and a comparison of active and abandoned leks was made using a chi-square test (Gould and Gould, 2002).

RESULTS—Vegetative cover of leks and pasture sites is presented in Table 1. Vegetative cover of leks differed from that of pasture sites in 2001 (Wilks' $\lambda$ = 0.714, $P < 0.001$), 2002 (Wilks' $\lambda$ = 0.791, $P = 0.001$), and 2003 (Wilks' $\lambda$ = 0.794, $P$ = 0.012). According to structural matrices of discriminant-function analyses, bare ground was

TABLE 1—Percentage vegetative cover of leks and associated pasture sites of lesser prairie-chickens (*Tympanuchus pallidicinctus*) in southeastern New Mexico, winter 2001–2003. ANOVA revealed no difference between leks and pasture sites at $P < 0.05$.

| | 2001 | | | | 2002 | | | | 2003 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plant | Lek | Pasture | *F* | *P* | Lek | Pasture | *F* | *P* | Lek | Pasture | *F* | *P* |
| *Andropogon* | 7.9 | 10.3 | 0.044 | 0.834 | 13.1 | 1.9 | 0.125 | 0.725 | 16.8 | 3.8 | 0.005 | 0.945 |
| *Aristida* | 4.5 | 6.0 | 0.467 | 0.496 | 4.5 | 4.5 | 0.563 | 0.455 | 6.9 | 5.1 | 0.000 | 0.993 |
| *Artemisia*[a] | 0.5 | 0.8 | | | 0.5 | 0.4 | | | 0.7 | 0.9 | | |
| *Bouteloua* | 8.2 | 7.2 | 0.022 | 0.882 | 11.6 | 4.4 | 0.334 | 0.565 | 9.3 | 5.0 | 0.832 | 0.364 |
| *Eriogonum* | 0.5 | 0.5 | 0.018 | 0.893 | 0.4 | 0.7 | 0.001 | 0.975 | 0.5 | 0.5 | 0.214 | 0.644 |
| *Gutierrezia* | 3.1 | 1.6 | 1.488 | 0.225 | 4.9 | 1.9 | 3.688 | 0.057 | 2.8 | 0.5 | 2.678 | 0.104 |
| *Muhlenbergia* | 1.5 | 2.1 | 1.371 | 0.244 | <0.1 | 3.2 | 0.483 | 0.488 | <0.1 | 4.2 | 0.074 | 0.786 |
| *Prosopis* | 0.8 | 0.6 | 0.983 | 0.323 | 0.6 | 1.0 | 1.516 | 0.221 | 0.8 | 0.4 | 0.533 | 0.467 |
| *Quercus* | 8.3 | 9.2 | 1.383 | 0.242 | 8.2 | 8.4 | 0.290 | 0.591 | 9.9 | 8.4 | 0.442 | 0.508 |
| *Sporobolus* | 2.2 | 1.6 | 1.263 | 0.263 | <0.1 | 4.8 | 0.015 | 0.903 | <0.1 | 3.1 | 0.001 | 0.975 |
| *Yucca* | 2.3 | 2.8 | 1.976 | 0.162 | 2.9 | 1.7 | 0.325 | 0.569 | 3.3 | 2.3 | 0.326 | 0.569 |
| Bare | 41.1 | 31.8 | 2.838 | 0.095 | 34.9 | 48.1 | 2.190 | 0.142 | 22.9 | 40.8 | 0.361 | 0.549 |
| Litter | 17.1 | 24.1 | 0.359 | 0.550 | 16.4 | 17.9 | 0.419 | 0.519 | 24.5 | 23.8 | 0.038 | 0.847 |
| Other[ab] | 2.0 | 1.4 | | | 1.8 | 1.1 | | | 1.4 | 1.2 | | |

[a] Not included in analyses.

[b] Includes *Amaranthus*, *Ambrosia*, *Croton*, *Euphorbia*, *Helianthus*, *Mentzelia*, *Munroa*, *Opuntia*, *Panicum*, *Paspalum*, *Salsola*, *Senecio*, and unidentified plants.

the most important determinant of differences in 2001 and 2002, and *Gutierrezia* was the most important determinant in 2003. Although cover of leks differed from that of pasture sites in each year, ANOVAs conducted concurrently with discriminant-function analyses indicated no significant differences between any individual items in cover (Table 1).

Discriminant-function analyses indicated that vegetative cover of active leks in 2001 was significantly different from that of abandoned leks (Table 2; Wilks' $\lambda = 0.262$, $P < 0.001$). According to the structure matrix, most important variables in determining difference in cover between active and abandoned leks in 2001, in decreasing order of importance, were *Sporobolus*, *Muhlenbergia*, *Andropogon*, *Gutierrezia*, and *Bouteloua*. Vegetative cover of active leks in 2002 was significantly different from that of abandoned leks (Table 2; Wilks' $\lambda = 0.337$, $P < 0.001$). Most important variables in determining difference in cover between active and abandoned leks in 2002 were *Andropogon*, *Gutierrezia*, *Muhlenbergia*, *Bouteloua*, and *Sporobolus*. Vegetative cover of active leks in 2003 was significantly different from that of abandoned leks (Table 2; Wilks' $\lambda = 0.373$, $P < 0.001$). Most important variables in determining difference between cover of active and abandoned leks in 2003 were *Eriogonum*, *Andropogon*, *Muhlenbergia*, and *Gutierrezia*.

Discriminant-function analyses indicated that vegetative cover of pasture sites with active leks in 2001 was significantly different from that of pasture sites with abandoned leks (Table 2; Wilks' $\lambda = 0.272$, $P < 0.001$). Most important variables in determining difference between cover of pasture sites with active and abandoned leks in 2001 were *Andropogon*, *Sporobolus*, *Muhlenbergia*, *Gutierrezia*, and *Bouteloua*. Vegetative cover of pasture sites with active leks in 2002 was significantly different from pasture sites with abandoned leks (Table 2; Wilks' $\lambda = 0.330$, $P < 0.001$). Most important variables in determining difference between cover of pasture sites with active and abandoned leks in 2002 were *Muhlenbergia*, *Andropogon*, *Bouteloua*, and *Gutierrezia*. Vegetative cover of pasture sites with active leks in 2003 was significantly different from pasture sites with abandoned leks (Table 2; Wilks' $\lambda = 0.324$, $P < 0.001$). Most important variables in determining difference between cover of control points of active and abandoned leks in 2003 were *Muhlenbergia*, *Eriogonum*, *Andropogon*, and *Gutierrezia*.

Presence or absence of *Prosopis* ≥60 cm in height was observed at each lek, and active and abandoned leks were compared. Of 39 abandoned leks, 30 (76.9%) were associated with large *Prosopis*, while 9 of 33 active leks (27.3%) had large *Prosopis*. This difference was significant ($\chi^2 = 8.122$, $P < 0.01$).

Discussion—Excessive grazing by livestock often has been suggested as a possible cause for declines in populations of prairie grouse, including lesser prairie-chickens (Jackson and DeArment, 1963; Johnsgard, 2002; Silvy et al., 2004), but no study has established a correlation between overgrazing and these declines in southeastern New Mexico. Our study demonstrated a link between reduction in numbers of lesser prairie-chickens in southeastern New Mexico and vegetative characteristics associated with overgrazing.

Vegetative cover of leks was different from that of pasture sites each of the 3 years. According to structure matrices of discriminant-function analyses, the difference was mostly due to differences in amount of bare ground. However, direction of this difference was not consistent from year to year. In 2001, there was more bare ground on leks than at pasture sites, but in the other 2 years, the situation was reversed. This is surprising because displaying activities of males might be expected to increase amount of bare ground on active leks. Display of lesser prairie-chickens includes a great deal of foot-stamping (Grange, 1940), and flutter-jumps of males often end on any plant left on the lek (Sharpe, 1968). We expected these activities to increase amount of bare ground on leks compared to pasture sites. The common selection of abandoned oil well drill pads and little-used roads as lek sites (Crawford and Bolen, 1976; Taylor, 1980) also was expected to increase amount of bare ground at leks compared to pasture sites. However, ANOVAs conducted concurrently with discriminant-function analyses indicated no significant difference in amount of bare ground at leks and pasture sites in any of the 3 years. Results were the same, even when bare ground and litter were combined for consideration. In fact, these ANOVAs indicated no significant difference in any year between any tested variables. Analysis of vegetational information indicates that vegetative composition is not involved in choice of lek sites. Instead, sites probably are chosen for proximity to suitable nesting and brood-rearing habitat, and to allow for maximum visibility (Bergerud and Gratson, 1988).

Vegetative composition of active and abandoned leks, and of pasture sites, was different among years, but patterns of composition were not different among years. Active leks and pastures in which they occurred had greater cover of *Andropogon*, *Bouteloua*, and *Gutierrezia*, and lower cover of *Sporobolus*, *Muhlenbergia*, and *Eriogonum*, than did abandoned leks and their corresponding pastures, although not all of these variables contributed equally to overall annual differences. Most striking are differences in cover of *Andropogon* and *Sporobolus*. Pastures containing active leks had >5 times as much *Andropogon* as did those which contained abandoned leks. *Andropogon* grows in thick clumps that often have a somewhat open area at the center. These clumps are ideal nesting cover for ground-nesting birds such as lesser prairie-chickens. Lesser prairie-chickens preferentially select *Andropogon* as nest sites, and nesting success is much greater for those that select *Andropogon* (Riley et al., 1992; C. A. Davis, in litt.). *Sporobolus* grows in clumps that are not as thick as those of *Andropogon* (Powell, 1994). Nests placed in *Sporobolus* would be much more visible to predators than those placed in *Andropogon* (C. A. Davis et al., in litt.).

*Andropogon* is better forage for livestock than is *Sporobolus* (Valentine, 1989); it is highly palatable, and is selected by livestock over other grasses. *Sporobolus*, although consumed by livestock, is not selected preferentially, and its value as forage declines rapidly as it matures (Stubbendieck et al., 1997). Under heavy grazing, *Andropogon* decreases and *Sporobolus* increases (Ross and Bailey, 1967; Stubbendieck et al., 1997); thus, *Sporobolus* is considered an indicator of overgrazing (Stubbendieck et al., 1997). Relative amounts of the two grasses indicate that pastures containing abandoned leks are more likely to be in areas of heavy grazing than are those containing active leks. *Andropogon* also is less well adapted to areas of poor, sandy soil, while *Sporobolus* is well adapted to such soils (Ross and Bailey, 1967; Stubbendieck et al., 1997). Quality of soil in pastures containing abandoned leks often is poor (Ross and Bailey, 1967; Chug et al., 1971; Turner et al., 1974; Lenfesty, 1983). Poor soils will not support high levels of grazing by livestock (Ross and Bailey, 1967).

TABLE 2—Percentage of vegetative cover of active and abandoned leks of lesser prairie-chickens (*Tympanuchus pallidicinctus*) in southeastern New Mexico. In 2001, 32 active leks and pasture sites and 28 abandoned leks and pasture sites were surveyed. In 2002 and 2003, 33 active leks and pasture sites and 27 abandoned leks and pasture sites were surveyed. Results of ANOVA used to assess differences between active and abandoned leks or pastures are provided: * $P \leq 0.05$; ** $P \leq 0.001$.

| | Leks | | | | Pastures | | | |
|---|---|---|---|---|---|---|---|---|
| Plant/year | Active | Abandoned | *F* | *P* | Active | Abandoned | *F* | *P* |
| *Andropogon* | | | | | | | | |
| 2001 | 13.1 | 1.9 | 10.574 | 0.002** | 17.2 | 2.4 | 23.793 | <0.001** |
| 2002 | 10.7 | 1.7 | 21.673 | <0.001** | 14.8 | 1.7 | 12.196 | 0.001** |
| 2003 | 9.3 | 1.4 | 16.881 | <0.001** | 13.0 | 1.4 | 17.514 | <0.001** |
| *Aristida* | | | | | | | | |
| 2001 | 4.5 | 4.5 | 0.696 | 0.407 | 6.6 | 5.2 | 0.081 | 0.777 |
| 2002 | 4.6 | 4.5 | 0.690 | 0.410 | 5.8 | 4.5 | 0.072 | 0.790 |
| 2003 | 3.8 | 4.4 | 1.055 | 0.309 | 4.2 | 5.2 | 0.013 | 0.911 |
| *Artemisia*[a] | | | | | | | | |
| 2001 | 0.5 | 0.4 | | | 0.7 | 0.9 | | |
| 2002 | 0.5 | 0.6 | | | 0.7 | 1.2 | | |
| 2003 | 0.7 | 0.6 | | | 0.7 | 1.0 | | |
| *Bouteloua* | | | | | | | | |
| 2001 | 11.6 | 4.4 | 6.826 | 0.011* | 9.1 | 5.0 | 7.034 | 0.010* |
| 2002 | 7.2 | 4.5 | 13.036 | 0.001** | 5.5 | 3.4 | 7.685 | 0.007* |
| 2003 | 7.8 | 4.4 | 0.830 | 0.366 | 4.4 | 3.6 | 1.801 | 0.185 |
| *Eriogonum* | | | | | | | | |
| 2001 | 0.4 | 0.7 | 1.183 | 0.281 | 0.5 | 0.5 | 0.117 | 0.733 |
| 2002 | 1.0 | 1.5 | 1.439 | 0.235 | 1.5 | 1.9 | 0.007 | 0.935 |
| 2003 | 0.1 | 3.4 | 28.413 | <0.001** | 0.1 | 3.7 | 17.738 | <0.001** |
| *Gutierrezia* | | | | | | | | |
| 2001 | 4.9 | 1.1 | 9.545 | 0.003* | 2.7 | 0.4 | 10.338 | 0.002* |
| 2002 | 6.5 | 1.6 | 21.183 | <0.001** | 3.5 | 0.6 | 5.631 | 0.021* |
| 2003 | 5.3 | 1.2 | 8.264 | 0.006* | 2.9 | 0.5 | 6.199 | 0.016* |
| *Muhlenbergia* | | | | | | | | |
| 2001 | <0.1 | 3.2 | 43.349 | <0.001** | <0.1 | 4.5 | 21.475 | <0.001** |
| 2002 | 0.1 | 2.4 | 17.544 | <0.001** | <0.1 | 3.5 | 21.406 | <0.001** |
| 2003 | 0.2 | 3.1 | 16.866 | <0.001** | 0.3 | 3.8 | 21.936 | <0.001** |
| *Panicum* | | | | | | | | |
| 2001 | 0.3 | 0.1 | 0.564 | 0.456 | 0.6 | 0.2 | 2.925 | 0.093 |
| 2002 | 0.3 | 0.1 | 3.226 | 0.078 | 0.3 | <0.1 | 4.174 | 0.046* |
| 2003 | 0.2 | <0.1 | 1.729 | 0.194 | 0.1 | <0.1 | 0.884 | 0.351 |
| *Prosopis* | | | | | | | | |
| 2001 | 0.6 | 1.0 | 4.100 | 0.047* | 0.7 | 0.4 | 0.279 | 0.600 |
| 2002 | 0.5 | 1.3 | 0.337 | 0.564 | 0.8 | 0.5 | 0.055 | 0.815 |
| 2003 | 0.5 | 1.1 | 4.317 | 0.042* | 0.8 | 0.5 | 0.134 | 0.716 |
| *Quercus* | | | | | | | | |
| 2001 | 8.2 | 8.4 | 0.195 | 0.661 | 10.2 | 8.0 | 0.228 | 0.635 |
| 2002 | 8.2 | 7.3 | 1.444 | 0.234 | 11.0 | 8.8 | 0.255 | 0.615 |
| 2003 | 7.7 | 6.3 | 0.269 | 0.606 | 11.8 | 8.1 | 0.622 | 0.433 |
| *Sporobolus* | | | | | | | | |
| 2001 | <0.1 | 4.8 | 47.490 | <0.001** | <0.1 | 3.3 | 22.289 | <0.001** |
| 2002 | 0.9 | 7.0 | 3.704 | 0.059 | 1.2 | 5.8 | 1.835 | 0.181 |

Table 2—Continued.

| | Leks | | | | Pastures | | | |
|---|---|---|---|---|---|---|---|---|
| Plant/year | Active | Abandoned | *F* | *P* | Active | Abandoned | *F* | *P* |
| 2003 | 2.0 | 6.4 | 1.946 | 0.168 | 1.7 | 5.9 | 2.257 | 0.138 |
| *Yucca* | | | | | | | | |
| 2001 | 2.9 | 1.7 | 0.139 | 0.711 | 3.4 | 2.1 | 1.054 | 0.309 |
| 2002 | 2.9 | 2.0 | 1.862 | 0.178 | 3.5 | 2.0 | 0.174 | 0.678 |
| 2003 | 2.9 | 1.5 | 0.471 | 0.495 | 3.7 | 1.8 | 1.670 | 0.201 |
| Bare | | | | | | | | |
| 2001 | 34.9 | 48.1 | 0.763 | 0.386 | 22.3 | 42.7 | 0.368 | 0.546 |
| 2002 | 26.6 | 37.1 | 0.130 | 0.720 | 16.8 | 31.7 | 0.520 | 0.474 |
| 2003 | 35.6 | 38.7 | 0.549 | 0.462 | 25.9 | 32.7 | 0.008 | 0.929 |
| Litter | | | | | | | | |
| 2001 | 16.4 | 17.9 | 0.413 | 0.523 | 24.8 | 23.4 | 0.021 | 0.884 |
| 2002 | 28.8 | 26.5 | 0.836 | 0.364 | 33.6 | 31.7 | 0.007 | 0.934 |
| 2003 | 23.1 | 26.0 | 0.655 | 0.421 | 29.8 | 30.0 | 0.031 | 0.860 |
| Other[ab] | | | | | | | | |
| 2001 | 1.5 | 1.8 | | | 1.0 | 1.0 | | |
| 2002 | 1.2 | 1.9 | | | 0.9 | 1.7 | | |
| 2003 | 0.8 | 1.9 | | | 0.6 | 1.3 | | |

[a] Not included in analyses.
[b] Includes *Amaranthus*, *Ambrosia*, *Croton*, *Euphorbia*, *Helianthus*, *Mentzelia*, *Munroa*, *Opuntia*, *Paspalum*, *Salsola*, *Senecio*, and unidentified plants.

Cover of *Gutierrezia* was greater on active leks than on abandoned leks, but it also was greater on leks than on pasture sites. This suggests that greater levels of *Gutierrezia* may be a result of activities of lesser prairie-chickens. *Gutierrezia* is associated with disturbances such as grazing (Bowers, 1993; Dick-Peddie, 1993), and is an indicator of overgrazing (Stubbendieck et al., 1997). In this case, however, disturbance caused by the foot-stamping of displaying male lesser prairie-chickens probably has a greater role than overgrazing in creating patterns of occurrence of *Gutierrezia* on leks. Grazing is no heavier at leks than at pasture sites; if increased occurrence of *Gutierrezia* was caused by grazing, percentage cover should be the same at leks and pasture sties. Conversely, *Eriogonum* occurred in about equal percentages at leks and pasture sites, but was more common at abandoned leks than at active leks. *Eriogonum* also is an indicator of overgrazing (Clements, 1920).

Cover of *Prosopis* was not significantly greater for abandoned leks and associated pasture sites than for active leks and associated pasture sites, but *Prosopis* ≥60 cm in height were more likely to be near abandoned leks than near active leks. *Prosopis* can be spread by livestock (Heady, 1975; Kramp et al., 1998; Kneuper et al., 2003) and is an indicator of overgrazing (Clements, 1920; Bahre, 1995; Brown and Archer, 1999; Van Auken, 2000). *Prosopis* or other tall plants nearby may also cause abandonment of leks (N. J. Silvy, pers. comm.), presumably because they provide cover or perches for predators.

In New Mexico, shinnery oak is important as brood-rearing cover (C. A. Davis et al., in litt.) and as a source of food (Oberholser, 1974; C. A. Davis et al., in litt.). In New Mexico, lesser prairie-chickens preferentially spend time in areas with greater concentrations of shinnery oak (Patten et al., 2005), and there is such a close relationship with shinnery oak that they sometimes are considered to be ecological partners (Johnsgard, 2002). However, shinnery oak is considered a weed by some, it may be toxic to livestock, and it is believed to compete with grasses used as forage by livestock (Peterson and Boyd, 1998). Some control of shinnery oak has occurred on the study site, but treatments ceased in the early 1990s (J. S. Sherman, pers. comm.). Because shinnery oak grows slowly (Peterson and Boyd, 1998), differences in percentage cover of shinnery oak would be apparent for many years after removal. However, there was no significant difference in cover of shinnery oak at abandoned or active leks, or in pastures that contained them. Lack of difference in cover of shinnery oak between abandoned and active leks indicates that control of shinnery oak probably has not contributed to decline in populations of lesser prairie-chickens in southeastern New Mexico. This should not be construed to mean that removal of shinnery oak in areas where populations currently exist would have no adverse effect (Johnson et al., 2004). Lesser prairie-chickens living in areas of treatment with tebuthiuron consumed more foliage and less insects and acorns, resulting in differences in morphology of the small intestine, cecum, and gizzard necessary to process a lower quality, more fibrous diet. Lesser prairie-chickens in treated areas had lower body weight and smaller fat reserves than did those in untreated areas (Olawsky, 1987).

Abandoned leks in the study area were associated with plants that usually were recognized as symptoms of overgrazing. Recent sightings of lesser prairie-chickens in areas where breeding populations no longer exist (T. L. Best, pers. observ.) indicate that there is some movement back into the area. For example, several individuals were observed on the Hat Mesa in southwestern Lea County in 2004 (S. Belinda and T. L. Best, pers. comm.), where none were found during breeding surveys. Some consideration has been given to reintroduction of lesser prairie-chickens into the study area. However, when birds are reintroduced or naturally return to the area, overgrazing may make it difficult for them to maintain a viable population. If breeding populations are to become reestablished in eastern Eddy and southern Lea counties, it is essential that excessive grazing is eliminated or reduced in large enough areas to provide adequate nesting territories.

Much of the area formerly and presently occupied by lesser prairie-chickens in southeastern New Mexico is heavily used for petroleum development. Although oil and natural gas production has occurred in southeastern New Mexico since the 1920s (Rundell, 1982), a dramatic increase in such activity has occurred in the past 20 years. Although amount of petroleum produced in New Mexico has remained fairly constant, the number of new wells drilled in eastern New Mexico each year also has remained constant (American Petroleum Institute, 1984, 1987, 1998; United States Bureau of the Census, 1990; United States Census Bureau, 2003). These activities require destruction of significant amounts of habitat, installation of a large number of pumpjacks and other equipment, erection of an extensive network of power lines, and construction and use of a substantial number of roads (Weller et al., 2002). Nesting lesser prairie-chickens in Kansas avoided structures and roads associated with extraction of petroleum (Robel et al., 2004; Pitman et al., 2005), and collisions with power lines were a major cause of mortality for lesser prairie-chickens in Oklahoma and New Mexico (Wolfe et al., 2007). Interaction of such avoidance and increased mortality with the effects of overgrazing demonstrated in this study may contribute to the reduction in breeding populations of lesser prairie-chickens in southeastern New Mexico. More research is needed to study possible interactions.

A study of a population of lesser prairie-chickens in Oklahoma and Texas (Fuhlendorf et al., 2002) indicated that study of variables at broader scales than that attempted in our study might give different results from those obtained here. However, while intensity of use of the land within the study area has changed, overall patterns of use remained consistent for the years preceding the study (New Mexico Department of Game and Fish, in litt.).

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## Literature Cited

Aebischer, N. J., and P. A. Robertson. 1992. Practical aspects of compositional analysis as applied to pheasant habitat utilization. Pages 285–293 in Wildlife telemetry: remote monitoring and tracking of animals (I. G. Pride and S. M. Swift, editors). Ellis Horwood, New York.

Ahlborn, G. G. 1980. Brood-rearing habitat and fall-winter movements of lesser prairie chickens in eastern New Mexico. M.S. thesis, New Mexico State University, Las Cruces.

Aitchison, J. 1986. The statistical analysis of compositional data. Chapman and Hall, London, United Kingdom.

American Petroleum Institute. 1984. Quarterly review of drilling statistics for the United States. American Petroleum Institute 17(4):1–39.

American Petroleum Institute. 1987. Quarterly completion report. American Petroleum Institute 14(4): 1–82.

American Petroleum Institute. 1998. Quarterly well completion report. American Petroleum Institute 14(4):1–58.

Bahre, C. J. 1995. Human impacts on the grasslands of southeastern Arizona. Pages 230–264 in The desert grassland (M. P. McClaran and T. R. Van Devender, editors). University of Arizona Press, Tucson.

Beck, W. A. 1962. New Mexico: a history of four centuries. University of Oklahoma Press, Norman.

Bergerud, A. T., and M. W. Gratson. 1988. Survival and breeding strategies of grouse. Pages 473–577 in Adaptive strategies and population ecology of northern grouse (A. T. Bergerud and M. T. Gratson, editors). University of Minnesota Press, Minneapolis.

Best, T. L., K. Geluso, J. L. Hunt, and L. A. McWilliams. 2003. The lesser prairie chicken (*Tympanuchus pallidicinctus*) in southeastern New Mexico: a population survey. Texas Journal of Science 55: 225–234.

Bonham, C. D. 1989. Measurements for terrestrial vegetation. John Wiley & Sons, New York.

Bowers, J. E. 1993. Shrubs and trees of the Southwest deserts. Southwest Monuments and Parks Association, Tucson, Arizona.

Brown, J. R., and S. Archer. 1999. Shrub invasion of grassland: recruitment is continuous and not regulated by herbaceous biomass or density. Ecology 80:2385–2396.

Campbell, H. 1972. A population study of lesser prairie chickens in New Mexico. Journal of Wildlife Management 36:689–699.

Chug, J. C., G. W. Anderson, D. L. King, and L. H. Jones. 1971. Soil survey of Eddy area, New Mexico. United States Department of Agriculture, Soil Conservation Service, Washington, D.C.

Clements, F. E. 1920. Plant indicators: the relation of plant communities to process and practice. Carnegie Institution of Washington, Washington, D.C.

Copelin, F. F. 1963. The lesser prairie chicken in Oklahoma. Oklahoma Wildlife Conservation Department, Technical Bulletin 6:1–58.

Cox, G. W. 1997. Conservation biology: concepts and applications. Second edition. Wm. C. Brown Publishers, Dubuque, Iowa.

Crawford, J. A., and E. G. Bolen. 1976. Effects of lek disturbances on lesser prairie chickens. Southewestern Naturalist 21:238–240.

De Juana, E. 1994. Family Tetraonidae (grouse). Pages 376–410 in Handbook of birds of the World: New World vultures-guineafowl (J. Del Hoyo, A. Elliot, and J. Sargatal, editors). Lynx Edicions, Barcelona, Spain.

Dick-Peddie, W. A. 1993. New Mexico vegetation: past, present, and future. University of New Mexico Press, Albuquerque.

Fleischner, T. L. 1994. Ecological costs of livestock grazing in western North America. Conservation Biology 8:629–644.

Fuhlendorf, S. D., A. J. W. Woodward, D. M. Leslie, Jr., and J. S. Shackford. 2002. Multi-scale effects of habitat loss and fragmentation on lesser prairie-chicken populations of the US Southern Great Plains. Landscape Ecology 17:617–628.

Giesen, K. M. 1994. Movements and nesting habitat of lesser prairie-chicken hens in Colorado. Southwestern Naturalist 39:96–98.

Giesen, K. M. 1998. *Tympanuchus pallidicinctus*: lesser prairie chicken. Birds of North America 364: 1–19.

Gould, J. L., and G. F. Gould. 2002. Biostats basics: a student handbook. W. H. Freeman and Company, New York.

Grange, W. 1940. A comparison of the displays and vocal performances of the greater prairie chicken, lesser prairie chicken, sharp-tailed grouse and sooty grouse. Passenger Pigeon 2:127–133.

Green, S. B., N. J. Salkind, and T. M. Akey. 1997. Using SPSS for Windows. Prentice Hall, Upper Saddle River, New Jersey.

Hagen, C. A., B. E. Jamison, K. M. Giesen, and T. Z. Riley. 2004. Management guidelines for lesser prairie-chicken populations and their habitats. Wildlife Society Bulletin 32:69–82.

Hair, J. F., Jr., R. E. Anderson, R. L. Tatham, and W. C. Black. 1998. Multivariate data analysis. Fifth edition. Prentice Hall, Upper Saddle River, New Jersey.

Heady, H. F. 1975. Rangeland management. McGraw-Hill, New York.

Heady, H. F., and R. D. Child. 1994. Rangeland ecology and management. Westview Press, Boulder, Colorado.

Jackson, A. S., and R. Dearment. 1963. The lesser prairie chicken in the Texas Panhandle. Journal of Wildlife Management 27:733–737.

Johnsgard, P. A. 2002. Grassland grouse and their conservation. Smithsonian Institution Press, Washington, D.C.

Johnson, K., B. H. Smith, G. Sadoti, T. B. Neville, and P. Neville. 2004. Habitat use and nest site selection by nesting lesser prairie-chickens in southeastern New Mexico. Southwestern Naturalist 49:334–343.

JONES, V. E., AND R. D. PETIT. 1984. Low rates of tebuthiuron for control of sand shinnery oak. Journal of Range Management 37:488–490.

KNEUPER, C. L., C. B. SCOTT, AND W. E. PINCHAK. 2003. Consumption and dispersion of mesquite seeds by ruminants. Journal of Range Management 56: 255–259.

KRAMP, B. A., R. J. ANSLEY, AND T. R. TUNNELL. 1998. Survival of mesquite seedlings emerging from cattle and wildlife feces in a semi-arid grassland. Southwestern Naturalist 43:300–312.

LENFESTY, C. D. 1983. Soil survey of Chaves County, New Mexico, northern part. United States Department of Agriculture, Soil Conservation Service, Washington, D.C.

MARTIN, B. H. 1990. Avian and vegetation research in the shinnery oak ecosystem of southeastern New Mexico. M.S. thesis, New Mexico State University, Las Cruces.

OBERHOLSER, H. C. 1974. The bird life of Texas. University of Texas Press, Austin.

OLAWSKY, C. D. 1987. Effects of shinnery oak control with tebuthiuron on lesser prairie-chicken populations. M.S. thesis, Texas Tech University, Lubbock.

PATTEN, M. A., D. H. WOLFE, E. SHOCHAT, AND S. K. SHERROD. 2005. Effects of microhabitat and microclimate selection on adult survivorship of the lesser prairie-chicken. Journal of Wildlife Management 69:1270–1278.

PETERSON, R. S., AND C. S. BOYD. 1998. Ecology and management of sand shinnery communities: a literature review. United States Department of Agriculture Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-16:1–44.

PITMAN, J. C., C. A. HAGEN, R. J. ROBEL, T. M. LOUGHIN, AND R. D. APPLEGATE. 2005. Location and success of lesser prairie-chicken nests in relation to vegetation and human disturbance. Journal of Wildlife Management 69:1259–1269.

PITMAN, J. C., C. A. HAGEN, B. E. JAMISON, R. J. ROBEL, T. M. LOUGHIN, AND R. D. APPLEGATE. 2006. Nesting ecology of lesser prairie-chickens in sand sagebrush prairie of southwestern Kansas. Wilson Journal of Ornithology 118:23–35.

POWELL, A. M. 1994. Grasses of the Trans-Pecos and adjacent areas. University of Texas Press, Austin.

RILEY, T. Z., C. A. DAVIS, M. ORTIZ, AND M. J. WISDOM. 1992. Vegetative characteristics of successful and unsuccessful nests of lesser prairie chickens. Journal of Wildlife Management 56:383–387.

ROBEL, R. J., J. A. HARRINGTON, C. A. HAGEN, J. C. PITMAN, AND R. R. RECKER. 2004. Effect of energy development and human activity on the use of sand sagebrush habitat by lesser prairie-chickens in southwestern Kansas. Transactions of the North American Natural Resource Conference 69:251–266.

ROSS, W. J., AND O. F. BAILEY. 1967. Soil survey of Roosevelt County, New Mexico. United States Department of Agriculture, Soil Conservation Service, Washington, D.C.

RUNDELL, W., JR. 1982. Oil in West Texas and New Mexico: a pictorial history of the Permian Basin. Texas A&M University Press, College Station.

SCHROEDER, M. A., AND L. A. ROBB. 1993. Greater prairie-chicken (*Tympanuchus cupido*). Birds of North America 36:1–24.

SELL, D. L. 1979. Spring and summer movements and habitat use by lesser prairie chicken females in Yoakum County, Texas. M.S. thesis, Texas Tech University, Lubbock.

SHARPE, R. S. 1968. The evolutionary relationships and comparative behavior of prairie chickens. Ph.D. dissertation, University of Nebraska, Lincoln.

SILVY, N. J., M. J. PETERSON, AND R. R. LOPEZ. 2004. The cause of the decline of pinnate grouse: the Texas example. Wildlife Society Bulletin 2004:16–21.

STUBBENDIECK, J., S. L. HATCH, AND C. H. BUTTERFIELD. 1997. North American range plants. Fifth edition. University of Nebraska Press, Lincoln.

TAYLOR, M. A. 1978. Fall and winter habitat use of lesser prairie chickens. M.S. thesis, Texas Tech University, Lubbock.

TAYLOR, M. A. 1980. Lesser prairie chicken use of man-made leks. Southwestern Naturalist 24:706–707.

TAYLOR, M. A., AND F. S. GUTHERY. 1980*a*. Fall-winter movements, ranges, and habitat uses of lesser prairie chickens. Journal of Wildlife Management 44:521–524.

TAYLOR, M. A., AND F. S. GUTHERY. 1980*b*. Status, ecology, and management of the lesser prairie chicken. United States Department of Agriculture Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-77: 1–15.

TURNER, M. T., D. N. COX, B. C. MICKELSON, A. J. ROATH, AND C. D. WILSON. 1974. Soil survey of Lea County, New Mexico. United States Department of Agriculture, Soil Conservation Service, Washington, D.C.

UNITED STATES BUREAU OF THE CENSUS. 1990. Statistical abstract of the United States: 1990. 110th edition. United States Bureau of the Census, Washington, D.C.

UNITED STATES CENSUS BUREAU. 2003. Statistical abstract of the United States: 2003. 123rd edition. United States Census Bureau, Washington, D.C.

VALENTINE, J. F. 1989. Range development and improvments. Third Edition. Academic Press, San Diego, California.

VAN AUKEN, O. W. 2000. Shrub invasions of North American semiarid grasslands. Annual Review of Ecology and Systematics 31:197–215.

Weller, C., J. Thomson, P. Morton, and G. Aplet. 2002. Fragmenting our lands: the ecological footprint from oil and gas development. Wilderness Society, Washington, D.C.

Westemeier, R. L., J. D. Brawn, S. A. Simpson, T. L. Esker, R. W. Jansen, J. W. Walk, E. L. Kershner, J. L. Bouzat, and K. N. Paige. 1998. Tracking the long-term decline and recovery of an isolated population. Science 282:1695–1698.

Wolfe, D. H., M. A. Patten, E. Shochat, C. L. Pruett, and S. K. Sherrod. 2007. Causes and patterns of mortality in lesser prairie-chickens *Tympanuchus pallidicinctus* and implications for management. Wildlife Biology 13(supplement 1):95–104.

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