Lesser Prairie Chicken Habitat Assessment
Comanche National Grassland

Prepared for U.S. Forest Service

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Introduction

The Lesser Prairie-Chicken (*Tympanuchus pallidicinctus*) is one of several gallinaceous birds native to Colorado's eastern plains. Although similar to the Greater Prairie-Chicken (*Tympanuchus cupido*), whose distribution slightly overlaps that of the Lesser Prairie Chicken (LEPC) in western Kansas, the *T. pallidicinctus* is smaller, has different courtship displays and vocalizations, and inhabits midgrass and sandsage (*Artemisia filifolia*) rangelands associated with sandy soils rather than native tallgrass prairies interspersed with agricultural habitats that are more typical of loamy soil (Hagan and Giesen 2005). The historic distribution of LEPC covers parts of 5 states in the southern Great Plains. The southeastern corner of Colorado represents a small portion of the historic range of this species, which once inhabited a substantial portion of southwestern Kansas, eastern New Mexico, western Oklahoma, and north-central Texas (Figure 1). In Colorado, the species has been documented in Baca, Cheyenne, Kiowa, and Prowers counties within the past ten years (CNHP 2010).

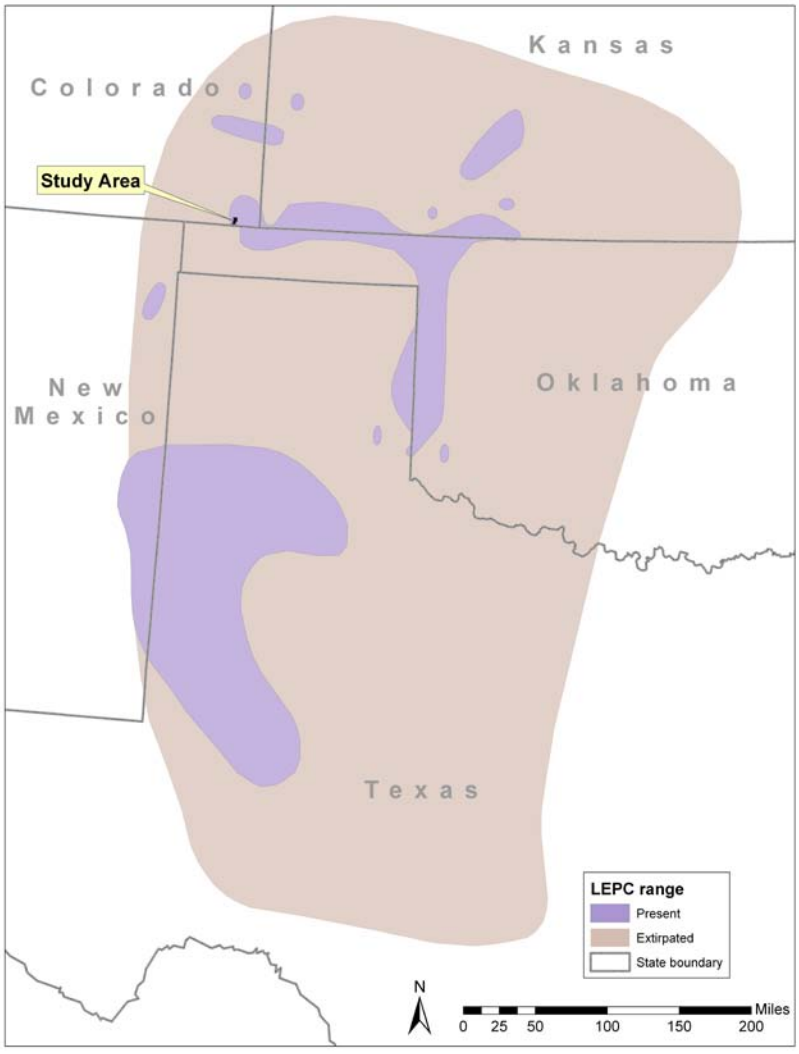


Figure 1. Approximate historic and current range of LEPC (Ridgely et al. 2007).

Although lands within the range of LEPC generally have low human population density, historic anthropogenic activities appear to have had a significant impact on LEPC populations. Incompatible agricultural practices, such as excessive livestock grazing of rangelands and conversion of native rangelands to cropland, combined with periodic drought, have significantly reduced populations sizes as well as the overall distribution of the Lesser Prairie-Chicken since the early 1900s (Hagan and Giesen 2005). The LEPC is considered Threatened by the state of Colorado, but currently lacks federal protection. The species is a candidate for listing under Federal Endangered Species Act.

Rangewide, LEPC needs for vegetation structure and composition depend on season and life stage (i.e., nesting or brood-rearing, chicks or adults), but can be described generally as native rangeland in different stages of plant succession and consisting of a diversity of native, short- to tall-height grasses and forbs interspersed with low-growing shrubby cover. In Colorado, sand sagebrush communities dominated by a mix of sand dropseed, side oats grama, and little bluestem are the habitats where LEPC are most often found.

Study Area

The Comanche National Grasslands encompass more than 440,000 acres in Otero, Las Animas, and Baca counties in southeastern Colorado. The National Grasslands have their origin in the agricultural difficulties of the 1930's, when cultivation of sub-marginal lands, in combination with severe drought, led to severe erosional damage and eventual abandonment of farms during the period generally referred to as the Dust Bowl. These lands were subsequently brought under federal ownership and management by a variety of mechanisms, but primarily the Bankhead-Jones Farm Tenant Act of 1937. This legislation permitted the federal government to purchase or otherwise acquire sub-marginal farmlands. In 1954 the Forest Service assumed administration of about 3.85 million acres of these lands from the Soil Conservation Service (now the Natural Resource Conservation Service), and in 1960 the lands were designated as National Grasslands by the Secretary of Agriculture (Olson 1997).

The study area is dominated by a sandhills ecosystem on gently rolling sandy soils of the Otero, Vona and Manter series, and support moderately dense sandsage with a grass dominated understory. Otero soils on the site (OeB and OeD) are light-colored, moderately sandy soils, somewhat excessively drained, with moderate fertility. Vona (VnB) and Manter (MaB) soils are light-colored sandy loams and loamy sands, well drained, and primarily in native range cover. Soils with minor coverage in the study area include Bankard series sand and Glenberg series sandy loam along the drainages, Dalhart loamy sands and sandy loams, scattered gravely breaks of the Potter series, pockets of deep sand of the Tivoli series, and occasional smaller patches of other Vona series soils. All of the sandy soils are highly susceptible to wind erosion (Woodyard et al. 1973).

The NRCS considers a blue grama-prairie sandreed-sand bluestem plant community to be the Historic Climax Plant Community (Berlinger et al. 2007). This plant community evolved with grazing by large herbivores. The potential vegetation is dominated by 70-85% grasses and graminoids, with 10-15% forbs and 5-15% woody plants. The dominant tall warm season grasses are prairie sandreed, sand bluestem and switchgrass, and blue grama dominates the understory. Important cool season species are needle-and-thread, western wheatgrass and sun sedge. Key

forbs and shrubs include American vetch, purple prairie clover, western sandcherry and fourwing saltbush (Berlinger et al. 2007).This historic plant community was well adapted to the Northern Great Plains climatic conditions, with a diversity in plant species that provided high drought tolerance and resistance to many natural disturbances. Extended periods of continuous grazing, conversion to cropland, and development have removed this community in much of the area. Although the National Grasslands are now maintained in primarily native vegetation, the study area represents an area that is probably not on the same trajectory that would be observed had the disturbances of the 1930's and subsequent restoration efforts not taken place. Current vegetation of the area is variable, depending on site history. Areas with low species diversity are probably those that have been seeded in post-Dust Bowl years, while species-rich areas are more similar to the original vegetation.

Within these lands, LEPC occurrences have been documented from National Grassland parcels in southern Baca County, particularly in sandy areas north of the Cimarron River. We assessed high priority LEPC habitat on 9,300 acres of the Mt. Carmel and LPC allotments, in the extreme southeastern portion of the Comanche NG, about 12 miles southeast of Campo.

Methods

Vegetation was evaluated with regard to requirements for nesting and brood-rearing LEPC, according to target conditions shown in Table 1. High quality LEPC nesting habitat is characterized by grass condition; ideally the area would be a mosaic of about 65% grassy clumps, interspersed with 20-30% shrubs, and 5-15% forbs. Grasses and shrubs should average at least 20 inches in height (USFWS 1999). In considering the quality of brood-rearing habitat, the focus is on vegetation structure that provides high abundance of insects. Ideal LEPC brood-rearing cover has an interspersion of 40-45% of shrubs (in Colorado, sand sagebrush, yucca and snakeweed); 40-45% of short- to medium height grasses, and 15-20% forbs (USFWS 1999).

Table 1. Lesser Prairie Chicken vegetation attributes for nesting and brood-rearing habitat.

Habitat factor	Nesting	Source
Shrub cover (%)	>20, (10 better than 0) 5-30+*	Patten et al. (2005) Giesen (1994)
Shrub height (cm)	≥47.6* ≥50	Giesen (1994) USFWS (1999)
Forb cover (%)	≥15 5-15*	Hagen et al. (2005) USFWS (1999)
Forb height (cm)	21	Giesen (1994)
Grass cover (%)	>20* 65% "grassy mottes" (clumps)	Bidwell et al. (no date) USFWS (1999)
Grass height (cm)	≥48-51 >36 ≥20*	Bidwell et al. (no date) Giesen (1994) USFWS (1999)
	Brood-rearing	
Shrub density (plants/ha)	2000-7000 * 3471	Hagen et al. (2005) Giesen (1994)
Shrub cover (%)	40-45	USFWS (1999)
Forb cover (%)	15-20	USFWS (1999)
Grass cover (%)	40-45	USFWS (1999)
Grass height	Short to medium	USFWS (1999)

* Target condition

Vegetation sampling was conducted at the Comanche NG on May 24-27, 2010 by Renée Rondeau and Karin Decker of CNHP, assisted by Steve Olson, Stephanie Shively, and Christina Kemp of the USFS. In the area of the allotments dominated by sandy soils of the Otero, Vona and Manter series, thirty-six 50 m transect points were randomly allotted by GIS such that the number of transects per soil type was balanced (nine transects per type), no transects were closer than 100 m to a fence, and a distance of ~400 m between transects was maintained (Figure 2). At each transect point, the transect direction was randomly chosen by tossing the 1 m stick and aligning the transect according to the arrow on one end of the stick. Transect direction was recorded to the nearest 5 degrees. The transect layout is shown in Figure 3. At each transect, the following was measured: 1) shrub density (sandsage, yucca, and snakeweed), 2) shrub, grass, and forb cover and height, and 4) overall vegetation height-density (Robel method).

A 50 m x 1 m belt transect was used to measure shrub density (Bonham 1989). Individual sandsage, yucca (*Yucca glauca*) and snakeweed (*Gutierrezia sarothrae*) shrubs were counted in a 50 cm band on both sides of each 50 m transect. A shrub was counted if >50% of its basal stem(s) was within the transect line. Because yucca is rhizomatous and therefore difficult to distinguish as individual plants, individual stems were counted.

To estimate percent cover of shrubs, grasses, and forbs, a point-intercept reading was taken every meter along the 50 m tape, beginning at the 0.5 m mark. Bare soil, macrophytic crusts, pebbles, downed litter (including stump remains of grasses), and cowpies were counted under the bare ground/litter category. Only standing plants (may be green or brown) were measured. It was possible to have greater than 100% total cover as grasses may be underneath forbs. Grasses and shrubs were identified to species; forbs were lumped, except for *Opuntia* spp. and *Salsola* spp
.
Vegetation height-density at each transect was estimated by using a 150 cm round pole with 1-inch increments marked along its length (Robel 1970 visual obstruction method). At four positions along each transect the highest point on the pole obscured by vegetation was recorded. At each of these four positions, the height of the nearest shrub, nearest grass, and nearest forb was also measured, and the height of green material as well as residual (senesced) material recorded.

Digital photographs were used to document the condition at the 0 meter mark of each transect location. A Fujifilm Finepix F31fd camera with a focal length of 8-24mm was used, with the middle of the lens positioned at 1.47m above ground level. At each transect point, a landscape photo along the transect direction and a microplot photo were taken (Figure 4).

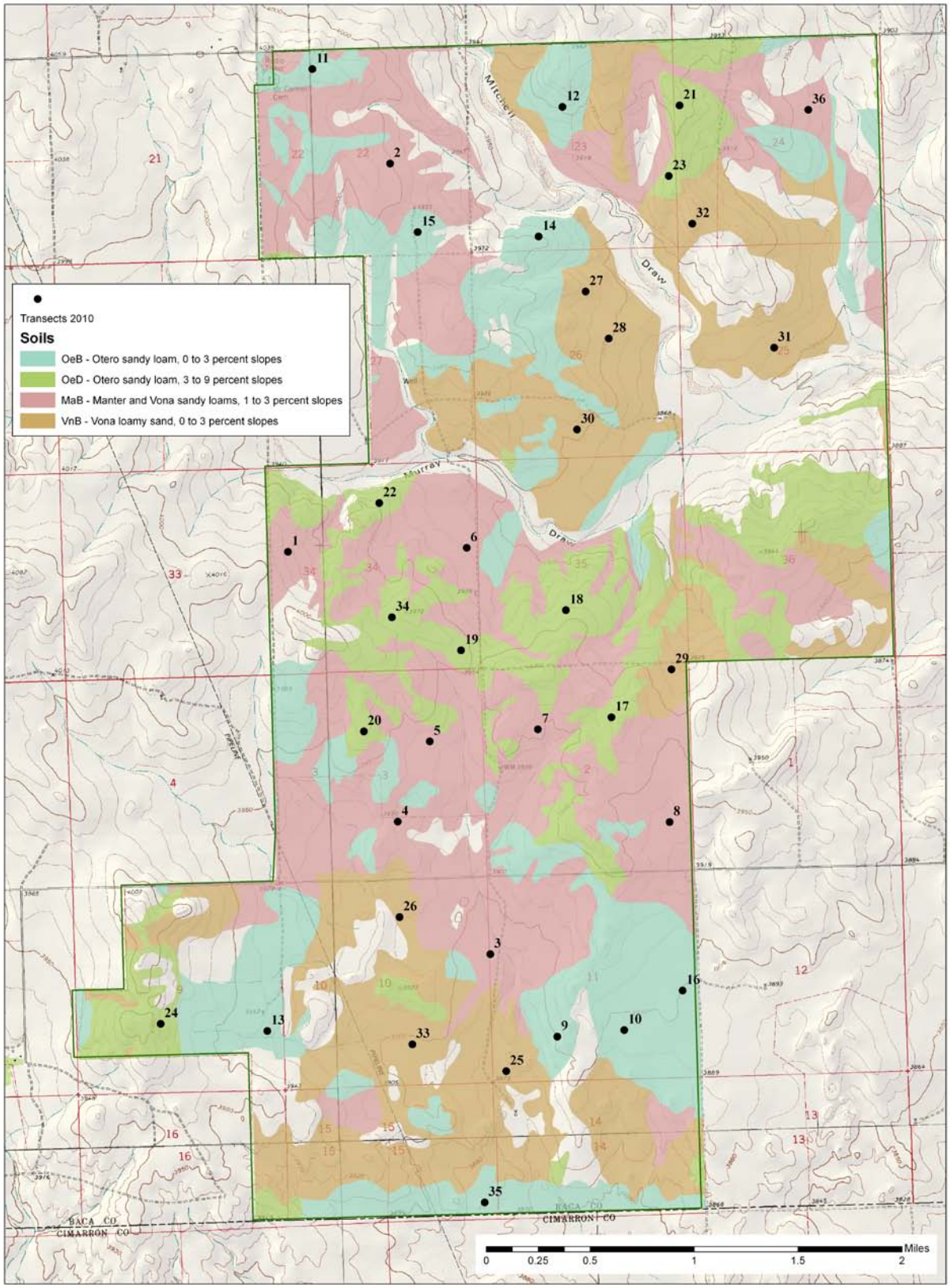
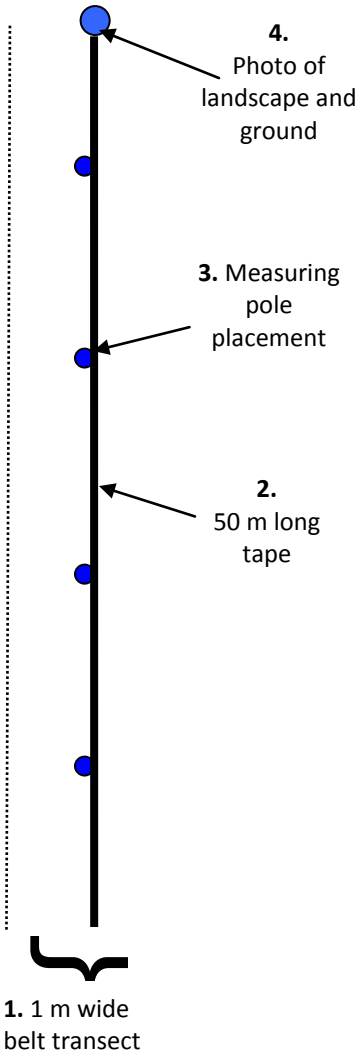


Figure 2. Transect locations and soil types at Mt. Carmel and Lesser Prairie Chicken allotments, Comanche NG.



1. **Shrub density** measured by counting plants in a 1 m wide belt transect; >50% of the sandsage trunk must be within the transect; stems of yucca will be counted.
2. **Vegetation cover** by point- intercept method every ½ meter on 50 m tape.
3. **Height of shrubs, forbs, grasses, and height-density** measured at 15, 25, 35, 45 m mark (always perpendicular to line on right side of line).
4. **Photo** taken from 0 m mark (landscape and microplot).

Figure 3. General layout of a transect. Numbers 1-4 describe the general method for measuring cover, density, and height of vegetation.

Figure 4. Example of landscape photo (top) and microplot photo (bottom) at Transect 27.

Results

Vegetation results by transect for shrub density, cover, and height, and grass and forb cover are shown in Table 2. In 2010, only transects 1 and 29 met all vegetation criteria for ideal nesting or brooding habitat. However, means for all criteria were within desired ranges from Table 1, indicating that the overall condition of the study area meets most criteria for nesting or brooding habitat.

Table 2. Habitat characteristics by transect. Values meeting ideal nesting habitat requirements are in boxes.

Transect	Soil unit	Shrub density (plants/ha)	Shrub cover (%)	Shrub height (cm)	Forb cover (%)	Forb Height (cm)	Grass cover (%)	Grass height (cm)	Height density (cm)	Bare ground (%)
1	MaB	6,200	24	70.5	6	9.5	44	36.2	23.9	22.0
2	MaB	5,400	14	66.0	2	14.0	36	25.4	19.0	30.0
3	MaB	5,200	14	56.5	0	14.6	28	15.9	23.9	42.0
4	MaB	1,200	2	34.9	0	24.8	56	13.3	7.4	40.0
5	MaB	5,400	4	36.2	0	8.9	74	14.0	6.1	18.0
6	MaB	1,200	2	45.7	0	10.8	66	15.9	8.0	26.0
7	MaB	5,000	20	54.6	4	7.6	50	12.7	9.2	18.0
8	MaB	5,200	16	51.4	10	10.8	32	14.0	6.1	26.0
9	OeB	4,800	12	50.2	0	7.6	48	22.9	22.7	36.0
10	OeB	2,800	0	33.7	8	5.7	52	15.9	4.9	30.0
11	OeB	6,800	16	56.5	0	8.3	66	15.2	19.6	18.0
12	OeB	1,800	0	40.0	0	11.4	72	23.5	4.3	20.0
13	OeB	15,800	20	41.9	0	7.0	44	27.3	11.6	30.0
14	OeB	7,000	14	45.7	2	7.0	40	29.2	12.3	26.0
15	OeB	4,200	6	50.8	2	38.1	86	38.1	12.9	4.0
16	OeB	1,600	0	61.0	0	7.0	32	13.3	4.3	38.0
17	OeD	800	0	48.9	0	15.9	78	29.2	11.0	12.0
18	OeD	5,800	22	55.2	6	10.8	42	10.2	5.5	26.0
19	OeD	3,800	18	71.1	0	8.9	46	34.9	19.0	24.0
20	OeD	1,000	2	54.0	0	19.7	80	23.5	6.1	18.0
21	OeD	6,000	24	73.0	0	15.9	40	15.9	14.7	30.0
22	OeD	10,400	20	68.6	4	10.8	50	16.5	7.4	22.0
23	OeD	7,000	10	64.8	0	15.9	60	22.9	9.2	26.0
24	OeD	6,600	16	35.6	12	5.1	56	28.6	12.9	18.0
25	VnB	1,200	0	43.8	0	7.6	64	15.9	6.1	20.0
26	VnB	2,400	16	64.1	2	8.3	40	26.7	6.1	32.0
27	VnB	2,800	6	54.0	0	11.4	52	34.9	12.9	28.0
28	VnB	4,200	6	69.9	0	10.2	64	19.1	15.3	20.0
29	VnB	4,000	8	58.4	6	11.4	48	21.0	10.4	24.0
30	VnB	800	4	44.5	0	8.9	68	57.2	8.0	20.0
31	VnB	5,600	28	96.5	38	10.8	10	26.7	45.9	22.0
32	VnB	4,200	8	53.3	0	7.0	74	21.0	4.9	18.0
33	MaB	1,800	6	31.8	0	6.4	54	21.6	10.4	32.0
34	OeB	9,600	20	65.4	0	8.9	68	44.5	20.2	8.0
35	OeD	3,600	6	43.8	0	7.6	36	48.3	20.2	28.0
36	VnB	1,000	0	72.4	0	9.5	70	25.4	7.4	24.0
Mean		**4,506**	**10.7**	**54.6**	**15.1**	**11.2**	**53.5**	**24.3**	**12.5**	**24.3**
Stdev		3,122	8.4	14.0	9.6	6.2	16.8	10.8	8.3	8.2
CV		0.69	0.79	0.26	0.64	0.55	0.31	0.44	0.66	0.34

The proportion of transects meeting the target conditions is shown in Table 3, and vegetation heights are summarized in Table 4. Results are presented by soil type in Table 5.

Table 3. Proportion of transects meeting habitat goals.

Habitat character	% transects meeting goal	% transects below goal	% transects above goal
Shrub density (2000-7000/ha)	64%	28%	8%
Shrub cover - nesting (5-30+%)	69%	31%	0%
Shrub cover - brooding (>40%)	0%	100%	N/A
Shrub height (>47.5 cm = 18.7in)	67%	33%	N/A
Forb cover - nesting (5-15%)	42%	11%	47%
Forb cover - brooding (15-20%)	28%	53%	19%
Grass cover - nesting (>20%)	97%	3%	N/A
Grass cover - brooding (>40%)	75%	25%	N/A

Table 4. Vegetation height by category. N=144

Height	Mean (stdev)	Range	CV
Height density (Robel, cm)	12.5 (± 8.3)	0 - 73.7	0.66
Residual			
Shrub height (cm)	54.6 (± 14)	12.7 - 132.1	0.26
Grass height (cm)	24.3 (± 10.8)	5.1 - 76.2	0.44
Forb height (cm)	11.2 (± 6.2)	2.5 - 66	0.55
Green			
Shrub height (cm)	47.1 (± 11.1)	12.7 - 106.7	0.24
Grass height (cm)	20.2 (± 9.6)	5.1 - 66	0.48
Forb height (cm)	11.2 (± 6.2)	2.5 - 66	0.55

Table 5. Habitat characteristics by soil type. Mean ± one standard deviation.

Soil Series	Soil unit	Shrub density (plants/ha)	Shrub cover (%)	Shrub height (cm)	Forb cover (%)	Forb Height (cm)
Otero		**5,522 (± 3,772)**	**11.4 (± 8.6)**	**47.1 (± 9.9)**	**13.8 (± 8.3)**	**11.7 (± 7.8)**
	OeB	6,044 (± 4,508)	9.8 (± 8.5)	45.1 (± 9.8)	14.7 (± 8.8)	11.2 (± 10.2)
	OeD	5,000 (± 3,050)	13.1 (± 8.9)	49.1 (± 10.2)	12.9 (± 8.1)	12.3 (± 4.8)
Vona-Manter		**3,489 (± 1,912)**	**9.9 (± 8.3)**	**47 (± 12.5)**	**16.3 (± 10.9)**	**10.7 (± 4.2)**
	VnB	2,911 (± 1,697)	8.4 (± 8.8)	50 (± 12.7)	17.1 (± 12)	9.4 (± 1.6)
	MaB	4,067 (± 2,035)	11.3 (± 8.1)	44.1 (± 12.2)	15.6 (± 10.3)	11.9 (± 5.5)

Soil Series	Soil unit	Grass cover (%)	Grass height (cm)	Height density (cm)	Bare ground (%)
Otero		**55.3 (± 16.3)**	**21.2 (± 9)**	**5 (± 2.5)**	**23 (± 9)**
	OeB	56.4 (± 17.5)	19.4 (± 6)	5.1 (± 2.9)	23.3 (± 11.8)
	OeD	54.2 (± 16)	22.9 (± 11.4)	4.8 (± 2.2)	22.7 (± 5.7)
Vona-Manter		**51.6 (± 17.5)**	**19.3 (± 10.4)**	**5.2 (± 4.2)**	**25.7 (± 7.2)**
	VnB	54.4 (± 20.1)	22.3 (± 13.8)	5.3 (± 5.2)	23.1 (± 4.5)
	MaB	48.7 (± 15.1)	16.3 (± 4.3)	5.2 (± 3)	28.2 (± 8.7)

Figure 5 compares the values measured in 2010 with those documented from the same area by Giesen in 1994. Means for 2010 (diamond shaped points) are generally higher than Giesen (1994) means (round or triangular points) for vegetation density and percent cover, and considerably lower than 1994 levels for percent of bare ground. The ranges of data from the 2010 study are shown as bars, with the quartiles indicated by darker shading for the center quartiles (central 50% of observations), while ranges of Giesen (1994) data area shown as overlaid black lines. With the exception of forb cover, variation is comparable between the two data sets, although means have shifted. Shrub height in 2010 appears most similar to Giesen's observed values for actual nesting sites, while forb height, grass height, and overall height-density are more similar to his observed values for the surrounding habitat (transect).

Vegetation classification

Vegetation cover data collected by the line-intercept method formed the primary analysis matrix. Species cover data were compiled in list format, then imported into PC-Ord (McCune and Mefford, 1999). The analysis data set contained 36 transects and 16 species or species groups (Table 6).

Table 6. Species included in cluster analysis.

	Scientific name	Common name
Shrubs	*Artemisia filifolia*	sandsage
	Gutierrezia sarothrae	broom snakeweed
	Yucca glauca	soapweed yucca
Grasses	*Aristida* spp.	threeawn
	Bothriochloa laguroides	silver beardgrass
	Bouteloua (=Chondrosum) gracilis	blue grama
	Bouteloua curtipendula	sideoats grama
	Buchloe dactyloides	buffalo grass
	Elymus elymoides	squirreltail
	Hesperostipa comata	needle-and-thread
	Sporobolus cryptandrus	sand dropseed
	Vulpia octoflora	sixweeks fescue
	Other grasses (*Bromus tectorum, Chloris virgata, Erioneuron pilosum, Muhlenbergia* spp.)	
Other	Forbs	---
	Opuntia spp.	pricklypear or cholla
	Salsola spp.	Russian thistle

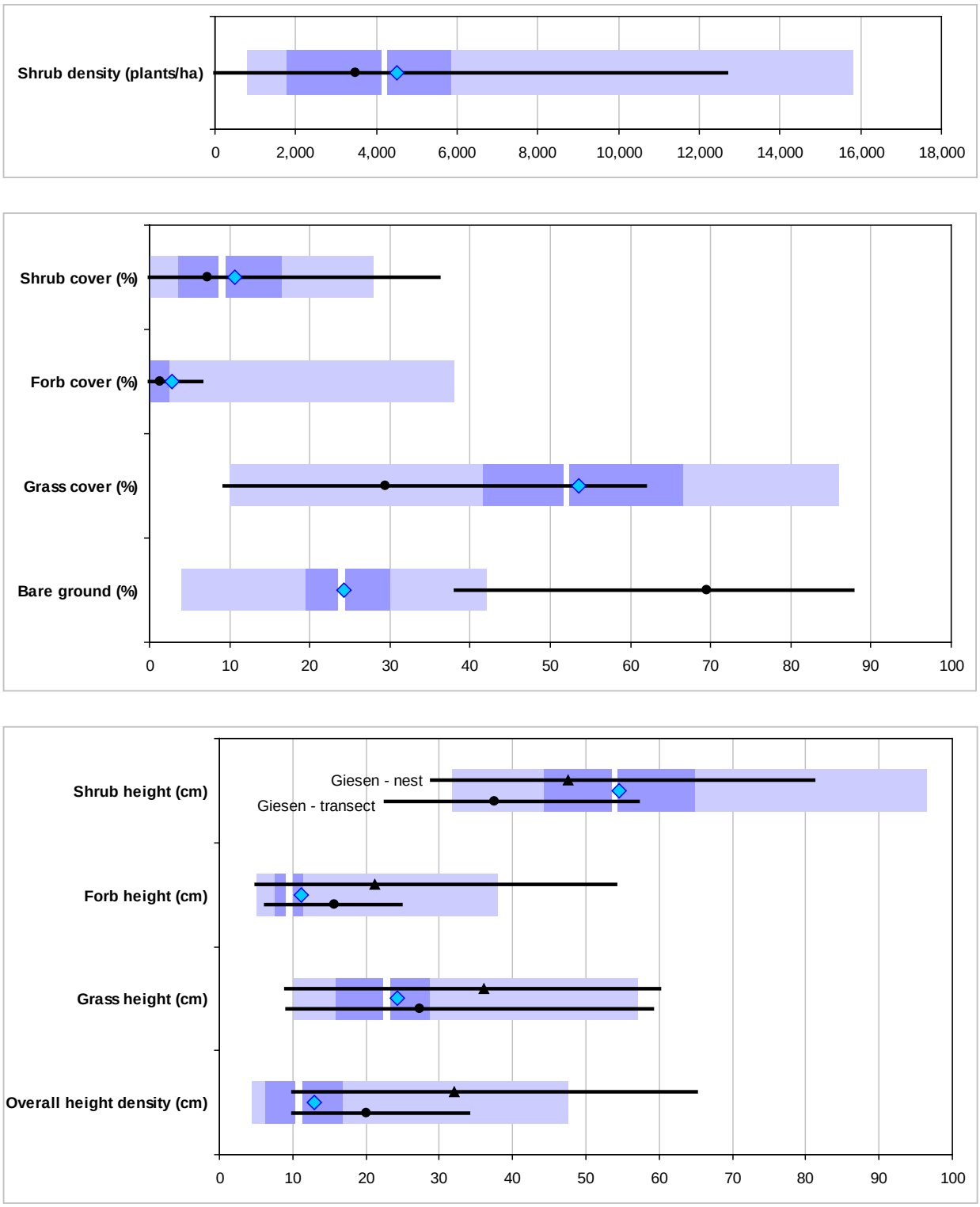


Figure 5. Comparison of 2010 Comanche NG LEPC allotments with values reported from the same area by Giesen (1994). Shaded bars indicate quartiles for 2010 data, with the mean shown as diamond-shaped point. Black points and lines indicate mean and range of values from Giesen.

In order to identify groups defined by shared species within the dataset, we used cluster analysis (Relative Euclidean, Ward's linkage method) as implemented in PC-Ord (McCune and Mefford, 1999). The analysis identified nine primary groups (Figure 6) representing types distinguished by blue grama, sideoats grama, sideoats grama with forbs, buffalo grass, sand dropseed with bare ground/litter, sand dropseed with forbs, needle-and-thread, Russian thistle, and threeawn. There is a tendency for sites in the sideoats grama groups to occur on Otero series soils, and for buffalo grass sites to be confined to Manter-Vona series soils, but the correspondence is not perfect, indicating that either soil mapping is too imprecise to reflect true habitat preferences, or that factors other than soil are influencing the distribution of species on the landscape. The spatial distribution of types is shown in Figure 7, for clarity the nine groups are combined into four higher-level groups (sideoats grama, blue grama, buffalo grass, and sand dropseed/forbs/other grasses). Sites meeting habitat criteria for at least five factors are circled.

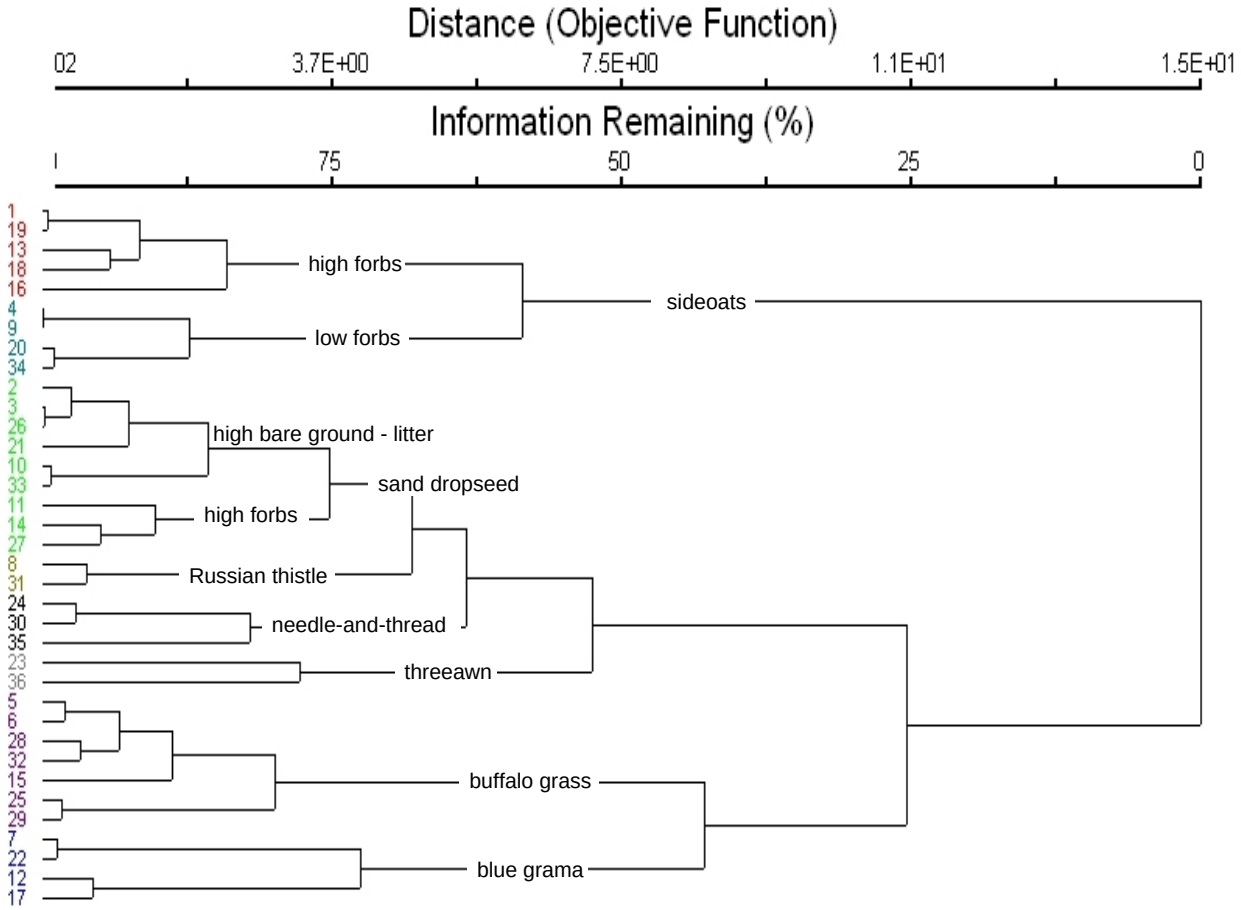


Figure 6. Cluster diagram for vegetation types at Mt. Carmel and Lesser Prairie Chicken allotments, Comanche NG.

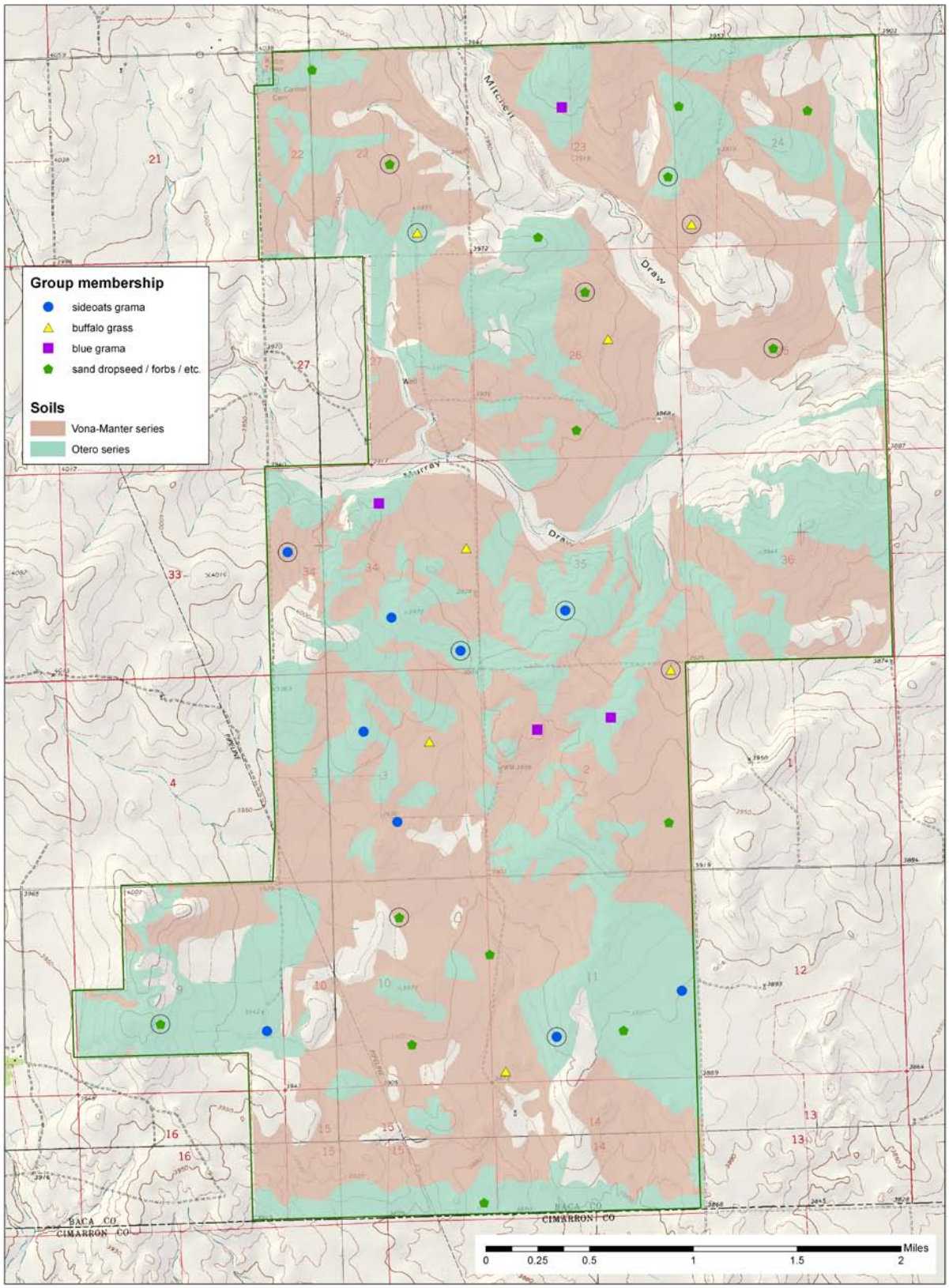


Figure 7. Spatial distribution of vegetation types at Mt. Carmel and Lesser Prairie Chicken allotments, Comanche NG. Sites meeting goals for at least five habitat factors are circled.

Other observations

The following vertebrate species were observed during the project field work.

Common name	Scientific name	Rank	Tracked
Cassin's Sparrow	*Peucaea cassinii*	G5 S4B	Watchlist
Chihuahuan Raven	*Corvus cryptoleucus*	G5 S3S4	No
Common Nighthawk	*Chordeiles minor*	G5 S5	No
Grasshopper Sparrow	*Ammodramus savannarum*	G5 S3S4B	No
Great Blue Heron	*Ardea herodias*	G5 S3b	No
Horned Lark	*Eremophila alpestris*	G5 S5B	No
Killdeer	*Charadrius vociferus*	G5 S5	No
Lark Bunting	*Calamospiza melanocorys*	G5 S4	No
Lark sparrow	*Chondestes grammacus*	G5 S4	No
Loggerhead Shrike	*Lanius ludovicianus*	G4 S3S4B	No
Mallard	*Anas platyrhynchos*	G5 S5	No
Mourning dove	*Zenaida macroura*	G5 S5	No
Northern Bobwhite	*Colinus virginianus*	G5 S4	No
Red-winged Blackbird	*Agelaius phoeniceus*	G5 S5	No
Swainson's Hawk	*Buteo swainsoni*	G5 S5B	No
Western Kingbird	*Tyrannus verticalis*	G5 S5B	No
Western Meadowlark	*Sturnella neglecta*	G5 S5	No
Lesser earless lizard	*Holbrookia maculata*	G5 S5	No
Ornate box turtle	*Terrapene ornata*	G5 S5	No
Texas horned lizard	*Phrynosoma cornutum*	G4G5 S3	Yes
Coachwhip	*Masticophis flagellum*	G5 S5	No
Bull snake	*Pituophis catenifer sayi*	G5 S5	No
Black-tailed jackrabbit	*Lepus californicus*	G5 S5	No
Black-tailed prairie dog	*Cynomys ludovicianus*	G3 S3	Yes
White-tail deer	*Odocoileus virginianus*	G5 S5	No

Discussion

The only noteworthy change in the vegetation of the study area between 1994 and 2010 is an increase in grass cover and a corresponding decrease in the amount of bare ground. Other vegetation characteristics appear to be more-or-less the same as observed in 1994. It is difficult to imagine that LEPC are declining solely due to higher grass cover: it is more likely that factors not measured in these studies, including processes originating outside the boundaries of the study area are responsible for the observed decline in LEPC populations.

Occupied habitat for LEPC is generally described as native vegetation with a substantial mixed-grass component of warm-season species including sand or big bluestem, little bluestem, sand dropseed, sideoats grama, and others (e.g., Bidwell et al. no date, Robb and Schroeder 2005, Fields et al. 2006). Rodgers and Hoffman (2005) note that although much early reseeding in southeastern Colorado used a native warm-season mixture, these were, in fact, largely dominated by sideoats grama. The Mt. Carmel and LPC allotments are largely characterized by sideoats grama, sand dropseed, buffalo grass, and blue grama (Figure 5), and are depauperate in the bluestem species that may be important for LEPC habitat.

The geographic distribution of the LEPC is believed to have declined by over 90% since European settlement. Within this greatly reduced range, population numbers have also suffered dramatic declines, with estimated losses of at least 90% (Davis et al. 2008). Although early records are limited, it is likely that the number of LEPC in Colorado was historically small in comparison with numbers in the rest of the range. Even so, Colorado populations appear to have also suffered ongoing decline. Recent years appear to have been especially hard on LEPC populations in southeastern Colorado. Habitat conditions recovered somewhat from past drought years, however, the area was hit by a series of blizzards in the winter of 2006-2007 that may have had a serious impact on population numbers.

Davis et al. (2008) note that habitat requirements for LEPC are still not completely understood. Moreover, recent review of (Rotenberry and Wiens 2009) of the effectiveness of habitat models in predicting actual species population numbers suggests that it may be most important to concentrate on preserving large tracts of relatively undisturbed shrubland, in hopes of providing a diverse mosaic of natural habitat types that will allow the birds to survive under a variety of shifting environmental factors, rather than focusing on extensive manipulation of local habitat to achieve a particular “optimal” habitat condition.

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Appendix A. Transect coordinates (UTM NAD83, Zone 13) and directions.

Transect	Easting (X)	Northing(Y)	Direction (°)
1	733145	4102665	190
2	733935	4105678	130
3	734713	4099543	360
4	733995	4100572	130
5	734244	4101194	250
6	734530	4102696	300
7	735082	4101289	205
8	736103	4100569	345
9	735233	4098904	270
10	735751	4098954	340
11	733333	4106412	35
12	735272	4106118	60
13	732984	4098948	130
14	735088	4105112	180
15	734150	4105146	130
16	736204	4099262	85
17	735653	4101381	160
18	735299	4102213	355
19	734486	4101901	30
20	733733	4101272	340
21	736180	4106129	145
22	733853	4103044	105
23	736097	4105581	300
24	732157	4099003	115
25	734836	4098636	320
26	735692	4098233	350
27	735453	4104686	225
28	735631	4104320	140
29	736117	4101754	265
30	735386	4103614	10
31	736914	4104250	140
32	736279	4105211	210
33	734110	4098844	350
34	733950	4102158	25
35	733704	4097686	340
36	737178	4106095	250

Appendix B. Data

Density and vegetation height data

Count per transect	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
sandsage density	22	25	26		25	1	9	24	13		34	4	33	11	15	5	1	14
yucca density	6	2		6	2	5	8	2	3			5	19	24	6		3	11
other density (GUSA)	3						8		8	14			27			3		4
ALL HEIGHTS IN INCHES																		
shrub height green																		
15m	24	31	17	6	10	19	16	24	15	21	26	14	6	13	15	26	18	26
25m	34	28	20	17	17	18	24	19	12	5	14	19	22	14	16	22	20	18
35m	20	26	27	12	10	11	20	7	27	11	20	10	18	16	12	15	15	27
45m	20	8	16	13	8	23	12	19	21	12	21	19	12	22	21	24	10	10
shrub height residual																		
15m	28	37	17	12	24	19	20	27	15	22	29	14	6	13	20	28	32	28
25m	37	36	22	18	15	18	27	24	12	5	16	19	25	14	16	22	20	18
35m	22	21	29	12	10	11	20	7	28	12	23	10	20	16	18	15	15	31
45m	24	10	21	13	8	24	19	23	24	14	21	20	15	29	26	31	10	10
grass height green																		
15m	9	9	7	5	5	6	4	6	8	2	9	8	7	11	9	6	4	3
25m	12	3	5	7	2	6	4	5	6	4	3	2	9	7	8	4	17	4
35m	6	5	5	5	5	11	5	4	11	7	2	3	12	6	10	5	8	6
45m	14	9	8	6	7	5	6	6	7	9	10	12	4	7	16	4	8	5
grass height residual																		
15m	9	24	7	5	5	8	3	6	10	2	9	18	12	18	19	8	4	5
25m	22	3	5	3	3	2	4	6	6	4	3	3	8	14	14	4	17	4
35m	6	5	5	7	5	11	7	4	13	7	2	4	19	6	11	5	13	2
45m	20	8	8	6	9	4	6	6	7	12	10	12	4	8	16	4	12	5
forb height green																		
15m	3	12	8	10	4	2	6	6	4	2	6	6	3	4	26	3	9	6
25m	4	3	4	9	2	12	2	5	4	3	2	8	3	3	10	1	3	2
35m	3	5	6	13	2	1	2	2	3	2	2	2	4	2	6	3	5	2
45m	5	2	5	7	6	2	2	4	1	2	3	2	1	2	18	4	8	7
forb height residual																		
15m	3	12	8	10	4	2	6	6	4	2	6	6	3	4	26	3	9	6
25m	4	3	4	9	2	12	2	5	4	3	2	8	3	3	10	1	3	2
35m	3	5	6	13	2	1	2	2	3	2	2	2	4	2	6	3	5	2
45m	5	2	5	7	6	2	2	4	1	2	3	2	1	2	18	4	8	7
Robel obsc.																		
15m	4	18	2	3	4	3	2	1	6	0	22	4	6	8	5	2	1	1
25m	29	4	1	3	3	2	2	5	7	4	4	0	2	5	7	1	9	5
35m	2	3	25	4	1	6	4	4	20	1	2	1	9	1	3	3	4	1
45m	4	6	11	2	2	2	7	0	4	3	4	2	2	6	6	1	4	2

Count per transect	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
sandsage density	17		30	4	4	21	2	11	7		5		23	6	7	16	18	1
yucca density	2	4		48	22	11	1	1	7	21	6	4	5	15	2	21		3
other density (GUSA)		1			9	1	3				9					11		1
ALL HEIGHTS IN INCHES																		
shrub height green																		
15m	21	19	26	17	17	7	17	27	16	42	13	20	25	20	13	33	9	13
25m	26	32	17	21	14	16	17	30	25	19	19	19	30	16	10	9	18	12
35m	28	15	18	37	14	17	16	19	13	20	33	12	30	21	11	33	15	7
45m	15	18	33	18	37	10	15	16	18	19	12	13	30	15	15	23	17	19
shrub height residual																		
15m	24	20	33	17	19	8	17	27	22	31	20	20	30	20	13	33	9	48
25m	33	32	26	26	17	16	19	33	29	19	27	19	47	21	10	8	18	12
35m	35	15	20	37	14	22	16	25	16	34	33	13	39	24	11	35	22	32
45m	20	18	36	28	52	10	17	16	18	26	12	18	36	19	16	27	20	22
grass height green																		
15m	11	13	4	4	6	5	7	7	6	8	4	22	6	3	6	12	24	6
25m	7	10	10	7	10	6	6	9	8	9	7	22	14	3	6	7	10	2
35m	14	7	3	2	8	19	2	6	10	4	5	20	13	11	6	9	24	8
45m	11	4	8	3	8	14	7	13	10	2	7	26	9	7	11	19	18	7
grass height residual																		
15m	7	16	4	4	7	5	7	7	6	13	3	22	6	4	6	14	24	9
25m	6	3	10	12	13	7	6	13	17	11	12	22	14	3	3	8	10	3
35m	20	9	3	2	8	19	2	6	7	4	9	20	13	16	6	18	24	16
45m	22	9	8	8	8	14	10	16	25	2	9	26	9	10	19	30	18	12
forb height green																		
15m	6	3	6	3	1	1	1	1	3	3	4	5	1	1	3	2	3	2
25m	3	17	4	6	15	2	4	2	6	3	6	3	6	2	2	6	3	7
35m	3	8	6	2	4	1	3	7	5	5	2	2	4	5	4	4	5	2
45m	2	3	9	6	5	4	4	3	4	5	6	4	6	3	1	2	1	3
forb height residual																		
15m	6	3	6	3	1	1	1	1	3	3	4	5	1	1	3	2	3	3
25m	3	17	4	6	15	2	4	2	6	3	6	3	6	2	2	6	3	7
35m	3	8	6	2	4	1	3	7	5	5	2	2	4	5	4	4	5	2
45m	2	3	9	6	5	4	4	3	4	5	6	4	6	3	1	2	1	3
Robel obsc.																		
15m	4	4	3	2	2	8	2	1	8	5	8	6	19	2	1	4	8	4
25m	4	2	9	4	2	5	4	4	5	6	4	4	20	1	3	4	18	2
35m	16	2	8	4	3	4	1	2	6	8	1	3	29	3	5	5	5	4
45m	7	2	4	2	8	4	3	3	2	6	4	0	7	2	8	20	2	2

Line intercept data

Transect:

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
ARFR	22	14	14		4		14	16	10		16		12	8	2			12	16		24	4		10		14	2			2	24	4	4	14	6	
GUSA									2				4					6											2							
YUGL	2			2		2	6						4	6	4			4	2	2		16	10	6		2	4	6	6	2	4	4	2	6		
Andhal																																				
Arispp	4	6			2		2			4	16	4	6	8	24	4	8				6		40	4			22	12	4	12	2	10				18
Bocu	28			52	2				44	4	2		20			18	2	16	32	72			4	2	2	2								58		
Bola																							4													28
Buda	2			4	32	32	8				6	30		6	44	2	26	14		4		10			24	8		26	18	4		38				
Cala																																				
Chogra					8		38	2	2		8	28		10			22					38					2		2				4			
Elyely		2								2	2	2									2					2	4	2								
Hordeum																																				
Spocry	8	26	22		22	30	2	14	2	38	16	8	18	16	18	8	20	12	14	4	32	2	12	26	34	22	24	12	24	28	2	20	44	8	4	16
Sticom																								22						20			4		30	
Vuoc	2	2	4		6			16		4	16													2	4	6		10		4	6	6	2	2	2	
Forbs	12	24	16	2	12	8	10	26	6	10	18	8	6	24	8	30	16	10	12	4	6	8	4	4	20	14	18	12	18	8	6	4	8	10	30	8
salsola	4	2					2	10		6								6				2		12		2			6		38					
Oppspp	2						2			2				2	2							2														
bare+litter	22	30	42	40	18	26	18	26	36	30	18	20	30	26	4	38	12	26	24	18	30	22	26	18	20	32	28	20	24	20	22	18	32	8	28	24
other			2			4																						2								8
Direction	190	130	360	130	250	300	205	345	270	340	35	60	130	180	130	85	160	355	30	340	145	105	300	115	320	350	225	140	265	10	140	210	350	25	340	250
Soil type	MaB	MaB	MaB	MaB	MaB	MaB	MaB	MaB	OeB	OeB	OeB	OeB	OeB	OeB	OeB	OeB	OeD	OeD	OeD	OeD	OeD	OeD	OeD	OeD	VnB	VnB	VnB	VnB	VnB	VnB	VnB	VnB	MaB	OeB	OeD	VnB

Plot photographs delivered electronically