PETITION TO LIST THE
Lesser Prairie Chicken (*Tympanuchus pallidicinctus*)
AND THREE DISTINCT POPULATION SEGMENTS UNDER THE U.S. ENDANGERED SPECIES ACT
AND EMERGENCY LISTING PETITION FOR THE SHINNERY OAK PRAIRIE AND SAND SAGE PRAIRIE DISTINCT POPULATION SEGMENTS

Lesser prairie chicken. Photo: Larry Lamsa, courtesy Flickr Creative Commons

Petition Submitted to the U.S. Secretary of Interior
Acting through the U.S. Fish and Wildlife Service
September 8, 2016

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INTRODUCTION

WildEarth Guardians (Guardians), Defenders of Wildlife, and the Center for Biological Diversity (Center) respectfully request that the Secretary of the Interior, acting through the U.S. Fish and Wildlife Service (Service) list the lesser prairie chicken (*Tympanuchus pallidicinctus*) as "endangered" under the U.S. Endangered Species Act (ESA) (16 U.S.C. §§ 1531-1544). We also petition the Service to list three Distinct Population Segments (DPS) of lesser prairie chicken: the Shinnery Oak Prairie DPS, the Sand Sagebrush Prairie DPS, and the Mixed-Grass Prairie and Shortgrass Prairie/CRP Mosaic DPS. For two of these DPSs — the Shinnery Oak Prairie and Sand Sagebrush Prairie DPSs — we request emergency listing as "endangered" at the soonest possible time. WildEarth Guardians also requests that the Service concurrently designate critical habitat for this species and these DPSs.

ENDANGERED SPECIES ACT AND IMPLEMENTING REGULATIONS

The ESA was enacted in 1973 "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, [and] to provide a program for the conservation of such endangered species and threatened species." 16 U.S.C. § 1531(b). The protections of the ESA only apply to species that have been listed as endangered or threatened according to the provisions of the statute. The ESA delegates authority to determine whether a species should be listed as endangered or threatened to the Secretary of Interior, who has in turn delegated authority to the Director of the U.S. Fish and Wildlife Service. As defined in the ESA, an "endangered" species is one that is "in danger of extinction throughout all or a significant portion of its range." 16 U.S.C. § 1532(6); *see also* 16 U.S.C. § 533(a)(1). A "threatened species" is one that "is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." 16 U.S.C. § 1532(20). The Service must evaluate whether a species is threatened or endangered as a result of any of the five listing factors set forth in 16 U.S.C. § 1533(a)(1):

> A. The present or threatened destruction, modification, or curtailment of its habitat or range;
> B. Overutilization for commercial, recreational, scientific, or educational purposes;
> C. Disease or predation;
> D. The inadequacy of existing regulatory mechanisms; or
> E. Other natural or manmade factors affecting its continued existence.

A taxon need only meet one of the listing criteria outlined in the ESA to qualify for federal listing. 50 C.F.R. § 424.11. The Service has the authority to promulgate an emergency listing rule for any species when an emergency exists that poses a significant risk to the species. 16 U.S.C. §1533(b)(7). The dire risk of extinction for the Shinnery Oak Prairie and Sand Sage Prairie distinct population segments, together with their recent population instability, constitute such an emergency.

The Service is required to make these listing determinations "solely on the basis of the best scientific and commercial data available to [it] after conducting a review of the status of the species and after taking into account" existing efforts to protect the species without reference to the possible economic or other impacts of such a determination. 16 U.S.C. § 1533(b)(1)(A); 50 C.F.R. § 424.11(b). "The obvious purpose of [this requirement] is to ensure that the ESA not be implemented haphazardly, on the basis of speculation or surmise." *Bennett v. Spear*, 117 S.Ct. 1154, 1168 (1997). "Reliance upon the best available scientific data, as opposed to requiring absolute scientific certainty, 'is in keeping with congressional intent' that an agency 'take preventive measures' *before* a species is 'conclusively' headed for extinction." *Ctr. for Biological Diversity v. Lohn*, 296 F.Supp.2d 1223, 1236 (W.D.Wash.2003) (emphasis in original).

In making a listing determination, the Secretary must give consideration to species which have been "identified as in danger of extinction, or likely to become so within the foreseeable future, by any State agency or by any agency of a foreign nation that is responsible for the conservation of fish or wildlife or plants." 16 U.S.C. § 1533(b)(1)(B)(ii). *See also* 50 C.F.R. § 424.11(e) (stating that the fact that a species has been identified by any State agency as being in danger of extinction may constitute evidence that the species is endangered or threatened). Listing may be done at the initiative of the Secretary or in response to a petition. 16 U.S.C. § 1533(b)(3)(A).

After receiving a petition to list a species, the Secretary is required to determine "whether the petition presents substantial scientific or commercial information indicating that the petitioned action may be warranted." 16 U.S.C. § 1533(b)(3)(A). Such a finding is termed a "90-day finding." A "positive" 90-day finding leads to a status review and a determination whether the species will be listed, to be completed within twelve months. 16 U.S.C. §1533(b)(3)(B). A "negative" initial finding ends the listing process, and the ESA authorizes judicial review of such a finding. 16 U.S.C. § 1533(b)(3)(C)(ii). The applicable regulations define "substantial information," for purposes of consideration of petitions, as "that amount of information that would lead a reasonable person to believe that the measure proposed in the petition may be warranted." 50 C.F.R. § 424.14(b)(1).

The regulations further specify four factors to guide the Service's consideration on whether a particular listing petition provides "substantial" information:

i. Clearly indicates the administrative measure recommended and gives the scientific and any common name of the species involved;
ii. Contains detailed narrative justification for the recommended measure; describing, based on available information, past and present numbers and distribution of the species involved and any threats faced by the species;
iii. Provides information regarding the status of the species over all or significant portion of its range; and
iv. Is accompanied by appropriate supporting documentation in the form of bibliographic references, reprints of pertinent publications, copies of reports or letters from authorities, and maps. 50 C.F.R. § 424.14(b)(2)(i)-(iv).

Both the language of the regulation itself (by setting the "reasonable person" standard for substantial information) and the relevant case law underscore the point that the ESA does not require "conclusive evidence of a high probability of species extinction" in order to support a positive 90-day finding. *Ctr. for Biological Diversity v. Morgenweck*, 351 F.Supp.2d 1137, 1140. See also *Moden. U.S. Fish & Wildlife Serv.*, 281 F.Supp.2d 1193, 1203 (D.Or. 2003) (holding that the substantial information standard is defined in "non-stringent terms"). Rather, the courts have held that the ESA contemplates a "lesser standard by which a petitioner must simply show that the substantial information in the Petition demonstrates that listing of the species may be warranted" (emphasis added). Morgenweck, 351 F.Supp.2d at 1141 (quoting 16 U.S.C. § 1533(b)(3)(A)). See also *Ctr. for Biological Diversity v. Kempthorne*, No. C 06-04186 WHA, 2007 WL 163244, at *3 (holding that in issuing negative 90-day findings for two species of salamander, the Service "once again" erroneously applied "a more stringent standard" than that of the reasonable person).

CLASSIFICATION AND NOMENCLATURE

Common Name. *Tympanuchus pallidicinctus* is commonly known as the lesser prairie chicken or lesser prairie-chicken. This species was initially known as lesser prairie hen, which was changed to lesser prairie chicken in 1910 (Haukos and Boal 2016: 3). In this petition we refer to the species by its scientific name or as "lesser prairie chicken."

Taxonomy. The petitioned species is *Tympanuchus pallidicinctus* (Table 1). In 1758, Carl Linnaeus first described a new grouse species from the New World, *Tetrao cupido*; in 1842 Glöger reviewed this species and asserted that a generic distinction from *Tetrao* was warranted, proposing the genus *Tympanuchus* for the New World species (Sharpe 1968: 11). Baird and Ridgway (1873: 199) initially classified the greater and lesser prairie chicken as the same species, and the lesser prairie chicken as a variant of that species (*Cupidonia cupido* var. *pallidicincta*). Ridgway (1885) subsequently amended his classification, primarily on the basis of plumage differences, to list the lesser prairie chicken as a distinct species (*Tympanuchus pallidicinctus*). Ellsworth et al. (1994: 668) pointed to significant behavioral and morphometric differences in addition to genetic distinctness, each of which supports separate species status for *T. pallidicinctus*. It is recognized as a distinct species by the American Ornithologists' Union (1998); the first AOU Checklist recognition as a separate species was in 1886 (Haukos and Boal 2016: 3).

Historically, some scientists have lumped the greater prairie chicken, heath hen, Attwater's prairie chicken, and lesser prairie chicken into one species known as the 'pinnated grouse,' in contrast to the sharp-tailed grouse (*Tympanuchus phasianellus,* later *Tymapnuchus phasianellus*) (Johnsgard 2002: 32). Bent (1932: 280) described the lesser prairie chicken as *Tympanuchus pallidicinctus*. Short (1967: 26) subsequently argued that both the lesser and Attwater's prairie chickens were subspecies of greater prairie chicken (*Tympanuchus cupido*) rather than species of their own, and also argued that the sharp-tailed grouse should be reclassified into the genus *Tympanuchus* on the basis of skeletal similarities and interbreeding with greater prairie chickens. But Jones (1964: 67, 70, 72)

Table 1. Taxonomy of *Tymapnuchus pallidicinctus*

Kingdom	*Animalia*—animals
Phylum	*Craniata*—chordates
Subphylum	*Vertebrata*—vertebrates
Class	*Aves*—birds
Order	*Galliformes*—grouse, quail, and allies
Family	Phasianidae, Subfamily *Tetraoninae*—forest, prairie, and tundra grouse
Genus	*Tympanuchus*—prairie chickens
Species	*Tymapnuchus pallidicinctus* (Ridgway, 1885)—lesser prairie chicken
DPSs	Shinnery Oak Prairie DPS Sand Sagebrush Prairie DPS Mixed-Grass Prairie and Shortgrass Prairie/CRP Mosaic DPS

noted significant behavioral differences (including habitat use), contrasting coloration, and significantly different vocalizations that mark the greater and lesser prairie chickens as distinct species, underscoring the validity of the separate species classification for the lesser prairie chicken.

Short (1967: 29) argued for a North American origin for all grouse genera. Lucchini et al. (2001: 149) examined the mitochondrial DNA of grouse and ptarmigans and confirmed a North American origin for all grouse and ptarmigan genera except *Tetrao*, which encompasses the black grouse and capercaillie. The lesser prairie chicken, along with other North American prairie grouse, appears to have evolved in North America (Aldrich 1963: 529). The prairie chickens, or pinnated grouse (*Tympanuchus* spp.), evolved from the woodland grouse species of the genus *Bonasa* and diverged into species following the retreat of Pleistocene ice sheets (Lucchini et al. 2001: 160). Hubbard (1974: 186) found that geographically isolated refugia for arid grasslands existed during Pleistocene glaciation (specifically the Wisconsin glacial period), and proposed this geographic isolation as a possible driver for speciation among species and subspecies of the *Tympanuchus* genus. However, Ellsworth et al. (1994: 667) found limited genetic support for the hypothesis that the three distinct groups of prairie chickens differentiated from a common ancestor while occupying three disjunct refugia during a period of Pleistocene glaciation, instead positing that most genetic differences arose later. Johnson (2008: 170) determined that speciation likely occurred for the lesser prairie chicken approximately 37,000 to 68,000 years before present, based on mitochondrial DNA.

While they are now recognized as two distinct species, the greater prairie chicken and lesser prairie chicken hybridize where they are sympatric at the margins of their ranges, are not genetically that dissimilar, and likely diverged relatively recently in evolutionary history (Dahlgren et al. 2016: 265).

Species Description

Physical appearance and field identification. Adult lesser prairie chickens range from 15 to 16 inches in length, in contrast to the 16- to 18-inch lengths of greater prairie chickens (Bidwell and Peoples 1991: 9004.1). Haukos (1988) found a significant difference between the sexes in weight during courtship season, with males averaging 810 grams (g) and females weighing 737 g. Wolfe et al. (2007: 100) found an average weight of male lesser prairie chickens of 778 g in April, but due to the rigors of mating season, average male weights decreased to 691 g in May.

In general, the plumage is made up of alternating bars of dark brown and buff-white, giving a grayish-brown appearance (Haukos and Boal 2016). Elongated feathers called "pinnae" are present on the back of the neck, and erected by males during courtship displays (Bidwell and Peoples 1991: 9004.1). Sexual dimorphism in lesser prairie chickens is considered slight (Sharpe 1968). The tailfeathers of males are almost uniformly black with under-tail covert feathers of black with a single round spot of white, while the tailfeathers of hens tend to be partially or entirely barred (Copelin 1963). Legs are feathered (Ligon 1961). Eye combs ranging from orange-yellow (Bidwell and Peoples 1991: 9004.2) to brilliant yellow (Copelin 1963) are erected above the eye by males during the courtship dance. Chicks have downy, mottled plumage (Bent 1932: 282), and are born with bills and legs of a warm orange color (Sutton 1968).

The lesser prairie chicken is smaller than the greater prairie chicken, with finer barring on the breast feathers and fine barring on the back feathers (in contrast to more uniform brown back feathers for the greater)(Copelin 1963). The back feathers of the lesser prairie chicken have a single brown bar enclosed between two black bars, in contrast to the greater prairie chicken, which has back feathers with a single, thick black bar (Copelin 1963), however this characteristic is not always distinguishable between the two species (Hagen and Giesen 2005). Inflatable neck sacs used by males for breeding vocalizations are variously described as having a rosy hue intermediate between the sharp-tailed grouse and the greater prairie chicken (Copelin 1963), orange-red or pale red neck sacs instead of the golden-yellow neck sacs possessed by greater prairie chickens (Applegate and Riley 1998: 13), or pale red neck sacs (Giesen 1998). Sutton (1977) described the neck sacs as "tan," but based on the color plate accompanying this article there is a distinct possibility that Sutton was color-blind. Overall, the two species are sufficiently similar that they can be difficult to tell apart (Giesen 1998).

Qualifications for Listing Three Distinct Population Segments

Lesser prairie chicken range is divided into four ecoregions: Shinnery Oak Prairie in New Mexico and the western Texas panhandle; Sand Sage Prairie in southeast Colorado and southwestern Kansas; Mixed-Grass Prairie in south-central Kansas, west-central Oklahoma and the northeastern Texas panhandle; and Shortgrass/CRP Reserve in west-central and northwestern Kansas (*see, e.g.,* McDonald et al. 2016: 1, and Figure 2). Hagen (2003: 185) found that in general, the genetic structure of the lesser prairie chicken population as a whole appears to follow general habitat types: sand sagebrush prairie of Colorado and western Kansas, mixed-shrub of Kansas and Oklahoma, mixed-grass prairie of northern Kansas, and sand shinnery oak of New Mexico.

Oyler-McCance et al. (2016: unnumbered 9) found little gene flow between the four ecoregions, and stated that for lesser prairie chickens, "ecoregions represent relatively discrete populations." These researchers stated, "The strong genetic patterns associated with ecoregions may be a result of the environmental variation across its geographic range" (*id.*: unnumbered 11). Thus, genetic data supports dividing lesser prairie chickens into four Distinct Population Segments, one for each ecoregional population, based on genetic data. Cushman et al. (2010: 25) argued that the lesser prairie chicken "is predicted to exist in three distinct and largely mutually-isolated metapopulations." Given the contradictory evidence regarding whether lesser prairie chickens are most properly divided into three discrete populations or four, the best available science, taken together, establishes distinctness and supports listing the species in at least three DPSs. Furthermore, Oyler-McCance et al. (2016: unnumbered 9) pointed out that for lesser prairie chickens, niche conservatism, in which ecological traits are retained across time, highlights the species' adaptations to specific environmental conditions and ecological niches, underscores the significance of each of the proposed Distinct Population Segments outlined below.

The Shinnery Oak Prairie and Sand Sage Prairie DPSs are isolated, distinct, and very small and imperiled, and therefore we petition for their emergency "endangered species" listing. The third DPS, covering two of the four ecoregions (Mixed-Grass Prairie and Shortgrass/CRP Reserve) is not petitioned for emergency listing but is petitioned for listing as "endangered." *See* Figure 1.

Shinnery Oak Prairie DPS. The Shinnery Oak Prairie population of lesser prairie chickens occupies remnant habitats on the Llano Estacado of Texas and New Mexico (Haukos 2011: 109). In New Mexico, 59-63% of the historically occupied lesser prairie chicken habitat is privately owned, while 20-21% is managed by the BLM and 17-19% is under state management (Bailey and Williams 2000: 163, New Mexico LPCSDL Working Group 2005: 16). However, New Mexico's state land purchases were "insufficient to curtail further population declines, which require public-private partnerships to increase the quantity and quality of Lesser Prairie-Chicken habitat across the ecoregion" (McDaniel and Williamson 2016: 243). In Texas, the vast majority of shinnery oak habitat is privately owned, and supports agricultural use and fossil fuel development (Haukos 2011: 110). Johnson et al. (2006: 3) found that 17% of their study area, encompassing a substantial portion of the New Mexico habitats, had been converted from native grasslands and shrublands to other cover types.

Lesser prairie chicken habitat in east-central New Mexico has been more or less continuously occupied by these birds throughout recorded history, while the areas in southeastern New Mexico may be marginal habitat occupied only during climactically favorable years, and the last record of lesser prairie chickens in the formerly occupied range in northeastern New Mexico occurred in 1993 (Massey 2001: 7). According to Sands (1968: 454), "A small remnant possibly exists in eastern Harding County

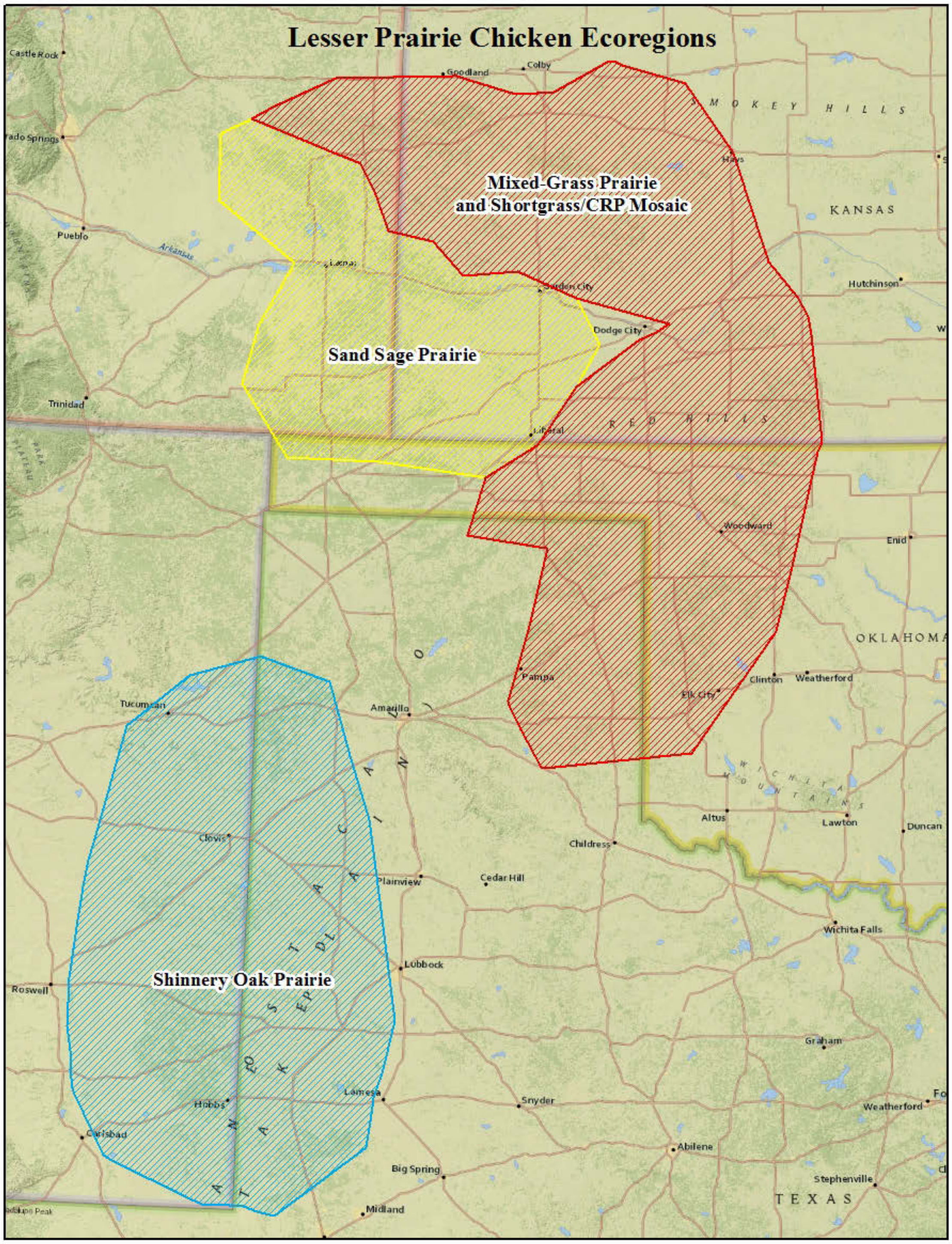

Figure 1. Proposed lesser prairie chicken Distinct Population Segments.

[northeastern New Mexico] although recent observations are lacking."

The sand dunes region, a subset of the Shinnery Oak Prairie, once contained many perched aquifers (aquifers that occur above the regional water table) that supported springs, but these springs dried up with the dewatering of the Oglalla Aquifer for irrigation (Haukos 2011: 105). These springs represent water sources that existed under natural conditions but are now unavailable to lesser prairie chickens and other native wildlife as water sources during drought conditions. Prairie chicken populations in Texas and New Mexico experience 7°C warmer temperatures and 7% less relative humidity on average than their conspecifics in Kansas, and thus are particularly vulnerable to climactic shifts projected in the context of the changing global climate (Grisham et al. 2013: 7)(*see* "Factor E: Climate change," *below*).

Discreteness. This population is discrete because it occupies the Llano Estacado ecosystem, which is unique in having strong components of shinnery oak (*Quercus havardi*) and is isolated by distance from other lesser prairie chicken populations. *See* Figure 3. As recently as the 1960s, small pockets of isolated occupied habitat occurred in the Texas panhandle between the Shinnery Oak and Sand Sage populations of today (Copelin 1963: 9, *and see* Litton 1978: unnumbered 7, and Figure 4); these intermediate populations are now extirpated. Vast areas of habitat in the center of the lesser prairie chicken's range — including much of the Texas panhandle that once provided these stepping-stone populations — have been lost due to conversion to cropland and are no longer suitable for the species (Hagen et al. 2010: 30, *and see* Figure 1). Recognizing the great distance between the Shinnery Oak Prairie population and other lesser prairie chicken core habitats, Cushman et al. (2010: 25) stated, "The extensively long corridor linking the southern core complex to the northern populations is probably too long to be mitigated through conservation actions." Thus, this population is isolated from other populations of conspecifics by a distance too far to be bridged by most dispersal movements.

A number of genetic studies have compared the lesser prairie chicken population of New Mexico to the nearest neighbor population in Oklahoma, and each of these studies has documented significant genetic differences between these regions that suggest substantial if not complete isolation by distance (Van den Bussche et al. 2003: 680, Hagen 2003: 185, Robb and Schroeder 2005, Hagen et al. 2010: 33, Pruett et al. 2011: 1212, Oyler-McCance et al. 2016: unnumbered 11). Johnson (2008: 170) examined mitochondrial DNA and estimated that the New Mexico population diverged from the Oklahoma population genetically about 8,000 years ago. These studies establish that the discreteness of this population has been maintained over long periods of time, perhaps even before agricultural crop conversion eliminated the 'stepping stone' populations in the central portion of the Texas panhandle.

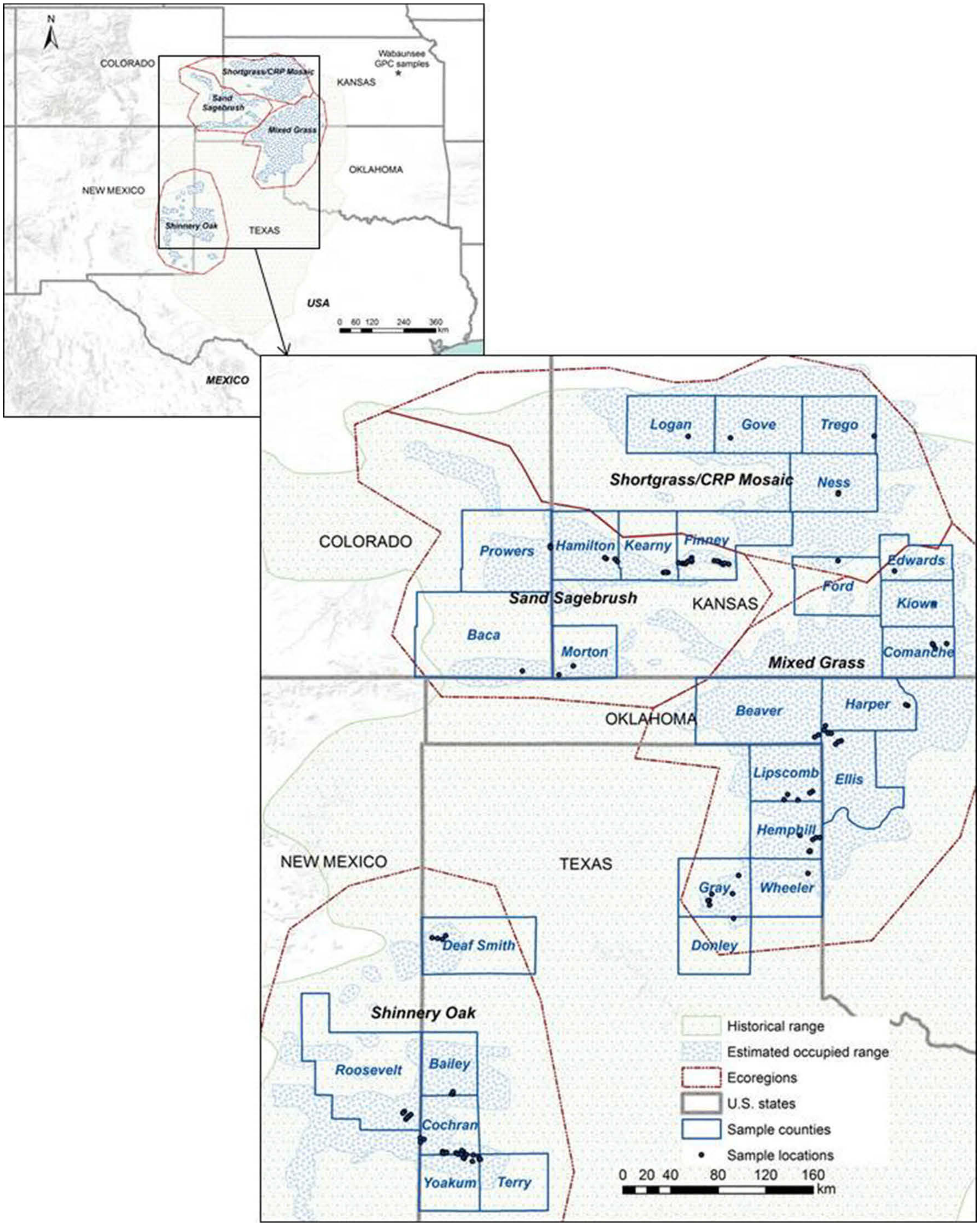

Figure 2. Map of lesser prairie chicken range with ecotregional populations delineated, and showing genetics sampling points, reproduced from Oyler-McCance et al. (2016: unnumbered 3).

Hagen et al. (2010: 34) hypothesized that the New Mexico population of lesser prairie chicken may have become isolated from the rest of the species with the retreat of continental glaciers at the end of the Pleistocene Epoch. The New Mexico population also shows significant isolation by distance from remaining conspecifics (Hagen et al. 2010: 33). Hagen et al. (2010: 34) concluded,

> The population in New Mexico was significantly different from all others, lacking of gene flow between Oklahoma, Kansas and Colorado (average $\Phi_{ST} = 0.080 \pm 0.007$). Moreover, in New Mexico haplotype diversity was lower than in all other populations sampled, and three of nine haplotypes found there were unique, further supporting the idea that this population is isolated with the potential risk of inbreeding (Bouzat and Johnson 2004).

According to Oyler-McCance et al. (2016: unnumbered 13), "the strong differentiation observed with the Lesser Prairie-Chicken population in the Shinnery Oak Prairie ecoregion in eastern New Mexico is most likely the result of geographic isolation because of the large distance that exists with the nearest population to the northeast." Hagen et al. (2010: 35) concluded, "The New Mexico population… is isolated and its genetic diversity is lower than that of all other populations." Oyler-McCance et al. (2016: unnumbered 14), by contrast, did not find a significant difference in genetic diversity between ecoregions, but cautioned the following:

> Effective population sizes were similar for all ecoregions and had overlapping confidence intervals. This suggests that no population has experienced a steep enough decline relative to other populations to influence levels of genetic diversity differently between ecoregions. The relatively low N_e values, however, may suggest that significant losses of genetic diversity are on the horizon, especially if long-term population declines continue.

The population in Deaf Smith County, Texas was found to have significantly lower genetic diversity than all other populations in this study, however.

While Garton et al. (2016: 71) included modest estimates of dispersal among ecoregions, giving the Sand Sage Prairie and Mixed Grass Prairie ecoregional populations some potential for a "rescue effect" via dispersing individuals from other ecoregions and thereby increasing their probability of persistence, this was not the case for the Shinnery Oak Prairie population, which is completely isolated. Van den Bussche et al. (2003: 678, 681) found only four mitochondrial alleles in common between lesser prairie chickens in Oklahoma and those in the New Mexico population of lesser prairie chickens, suggesting that long-distance movement from the Oklahoma population has occurred rarely over the existence of these populations.

Significance. The Shinnery Oak Prairie population occurs in an ecological setting unusual or unique for the taxon. Precipitation in sand shinnery oak habitat is half that of the northern edge of the species range (Grisham et al. 2016b: 317), an extreme environment for ground-nesting birds (Grisham et al. 2013, entire, Grisham et al. 2014: 858). Fire played a lesser role in shinnery oak prairie than in other Southern Plains grasslands, due

Figure 3. Original extent of the Llano Estacado ecosystem (reproduced from Morris 1997).

to the longer period it takes to accumulate a fuel load sufficient to carry fire across patchy vegetation on sandy soils (Haukos 2011: 106). Lesser prairie chickens in this area are closely tied to shinnery oak for food and cover. Adaptations to these unique conditions makes this population significant. Lesser prairie chickens in the sand shinnery oak ecoregion invest more in survival and less in reproduction than do lesser prairie chickens in more northerly regions (Patten et al. 2005b: 244, Grisham et al. 2014: 863). Sand shinnery oak birds have higher survival rates but smaller clutch sizes and lesser propensity to re-nest after nest failure (Grisham et al. 2016b: 325). There are also significant genetic differences between this population and other prairie chicken populations. Because of its isolation, if this population is lost there is no evidence that the area would be recolonized, leaving a significant gap in the range of the taxon.

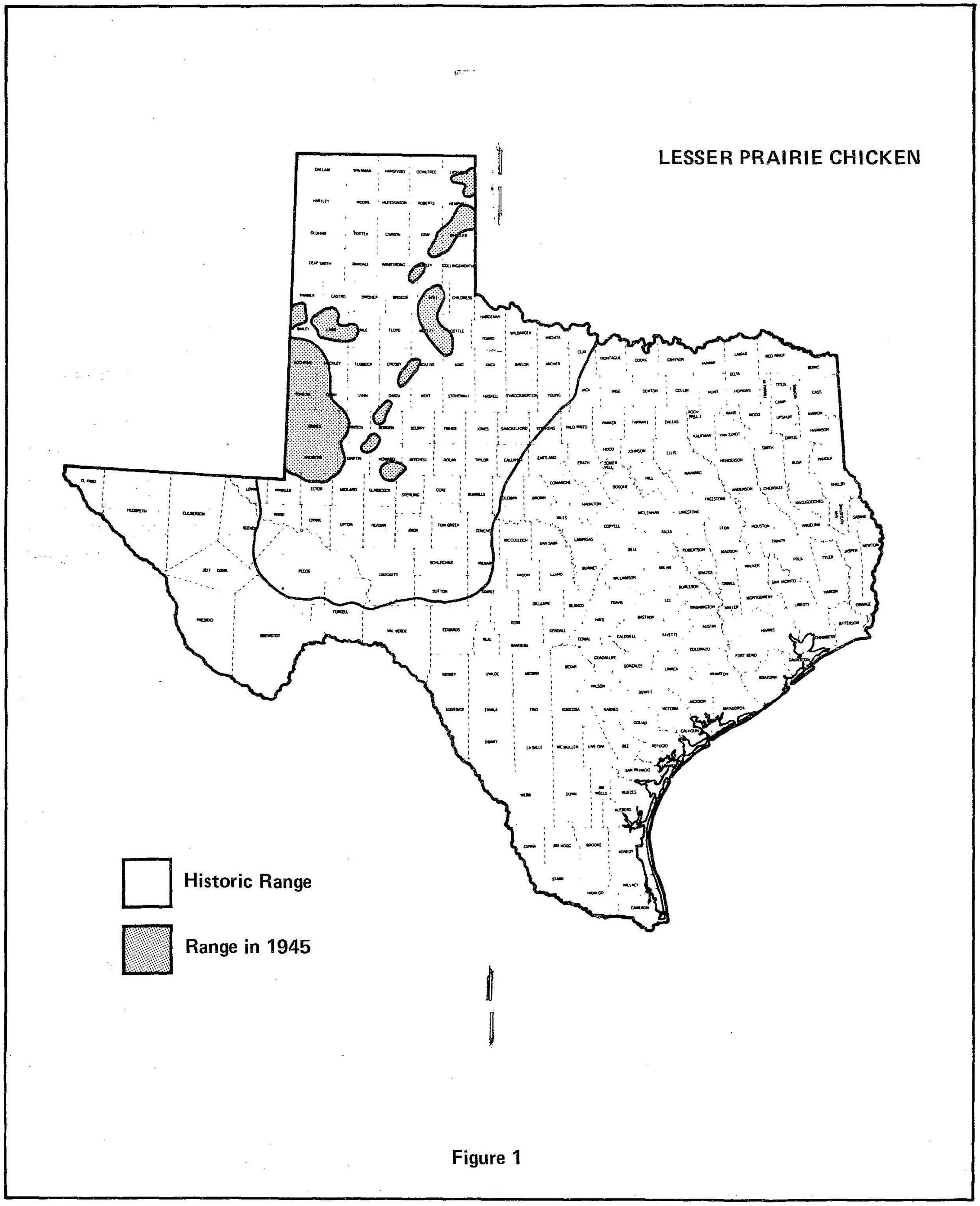

Figure 4. Range of lesser prairie chicken in Texas, circa 1945, showing existence of intermediate populations between Shinnery Oak Prairie and Sand Sage Prairie areas (reproduced from Litton 1978: unnumbered 7).

Petition for emergency listing. Emergency listing for this proposed DPS is warranted due to its dire population trends, with the boom and bust fluctuation of population numbers becoming perilously close to zero during the bust years. Davis (2005: 10) estimated the New Mexico population to total 9,600 birds at the time of his report. Garton et al. (2016: 65) projected that the Shinnery Oak Prairie population peaked at 11,000 birds in 1983 and remained relatively high through 1988, then dropped to 1,100 birds by 1997; the next population peak was estimated at 9,000 birds in 2006 (very close to the Davis 2005 estimate) before dropping to 2,900 birds in 2012. McDonald et al. (2016: 13), reported that this population hit bottom with an estimated 896 birds in 2015, and the most recent estimates place the population at 3,255 birds. This population size remains considerably less than the 5,000 individuals needed to provide a minimum viable population for grouse species (Aldridge and Brigham 2003: 30, Traill et al. 2010: 30). The occupied range of this population has shrunk considerably during historic times. *See, e.g.,* Figures 5 and 6.

Patten et al. (2005b: 246, Figure 6) modeled population persistence for the New Mexico population and found only a 5.5% probability of the population dropping below 1,000 females in 30 years. According to the projections of Garton et al. (2016: 66), the Shinnery Oak population was estimated to have a 2.3% chance of dropping below N_e=50 within 30 years, and a 19% likelihood of dropping below an effective population of 500 birds over the same timeframe. The 100-year extinction probabilities were estimated at a 38% likelihood of dropping below both the 50 and 500-bird effective population thresholds (*id*.), which places the species into an extinction spiral. Interestingly, the total population estimate for 2015 was 817 total birds of both sexes, and the effective population size would be subtsantially lower. This 817-bird figure is lower than the 852-male lek count threshold corresponding to N_e=500 used by Garton et al. (2016: 60), indicating that this ecoregional population has already dipped below the N_e=500 population viability threshold, projected estimates of the unlikelihood of this occurrence notwithstanding. Threats to this population are discussed in detail in the section describing the five listing factors, below.

Sand Sage Prairie DPS. The Sand Sage Prairie population of lesser prairie chickens occupies southeastern Colorado, the Oklahoma panhandle, and portions of west-central Kansas, lands which are dominated by sand sagebrush grasslands. *See* Figure 1. Sands (1968: 454), asserted that lesser prairie chickens were first officially documented in Colorado in 1959, although they were believed to be endemic to the southeastern corner of the state. However, Sharpe (1968) found records of the species in Colorado as far back as 1906, and Lincoln (1918: 236) collected a Colorado specimen in 1914, stating, “they were found to be fairly common in the sandhill country immediately to the south of the Arkansas River in the vicinity of Holly, Prowers County, where specimens were obtained.” The Sand Sage Prairie population once supported the highest densities of lesser prairie chickens in the range, but by 2014 was down to fewer than 500 birds across almost 4 million acres (Haukos et al. 2016b: 281). Berg (1994) described this plant association as sand sagebrush/mixed prairie, found on deep sandy soils on hilly landscapes, and noted that bluestems and switchgrass were abundant under light grazing, shifting to blue grama and sand dropseed under heavy grazing. Unlike many sagebrush species, sand sagebrush re-sprouts after fire, and prescribed fire results in only 10%

mortality for this shrub species (Vermeire et al. 2001). A component of shinnery oak

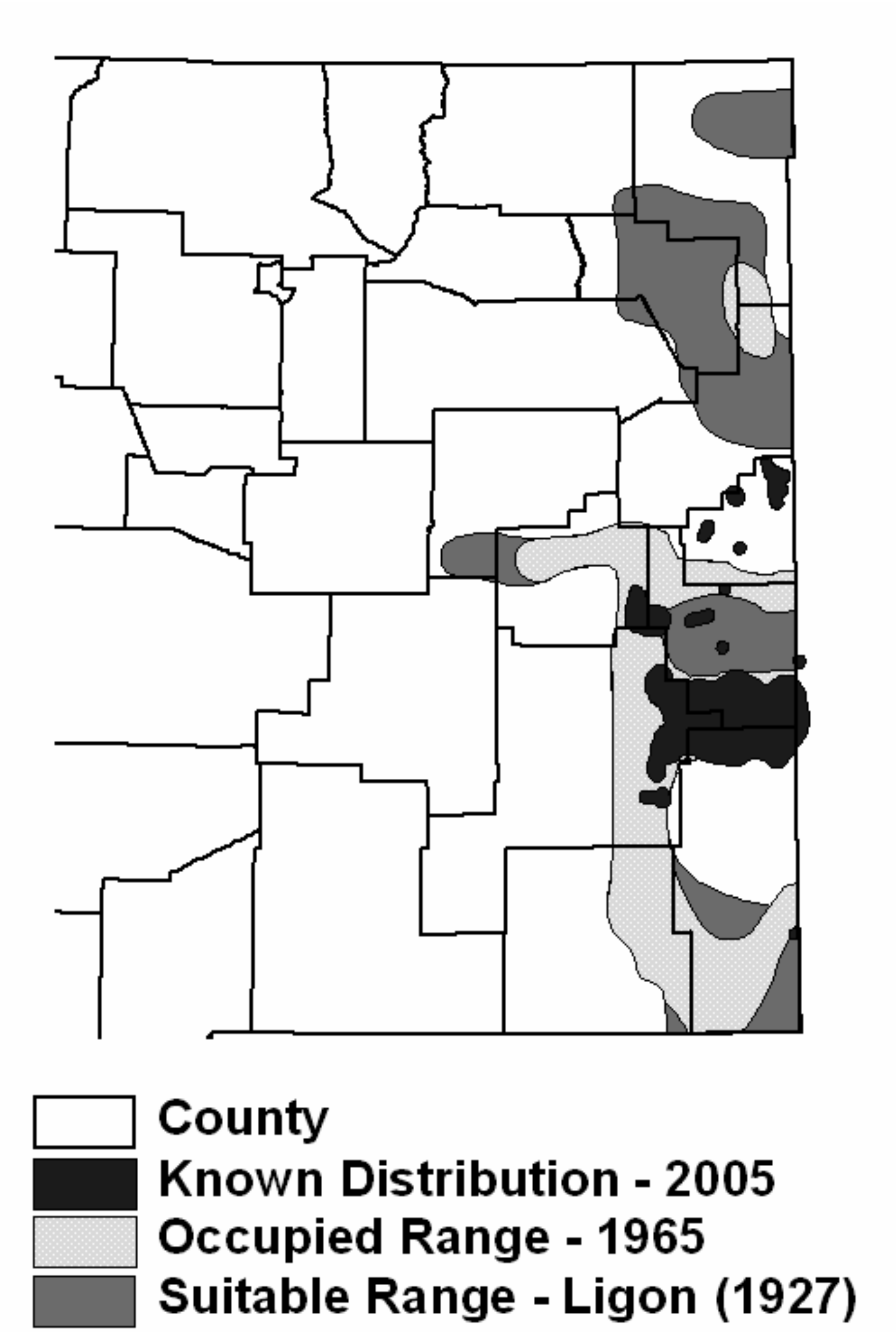

Figure 5. The shrinking range of the lesser prairie chicken in New Mexico (reproduced from Davis 2005: 12)

(present across 32% of the habitat) is also present for this population, and shinnery oak habitats harbored the greatest density of lesser prairie chickens (Cannon and Knopf 1980: 72).

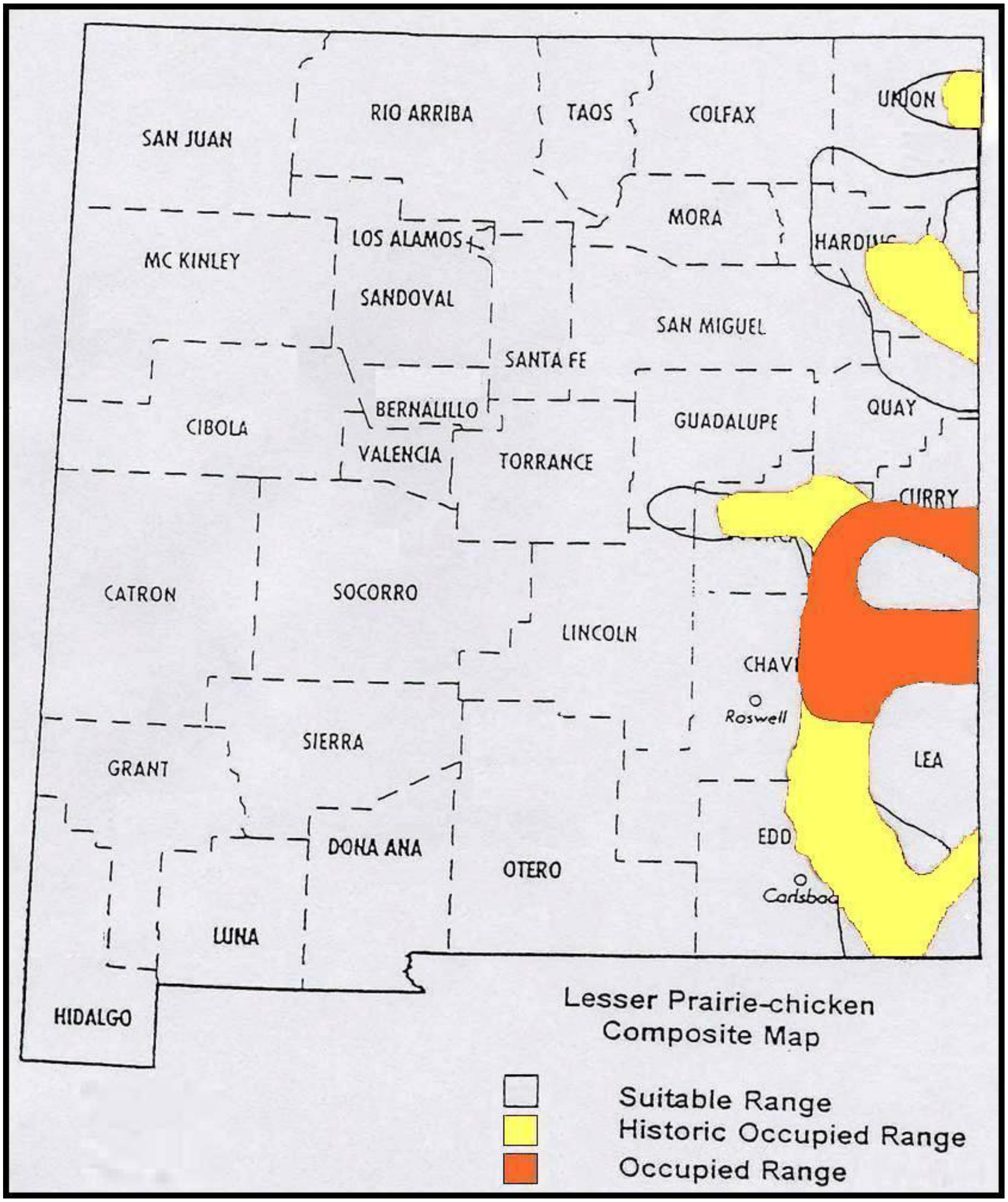

Figure 6. Suitable, historic, and occupied range in New Mexico (reproduced from McWilliams 2013).

Discreteness. Oyler-McCance et al. (2016: unnumbered 11) found that the Sand Sage Prairie population of lesser prairie chickens is genetically distinct. According to Haukos et al. (2016b: 282), "Habitats of Lesser Prairie-Chickens within the ecoregion are often separated by >60 km, effectively creating isolated populations in an increasingly fragmenting landscape." Haukos et al. (2016b: 288) added, "Due to increasing isolation by distance, Lesser Prairie-Chicken dispersal among populations in different habitat segments of the Sand Sagebrush Prairie Ecoregion is likely to be decreasing." This isolation and genetic distinctness underscores the discreteness of this population.

Significance. The Sand Sage Prairie population exists in an ecological setting unusual or unique for the taxon: the dominant vegetation in this area is short grama grasses and sand sagebrush, a unique and rigorous habitat for lesser prairie chickens to inhabit. This suggests that the current population is significant in having evolved mechanisms to survive in what would otherwise appear to be inadequate habitat conditions. Oyler-McCance et al. (2016: unnumbered 11) explain the "strong genetic patterns associated with ecoregions may be a result of the environmental variation across its geographic range." This population is genetically distinct from other lesser prairie chicken populations. Even though the Sand Sage Prairie and Mixed-Grass/Short Grass populations appear to be geographically close, Oyler-McCance et al. (2016: unnumbered 13) note that "the patterns of genetic structure" they found may be "due to reduced gene flow across inhospitable habitats that are not particularly far apart geographically." Thus, the Sand Sage Prairie population is also significant.

Petition for emergency listing. Emergency listing is warranted for this population due to its rapidly declining numbers. Garton et al. (2016: 62) projected that the Sand Sage Prairie population increased from 19,000 birds in 1966 to a peak population of more than 85,000 birds between 1970 and 1975, then dropped consistently through 1997 before rising to 20,000 birds in the early 2000s, then dropped to an estimated 3,005 birds in 2012. This is below the minimum viable population size for grouse species, as discussed below.

The largest Colorado population of these birds is located east of Campo on the Comanche National Grasslands and on private lands south of the Cimarron River (Davies 1993). Augustine (2006) estimated an annual population of lesser prairie chickens on the Cimarron National Grassland of 173-283 birds between 1995 and 2005. On the Comanche National Grassland, the estimated population ranged from a high of 348 birds in 1988 to a low of 64 birds in 2005, with a paucity of available nesting habitat due to a scarcity of taller grasses as a result of grazing pressure (*id*.). In 2013, only two active leks with around 11 males occurred on the Comanche National Grassland, and 3 active leks with only 30 birds occurred on the Cimarron National Grassland (Elmore and Dahlgren 2016: 188). Giesen (1994b: 180) pointed out that population densities in Colorado are significantly lower than in similar habitats in Oklahoma.

The estimated population density of lesser prairie chickens in this ecoregion declined 99% between 1988 and 2014; number of males counted on Colorado leks declined from 448 in 1989 to 40 in 2014 (Haukos et al. 2016b: 283). The observed minimum population estimate for 2014 for the Sand Sage Prairie ecoregion was 477 total birds, well below the 852 males used by Garton et al. (2016: 60) as the stand-in estimate for N_e=500. As noted above, the total population already dipped below 500 birds in 2014. Small and isolated populations in Kiowa and Cheyenne Counties in Colorado are at particularly high risk of extirpation (Giesen 2000: 144). Garton et al. (2016: 63) projected that the Sand Sage Prairie population had a 38% chance of dropping below an effective population size of 50 in 30 years, and a 76% chance of dropping below 500 birds during the same timeframe. Over 100 years, there is a more than 80% chance of the population dropping below the effective population thresholds of both 50 and 500 birds (Garton et al. 2016: 64).

Threats to this population are discussed in detail in the section describing the five listing factors, below.

Mixed-Grass Prairie and Shortgrass Prairie/CRP Mosaic DPS. We petition for consideration of the populations in these two ecoregions as one DPS, as there is contradictory evidence regarding whether they are genetically or geographically distinct from each other; however, this DPS is distinct from both the Sand Sage Prairie DPS and Shinnery Oak Prairie DPS.

Discreteness. The combined Mixed-Grass Prairie and Shortgrass/CRP Mosaic population extends from the northeast panhandle of Texas through central Oklahoma and central Kansas. As noted above, Cushman et al. (2010: 25) argued for organizing the lesser prairie chicken into three distinct and largely mutually-isolated metapopulations, while Oyler-McCance et al. (2016: unnumbered 11) argued that the Sand Sagebrush Prairie and Shinnery Oak Prairie populations are genetically distinct populations, while the Mixed-Grass prairie and Shortgrass Prairie/CRP Mosaic populations are genetically mixed. Other studies (Van den Bussche et al. 2003: 681, Hagen 2003: 185, Bouzat and Johnson 2004, Hagen et al. 2010: 33, and Pruett et al. 2011: 1212) support the discreteness and genetic separation of the Mixed-Grass Priairie and Shortgrass Prairie/CRP Mosaic birds. While we would support separate DPS status for the Mixed-Grass Priairie and Shortgrass Prairie/CRP Mosaic populations, these two populations are closer together geographically (suggesting greater potential for intermixing) and this distinction is not necessary for the purposes of this petition. Taken together, the best available science clearly shows that the Mixed-Grass Prairie and Shortgrass Prairie/CRP Mosiac ecoregional populations, when taken together, are discrete from the Shinnery Oak Prairie and Sand Sage Prairie populations, and also are isolated by distance.

Significance. The Shortgrass Prairie/CRP Mosaic population supports approximately 65% of the remaining birds left in the wild (Dahlgren et al. 2016: 263), and when combined with the Mixed-Grass Prairie population, the two populations represent the vast majority of remaining birds. Garton et al. (2016: 61, 66) gives each of these populations relatively low chances of extirpation compared to the remaining two proposed DPSs, and therefore the loss of this combined population would leave the lesser prairie chicken's survival dependent on the smaller populations that inhabit more arid and inhospitable climates where rates of growth and survival are intrinsically lower (*see, e.g.,* Engle and Kulbeth 1992). As the core of the remaining population of the species with the lowest chance of extinction, the importance of the Mixed-Grass Prairie and Shortgrass Prairie/CRP Mosaic combined populations cannot be disputed.

Justification for listing. The current population in the Mixed-Grass Prairie Ecoregion is estimated at less than 4,000 birds, the second-largest population of lesser prairie chickens (Wolfe et al. 2016: 299). In the Mixed-Grass Prairie ecoregion, Garton et al. (2016: 61) projected a minimal probability of the population dropping below N_e=50, but a 28% chance of the population dropping below N_e=500 within 30 years; at the 100-year timescale, there is a 39% chance of the effective breeding population dropping below 50 birds, and a 75% chance of the population dropping below N_e=500.

The Shortgrass Prairie/CRP Mosaic supports about 65% of the remaining lesser prairie chicken population (Dahlgren et al. 2016: 263). In this region, at least 73% of the landscape has been converted to cropland, with about 7% currently in the Conservation Reserve Program (Dahlgren et al. 2016: 262), which itself is a temporary solution that is subject to returning to tillage agriculture. Only small remnants of sand sagebrush habitat remain in this area (Fields et al. 2009: 931). Populations in this ecoregion were estimated at 19,000 birds in 2011 and peaked at more than 28,000 birds in 2008; there is a probability below 20% that this population will drop below an effective population (N_e) of 50 or 500 within the next century (Garton et al. 2016: 67).

These combined populations warrant "endangered" listing, but an immediate emergency does not exist for them as it does for the Shinnery Oak Prairie and Sand Sage Prairie populations. Threats to this population are discussed in detail in the section describing the five listing factors, below.

HABITAT REQUIREMENTS

The lesser prairie chicken is a bird of climax grasslands in the southwestern part of the Great Plains, and appears to be closely associated with shinnery oak (Aldrich 1963: 537) and sand sagebrush (Giesen 1994a, Jamison 2000: 172, Hagen 2003: 146). Kuchler (1964) described the plant associations inhabited by lesser prairie chicken primarily as grama-buffalo grass grassland, sandsage-bluestem prairie, and bluestem-grama prairie. The 100th meridian, a historically significant climactic boundary, bisects the lesser prairie chicken range, with semiarid grasslands to the west where evaporation exceeds precipitation on an annual basis, and moister prairies on the east; this climactic difference means that conservation approaches may differ between the eastern and western portions of the species' range (Haukos and Zavaleta 2016). Jones (1963a: 757) characterized lesser prairie chicken habitat as "small units of shortgrass prairie intermixed with larger units of shrub or half-shrub vegetation…" Silvy et al. (2004: 20) put it this way:

> Simply put, prairie grouse require prairie and lots of it. The only way managers can prevent the ultimate extinction of prairie grouse in the wild is to provide millions of hectares of prairie.

According to Askins et al. (2007), "preservation of large areas of natural or semi-natural grassland, where [ecological] processes can be studied and core populations of grassland birds can flourish, should be a high priority."

Hagen et al. (2004: 76) recommended that target areas no smaller than 64 by 64 kilometers (km) (over one million acres) be set aside as lesser prairie chicken management zones to encompass the longest known movements of individual birds. For Oklahoma, Haufler et al. (2012: 31) recommended establishing 15 core conservation areas averaging 50,000 acres in size, connected via linkages, with 70% of each core area being good to high quality lesser prairie chicken habitat. Toole (2005: 30) found that blocks of native rangeland at least 37,000 acres in size are required to sustain a complex of actively breeding leks in the Texas panhandle. According to the U.S. Fish and Wildlife Service, to maintain viable populations the lesser prairie chicken requires large, continuous areas of suitable habitat of a minimum size of 25,000 acres, which are connected to other large areas of suitable habitat. Declaration of Michelle Shaughnessy, Case No. 7:14-CV-00050-RAJ, at ¶4. Haukos and Zavaleta (2016: 107) noted,

> The U.S. Fish and Wildlife Service (2014) concluded that Lesser Prairie-Chickens are limited by the lack of contiguous, large patches of remaining prairie, and reported that 98.96% to 99.97% of remaining habitat patches were <486 and 6,475 ha, respectively. Thus, few remaining prairie patches are connected without fragmentation and available to meet the suggested minimum size for population persistence.

According to Bender et al. (1998), habitat specialists like the lesser prairie chicken require larger habitat patch sizes, and decline in population size associated with habitat fragmentation will be greater than the effect of acreage of habitat lost alone.

Fire is a natural part of Great Plains ecosystems, and together with heavy, infrequent grazing by bison, it was an important driver of shrub-grass patch dynamics (Patten et al. 2005a: 1277). Interestingly, late-successional areas with abundant cover provide the greatest nest success and hen survival, while chicks grew fastest and survived better in early-successional habitats with large components of forbs; overall, an interspersion of patches of different seral stages appears to provide the best overall habitat (Hagen et al. 2009: 1331). A mix of fire and bison grazing provides this patchy mosaic (Steuter and Hidinger 1999). Bison and domestic cattle graze differently, such that yearlong bison grazing leaves behind significantly more grass at the start of the dormant season than does season-long cattle grazing at the same stocking rates (Steuter and Hidinger 1999). If cattle and bison are stocked identically by biomass and grazed under the same management, bison grazing reduces grasses and increases forbs, while cattle grazing increases forbs, but overall the impacts on grasslands are similar (Towne et al. 2005). Thus, it appears that the pattern of grazing rather than the species of the grazer is the major change between unrestricted bison grazing during the presettlement era and modern, fenced yearlong cattle grazing. A century of fire suppression combined with heavy, continuous grazing by livestock has fostered an increase of trees and shrubs at the expense of native perennial grasses (Patten et al. 2005a: 1277). Elmore and Dahlgren (2016: 188) stated, "changes in natural disturbance factors such as fire and grazing have been altered and continue to degrade much of the remaining habitat for Lesser Prairie-Chickens." The removal of bison and fire from shortgrass prairie ecosystems likely fostered the expansion of mesquite and other shrubs (Bragg and Steuter 1996, Askins et al. 2007).

In addition to fire and bison grazing, prairie dogs also played an important role in maintaining the optimal mix of habitat patches for lesser prairie chickens (Brennan and Kuvlesky 2005: 5, Askins et al. 2007, Ripper et al. 2008: 207), providing ideal lek habitat and serving as a source of forb seeds for broods (Bidwell et al. 2002: 1). As a result of prairie dog eradication efforts, less than 1% of the original prairie dog colony acreage remains in Oklahoma (Bidwell et al. 2002: 1). Today, ants and pocket gophers can be major drivers of small-scale patch dynamics in shinnery oak grasslands, creating small-scale disturbances (and even blowouts in sandy habitats) that encourage the growth of forbs (Dhillion et al. 1994).

Seasonal home ranges for lesser prairie chickens in the northeast Texas panhandle ranged from 57 acres to 2,525 acres for a single bird, and averaged 512 acres (Toole 2005: 14). In southeastern New Mexico, pre-nesting home ranges for hens averaged 570 acres, 227 acres during nesting, and 294 acres during brood-rearing. Plumb (2015: 18) recorded an average hen home range size of 840 acres during the breeding season. Robinson (2015: 53) reported an average home range size during the fall and winter months of 750 acres. Merchant (1982) found post-nesting home ranges for hens to average 167 acres for hens with broods, and 158 acres for those without. Boal and Pirius (2012: Results 4) found an average home range size of 1,244 acres for females and 1,209 acres for males in north Texas. Giesen (1998) reported home range sizes in Colorado averaged 521 acres for males and 1,473 acres for females. Plumb (2015: unnumbered 5) calculated that each lesser prairie chicken hen needs at least 840 acres for a breeding season home range. Bidwell et al. (2002: 3) found that the collective home range of all the birds breeding at a particular lek averages 19 square miles, or more than 12,000 acres.

Shinnery oak grasslands, associated with sand dunes, are the heart of the current lesser prairie chicken occupied habitat along the Texas-New Mexico border (*see* Figure 7), perhaps due to the pervasive loss of other habitats due to agricultural conversion of grasslands rather than due to a preference by the birds (McCleery et al. 2007). Shinnery oak is also a significant component of the sand sagebrush grasslands of Oklahoma (Wiedeman 1960). Shinnery oak has a low-growing shrub form, and is often overtopped by native grasses under natural conditions (Wiedeman 1960, Peterson and Boyd 1998: 3). Pettit (1994) reported that this oak seldom grows over three feet tall, but may reach statures in isolated clusters over 10 feet tall. Clusters of this oak, called “mottes,” are clonal with many stems growing from a common rootstock with the belowground root network comprising the vast majority of the biomass of the plant (Wiedeman 1960, Pettit 1994, Mayes et al. 1998). True shinnery oak (about waist high) may hybridize with post oak to form mottes up to 20 feet tall (Pettit 1986, *and see* Wiedeman 1960).

Shinnery oak is restricted to sandy soils and stabilized dunes (Wiedeman 1960), and disappears with increasing clay content in the soil (Haukos 2011: 105). These dunes are the result of deposition between 11,000 and 8,000 years ago, and periodic droughts have resulted in periods of active dune migration over time (Holliday 2001). The sandy dune

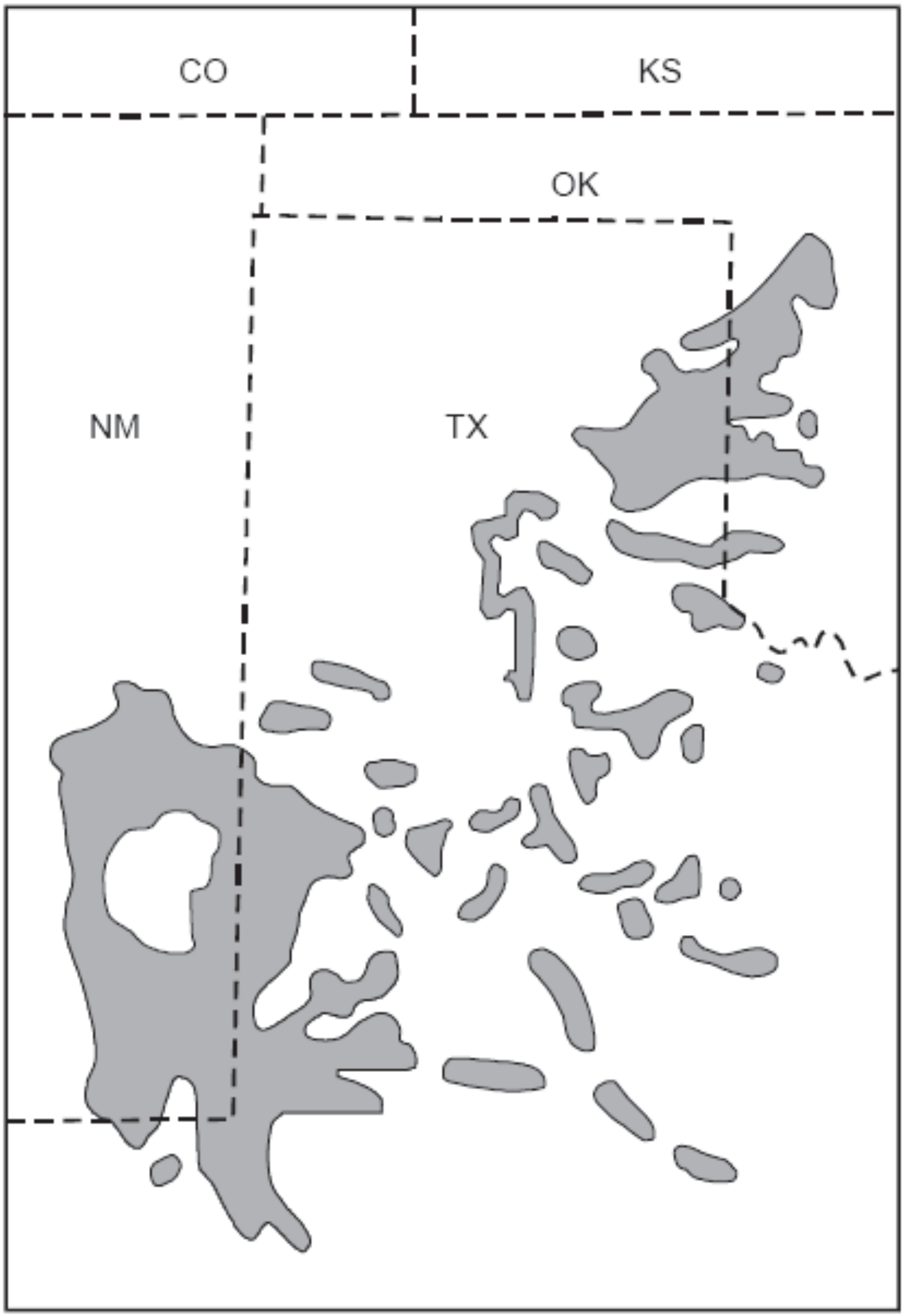

Figure 7. Distribution of shinnery oak, reproduced from Peterson and Boyd (1998: 2)

locations are highly susceptible to wind erosion, and removal of shinnery oak, which has root mats that stabilize sandy soils and crowns that retard wind erosion, can result in severe soil loss (Moldenhauer et al. 1958: 5). Hagen and Lyles (1988) found that sand sagebrush also serves an important purpose in reducing wind erosion on sandy soils where it occurs.

Providing a patchy, heterogeneous habitat with adequate food and cover over time is considered critical to maintaining populations of lesser prairie chicken (Fields et al. 2009: 937, Haufler et al. 2012: 14, 34). Haukos and Zavaleta (2016: 126) hypothesized that "habitat quality in the form of vegetation structure, patch size and configuration, and food resources are the main limiting factors that interact with current and past environmental conditions to exert ecological resistance on the recovery and distribution of populations of Lesser Prairie-Chicken." Robinson (2015: 96) found that survival of lesser prairie chickens was greater in areas with increasing numbers of patch types within lesser prairie chicken home ranges. Jamison et al. (2002) recommended protecting and restoring large tracts (at least 2,530 acres) of shinnery oak or sand sage grasslands to preserve lesser prairie chickens.

Toole (2005: 20) found that leks were sited in areas with predominantly native rangelands. Bartuszevige and Daniels (2013: 15) did a geographic analysis of where active leks occur, and found a greater proportion of both grassland and Conservation Reserve Program lands surrounding active leks, at multiple scales out to 20 km. For nesting, Applegate and Riley (1998: 14) recommended habitats dominated by native grasses with 30% cover of shrubs such as shinnery oak or sand sage, while brood-rearing habitats should have 40-45% grass cover and about an equal cover of shrubs. Lesser prairie chickens avoid creeks, rivers, and other low topography that reduces visibility and is characterized by a greater density of predators (Bidwell et al. 2002: 2).

Breeding habitat. Lesser prairie chickens typically choose areas of short grasses for lek sites (Copelin 1963, Jones 1963a, Davis et al. 1979) or blowouts in flat sandy country (Sharpe 1968), and also may choose elevated sites to enhance visibility (Davison 1940, Jones 1963a, Sharpe 1968, Cannon and Knopf 1979, Davis et al. 1979). In disturbed habitats, lekking commonly occurs on abandoned oil and gas well sites (Crawford and Bolen 1976b, Suminski 1977, Sell 1978, Davis et al. 1979, Taylor 1979, Ahlborn 1980, Locke 1992), windmill sites with much bare ground (Sell 1978), areas sprayed for brush control (Taylor 1979), or even infrequently used roads (Crawford and Bolen 1976b, Davis et al. 1979). Lesser prairie chickens may re-locate leks to recently burned sites, which have lower grasses (Cannon and Knopf 1979). Cultivated fields are rarely used for lek sites (Copelin 1963).

Patten et al. (2005a: 1273) found that lesser prairie chickens in New Mexico and Oklahoma selected microhabitats during spring with greater cover of shrubs and overall density of vegetation that were cooler, more humid, and less exposed to the wind. Larsson et al. (2013) also found that lesser prairie chickens selected habitats to optimize thermoregulation (seeking shade in hot weather, and open habitats in cooler weather), and selected habitats with cover to avoid predators.

Jarnevich et al. (2016: unnumbered 1) found that land cover type within five km of the lek site was the leading natural determinant of lek population, indicating that lek sites may be selected on the basis of surrounding nesting habitat. Similarly, Fuhlendorf et al. (2002: 622) determined that landscape change within 4.8 km of leks (7,238-ha scale) best explained the difference between leks with stable versus declining populations. Bartuszevige and Daniels (2016: 212) found that habitat in grassland plus CRP land were positively correlated with lek presence at the 3,000 and 5,000 meter (m) scales, but such variables were weakly correlated with lek presence at the 10,000 m scale, indicating that five km is the lek buffer distance that reflects impacts of land use.

Timmer (2012: 39) found lek density to be greatest when about half the landscape is comprised of shrubland patches, with shrubs less than five m tall comprising 20% or more of the total vegetation cover. McWilliams (2013: iii) found active lek sites in New Mexico to be positively associated with shinnery oak, bluestem (*Andropogon*), grama (*Bouteloua*), threeawn (*Aristada*), broom snakeweed (*Gutierrezia*), broom groundel (*Senecio*), and, counterintuitively, honey mesquite (*Prosopis*); active lek sites had less than expected sacaton (*Sporobolus*) and muhly grasses (*Muhlenbergia*).

In sand sagebrush habitats, Jamison (2000: 142) found that lesser prairie chickens selected sand sage habitats and avoided croplands and Conservation Reserve Program fields. Cannon and Knopf (1981) found that lesser prairie chickens selected lekking habitats with intermediate densities of sand sagebrush, but selected areas for lekking with greater grass cover and less shrub cover where sand shinnery oak was predominant. Predominant grasses are sand bluestem (*Andropogon hallii*), little bluestem (*Andropogon scoparius*), sand lovegrass (*Eragrostis trichodes*), sand dropseed (*Sporobolus cryptandrus*), switchgrass (*Panicum virgatum*) and Indiangrass (*Sorghastrum nutans*); Chickasaw plum (*Prunus angustifolia*) and fragrant sumac or skunkbush (*Rhus aromatica*) are also an important part of this plant association on stabilized dunes (Jackson and DeArment 1963: 734).

Nesting habitat. Nests sites are selected for their concealment (Jones 1963a, Sell 1978), and in the days before radio tracking, it was very difficult for researchers to locate them (Jones 1963a). Bent (1932) asserted that lesser prairie chickens often select nest sites atop a rise or on its sloping sides. Davis et al. (1979) found nests most frequently on north- or northeast-facing slopes or in depressions among sandhills in shinnery oak grasslands, where there was less direct sunlight and some protection from the wind. Riley (1978: 27) found that lesser prairie chickens in New Mexico chose nest sites in depressions within low sandhills, and selected shinnery oak grasslands but avoided mesquite grasslands for nesting. Hagen et al. (2013: 6) found that rangewide, lesser prairie chicken hens selected for cover (vertical cover, horizontal cover, and grass height) and against bare ground in choosing nest sites.

Lesser prairie chicken select nest sites beneath shrubs, or in *Andropogon* bunchgrass clumps where grasses are sufficiently tall (Davis et al. 1979, Hunt and Best 2004: 15). Leonard (2008) found that most prairie chickens in the sand sagebrush habitat type nested beneath sand sagebrush shrubs. Shinnery oak-bluestem habitat in good to excellent condition, near climax and not degraded by livestock grazing, is the preferred nesting habitat in New Mexico (Ahlborn 1980: 60). Wisdom (1980: 13) found in New Mexico that lesser prairie chickens nested exclusively in the shinnery oak-tallgrass vegetation type, selecting nest sites beneath shrubs taller than average for the area. Larsson et al. (2013) found the five plant species most selected by lesser prairie chickens in western Oklahoma and eastern New Mexico were windmill grass (*Chloris verticillata*), Illinois bundle flower (*Desmanthus illinoensis*), tumblegrass (*Schedonnardus paniculatus*), dropseed (*Sporobolus*), and alfalfa (*Medicago* spp.); the plants most avoided were broom snakeweed, Indian blanket (*Gaillardia pulchella*), sorghum, the non-native johnsongrass (*Sorghum halapense*), and hairy grama (*Bouteloua hirsuta*). Davis et al. (1979) and Wisdom (1980: 13) found that nesting hens completely avoided grasslands with honey mesquite.

Fields (2004: 38) found mid-height and tall grasses were the dominant plant type above the nest cup at 70% of nests. In Oklahoma, lesser prairie chickens selected sites beneath sand sage most frequently, even though shinnery oak was available (Sell 1978). Davis et al. (1979) found that ground cover within 10 feet of successful nests included more leaf litter and less bare ground than random points, and Riley (1978: 22) and Lautenbach (2015: 24) reported similar results. Wisdom (1980: 14) found that average grass height within nine meters of nests was more than seven inches, and that there was a strong preference for nesting in areas with more than 12 inches of grass height, associated with 31.5% utilization of bluestem by grazing livestock. Lautenbach (2105: Abstract) reported that hens select nest sites with 7.9 to 11.8 inches of visual cover. Johnson et al. (2004: 339) found that all hens chose nest sites with at least 35% shrub cover in the immediate vicinity. Hagen et al. (2013: 7) reviewed multiple studies rangewide and recorded an average of 58% horizontal cover at nest sites. Wisdom (1980: 16) found that in heavily grazed areas, hens selected nest sites beneath sand sage shrubs in the absence of suitable bluestem cover.

Pitman et al. (2005: 1267) found that most successful nests in southwestern Kansas were located in habitats with dense, mature sand sagebrush. Hagen (2003: 122) found that nest success was highest in areas of greatest shrub density, while the greatest chick survival rates were found in habitats with moderate densities of shrubs (4,000 to 6,000 plants per hectare). Davis et al. (1979) found that nest success was highest in areas with superior cover (in both height and density) from grasses or shrubs, providing greatest nest concealment. Wisdom (1980: 21) and Riley et al. (1992) found nests in lightly grazed or ungrazed clumps of bluestem grasses were more successful than other nests. Davis et al. (1979) found lower nest success in areas where livestock grazing had significantly reduced grass height.

Davis et al. (1979) found that plants concealing nests tended to be taller than surrounding vegetation, and where lesser prairie chickens nested in grassy areas devoid of shrubs, the grasses tended not to be heavily grazed. According to Dahlgren et al. (2016: 266), "In many native grasslands in this ecoregion, sideoats grama may be the only species capable of producing adequate structure for nesting." This species tends to be replaced by lower-growing grasses when grasslands are subjected to livestock grazing (Archer and Smeins 1991).

Brood-rearing habitat. In New Mexico, Ahlborn (1980: 59) documented that brood-rearing lesser prairie chickens preferred a sandhills habitat type with abundant shrubs and forbs to sand shinnery oak habitat types, and avoided sand shinnery oak habitats in poor or fair condition due to grazing, as well as reverted croplands. By contrast, Riley (1978) found that hens with broods preferred shinnery oak-tallgrass plant associations, and avoided mesquite-shortgrass types. Davis et al. (1979) noted that both broods and adult prairie chickens sought out summer habitats with a more extensive shrub component. Broods selected habitats with canopy cover of 25%, shrub canopy of 30-35%, and basal plant cover of 5% (Ahlborn 1980: 59). Ahlborn (1980: 43) found that shrub canopy height was more important for brood habitat selection than either grass or forb height, and recorded a preference of shrub canopy height between 29 and 31 centimeters (cm). Davis et al. (1979) found that the average height of vegetation cover in habitats used for brood foraging was 9.6 inches (24.3 cm), while Lautenbach (2015: Abstract) found that hens selected habitats with 7.9 to 11.8 inches of visual obstruction for brood habitat. Patten et al. (2005a: 1275) found that survival was maximized in habitats with more than 20% shrub cover, and found that 2.5% of occupied habitats had shrub cover of 50% or more, proposing this as an upper limit for lesser prairie chicken habitat. By contrast, Larsson et al. (2013) found that lesser prairie chickens in western Oklahoma and eastern New Mexico selected habitats with greater grass and forb cover and less shrub cover. Jamison (2000: 25, 28) demonstrated that forb cover was the greatest predictor of grasshopper biomass, meaning that the forb component of grassland ecosystems is also a critically important dietary and habitat factor for lesser prairie chickens.

Movements from brood-rearing habitats to winter ranges averaged 6.8 miles in one New Mexico study (Ahlborn 1980: 53). Copelin (1963) found that broods moved between 0.5 mile and 2.9 miles from their brooding locations to the next sping's lek habitat; adults moved shorter distances. In northeast Texas, Kukal (2010: 19) reported that ≥98% of winter locations were within 5 km (3.1 miles) of the lek of capture, and ≥98% were within 2.4 km (1.5 miles) of a known lek. Ahlborn (1980: 32) found that 97% of brood-rearing locations were within about one mile (1.5 km) of leks. Jamison et al. (2002) recommended maintaining suitable habitats within 4.8 miles of leks to encourage persistence of lesser prairie chickens. One hen trapped in Kansas and released in Colorado returned a distance of 300 km (186 miles) during the same year (Giesen 1998). Boal and Pirius (2012: Results 6) found that lesser prairie chickens in north Texas select for grassland-dominated areas with shinnery oak for their winter habitat.

Autumn and winter habitat. Ahlborn (1980: vi) found that 73% of radio-tagged lesser prairie chickens moved to feed in sorghum fields during fall and winter. Kukal (2010: 24), by contrast, found complete avoidance of agricultural fields by lesser prairie chickens; wheat rather than sorghum was the dominant row crop in his northeast Texas study area. Davis et al. (1979) found that in New Mexico, lesser prairie chickens selected grasslands with a small but important component of shinnery oak for their winter habitat. Fields (2004: 37) documented that rangelands received significant habitat use prior to the onset of the nesting season. Similarly, Kukal (2010: 24) documented that the vast majority of winter locations were on grassland habitat types with <15% canopy cover of shrubs. Bidwell and Peoples (1991: 9004.3) noted, "Some populations may benefit from sorghum grain food plots scattered throughout the management area; however, prairie chicken populations were abundant long before there were sorghum or other grain crops available for food."

Large-scale seasonal migrations of lesser prairie chickens may once have occurred, but by the time accurate records began to be kept, stories of these had become so far in the past as to be unverifiable (Henika 1940: 2, Jackson and DeArment 1963: 733). In modern times, most lesser prairie chickens spend their entire lives within a three-mile radius of a lek (Applegate and Riley 1998: 14). Studying the movements of lesser prairie chickens in New Mexico, Taylor and Guthery (1980b) found that virtually all lesser prairie chicken habitat use was within 4.8 km of a lek.

By contrast, Fields (2004: 45) found the average movements of hens during the pre-nesting period was 4.5 km from their lek of capture, with a range of 0.7-21.4 km. Plumb (2015: unnumbered 3) found that hen daily movements averaged 1.35 km during the breeding and nesting seasons, with daily movements peaking at an average of 2.1 km during the lekking season and being most sedentary during the brood-rearing season with an average of 0.78 km per day. In southeastern New Mexico, Riley et al. (1994) found much smaller movements, averaging 0.4 km during the pre-nesting period, 0.25 km during the nesting period, and 0.28 km during brood-rearing. In Texas, Boal and Pirius (2012: Results 6) found that 97.2% of lesser prairie chicken locations during the non-breeding season were within 3.2 km of their lek of capture, and 96.8% were within 1.7 km of the nearest known lek. Kukal (2010: 22) found that 98% of winter locations were within 1.5 miles (2.4 km) of a lek throughout the winter in the mixed-grass prairie region of Texas, with no difference between males and females. In Oklahoma, Wolfe et al. (2003: 9) documented that nests ranged from 0.35 km to 21.9 km from the lek of capture, averaging 3.7 km, and that 50% of hens nested within 2 km of the lek of capture. Giesen (1998) argued that most nesting and brood-rearing occurs within 3 km (1.86 miles) of a lek. Hagen et al. (2004: 77) recommended conserving grassland or shrub-dominated habitat within 3.5 km (2.2 miles) of leks to maintain nesting habitat. Toole (2005: 24) documented that lesser prairie chickens undertake larger movements in the autumn to access areas where shinnery oak acorns are abundant. By contrast, Robinson (2015: 54) found that lesser prairie chickens remain close to lek sites throughout the winter.

In fall, mixed-sex flocks of 15 to 80 mostly juvenile birds were observed on leks with displaying males (Ahlborn 1980: 53). Lesser prairie chickens are also known to form large flocks over the winter (Boal and Pirius 2012: Discussion 7). During autumn and winter, lesser prairie chickens in New Mexico selected almost exclusively for shinnery oak grasslands with tall grasses (Suminski 1977, Smith 1979), and showed the greatest avoidance for mesquite-shortgrass habitats (Smith 1979).

Roosting habitats differ from other habitats selected by lesser prairie chickens. Prairie chickens use shrubs and half-shrubs for day roosts, while overnight they tend to roost in pockets of shorter vegetation amid areas of taller vegetation; when snowdrifts are available in winter, lesser prairie chickens often roost in these (Jones 1963a). Tall coverts of scattered or clumped vegetation averaging 60 cm in height are preferred for escape cover (Jones 1963a).

GEOGRAPHIC DISTRIBUTION

Lesser prairie chickens inhabit the southern Great Plains states of Kansas, Oklahoma, Texas, Colorado, and New Mexico. Rangewide, some 94% to 95% of the lesser prairie chicken's range is in private ownership (Taylor and Guthery 1980a: 13, Elmore and Dahlgren 2016: 190, *and see* Figure 8). Most of the rain falls during summer in this region, with a small proportion of precipitation falling during winter (Patten et al. 2005b: 238). Some 59% of lesser prairie chicken's historic range in New Mexico is in private ownership, with the remainder managed by state or federal agencies; private ownership is 78% in northeast and east-central New Mexico, while public ownership is concentrated in southeast New Mexico (Davis 2005).

Sharpe (1968) referenced an unpublished paper from 1931 by Dr. Myron Swenk which asserted that lesser prairie chickens were historically present in small numbers as far north as the sandhills of central Nebraska, and Sharpe subsequently examined some of the mounted specimens referenced and definitively declared them to be *Tympanuchus pallidicinctus*. The greater and lesser prairie chicken likely overlapped in their native ranges from the beginning of European settlement (Duck and Fletcher 1944: 68, Sharpe 1968). The range of the greater and lesser prairie chickens originally overlapped in 16 counties in Texas, but the greater prairie chicken is now extinct in Texas (Silvy et al. 2004). Lesser prairie chicken bones dating from the Pleistocene or Early Recent periods have been documented in a cave in the southern Organ Mountains in southern New Mexico, outside their current range, and greater sage grouse bones were documented in two nearby caves dating from the same period (Howard and Miller 1933).

The Texas population initially inhabited the Texas panhandle as far south as Jeff Davis, Pecos, Maverick, and Bandera counties, and with confirmed historic records east of Wichita Falls, as far south as Kerrville, and as far west as the Fort Davis vicinity (Oberholser 1974: 268).

BEHAVIOR

While the scientific literature regarding the behavior of lesser prairie chickens is quite robust, some aspects of the species' behavior and ecology remain untested. However, scientific studies on other prairie grouse have broad applicability to lesser prairie chickens as well, and can be considered as the best available science in cases where applicable studies directly focusing on lesser prairie chickens are unavailable. According to De Young and Williford (2016: 78), "Similarities in the behavior, life history, and

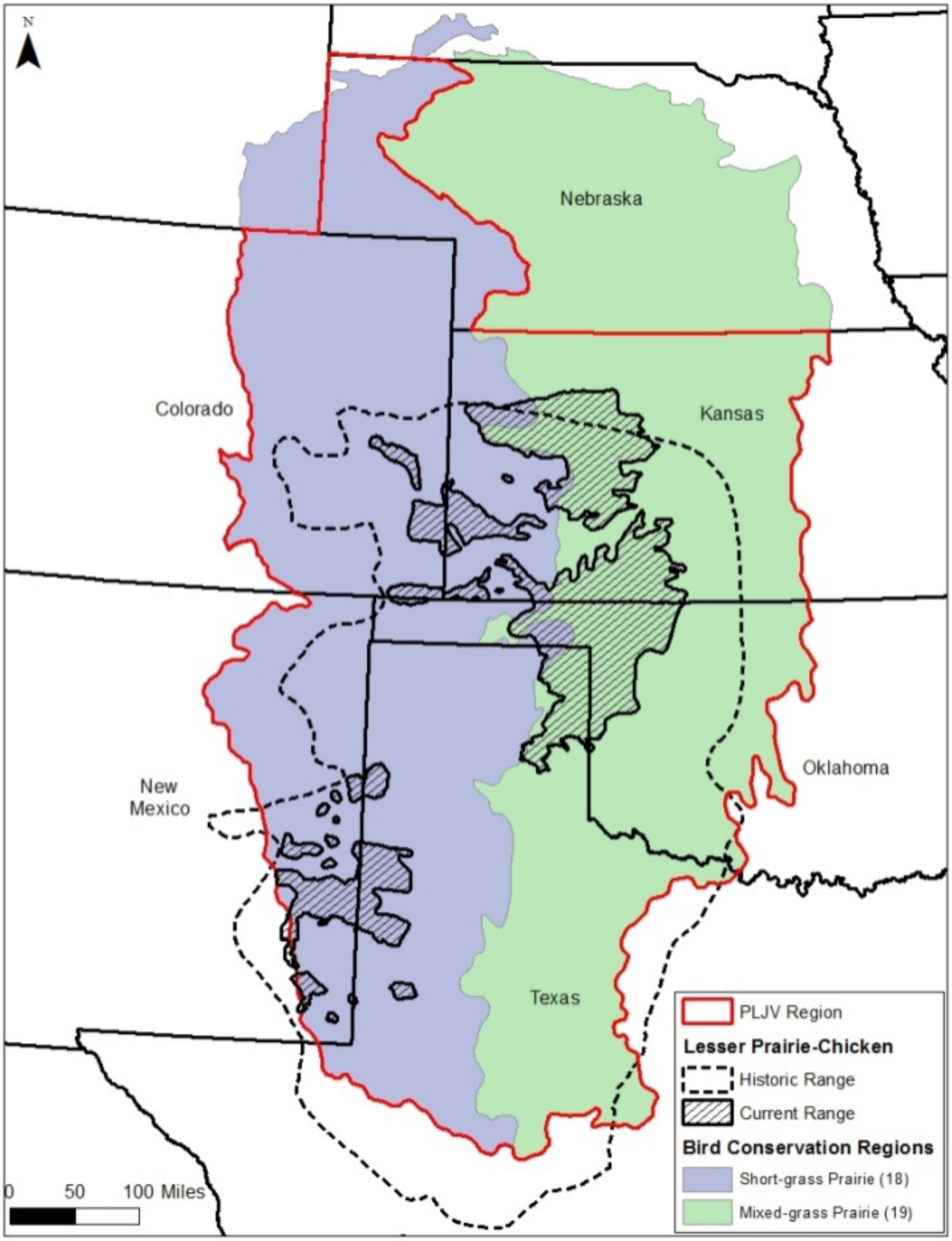

Figure 8. Current and historical range of the lesser prairie chicken, as mapped by Bartuszevige and Daniels (2013: 5).

recent demographic history of *Tympanuchus* suggest that population studies of Greater Prairie-Chickens and Sharp-tailed Grouse are directly relevant to Lesser Prairie-Chickens."

Feeding habits. Bidwell et al. (2002: 5) asserted that food scarcity is seldom considered to be a factor influencing lesser prairie chicken population dynamics. However, daily energy demands are almost entirely dependent on daily food intake rather than stored fat (Giesen 1998), and fat reserves average between 2.1 and 4.1% of body weight (Olawsky 1987: 59). As a result, daily food consumption can have a profound effect on the condition of individuals. Grisham et al. (2016b: 327) suggested that winter food availability is a limiting factor in sand shinnery oak prairie habitats. Haukos and Zavaleta (2016: 113) asserted that "[f]ood resources can be a major limiting factor for lesser prairie-chickens" but at the same time noted that "it may be difficult, if not impossible to focus habitat management efforts on food resources" due to large spatial scales and unpredictable abundance in native food resources. Crawford (1974: 45) found that forb cover was positively correlated with lesser prairie chicken populations, and suggested that forbs contribute doubly to the welfare of prairie chicken populations, both as a direct food source and by supporting increased insect populations. Intestinal droppings are brown, tan, or white in color; cecal droppings appear black and tarry (Hunt and Best 2004: 35).

In addition to forming an important habitat function in providing hiding and thermal cover, shinnery oak (*Quercus havardi*) provides leaves, catkins, acorns, and insect galls as food sources for lesser prairie chickens in areas where it occurs (Davis 2005: 4). These galls are caused by cynipid wasps (Johnsgard 2002: 31). Shinnery oak catkins are an important spring and summer food source, and acorns are an important food source in autumn and winter (Hunt 2004). Lesser prairie chickens rely heavily on green vegetation as a food source during spring, when it comprises 78.7% of the diet, with shinnery oak catkins making up 31.8% of the diet (Davis et al. 1980). Peak consumption of shinnery oak buds and catkins corresponds with the spring nesting season, when protein demands are high (Boyd et al. 2001). However, Doerr (1980: 27) found that insects make up 68% of the spring diet based on analysis of crop contents in Texas.

Insects dominate the summer diet of lesser prairie chickens, in contrast to greater prairie chickens, which focus on seeds (Jones 1963a). During summer, grasshoppers and treehoppers are the primary food of young prairie chickens (Applegate and Riley 1998: 14), and insects make up 99-100% of the diet of chicks under 10 weeks of age (Davis et al. 1979); Jones (1963b) reported slightly less at 97%. Suminski (1977) found that insects comprised the entire diet of chicks under 4 weeks of age, and larger chicks of 6-10 weeks of age began to eat small quantities of vegetation, but insects still comprised 98.7% of their total diet. Ground beetles (Carabidae) and June beetles (Scarabaeidae) also are important summer foods (Jones 1963a). Insects also make up 56% of the summer diet of adult birds in New Mexico, while vegetative matter made up 23.3% and acorns made up 21.4% (Davis et al. 1979). Insect larvae may be a locally important component of the winter diet (Jones 1963b). While vegetation is a minor component of the summer diet, skunkbush sumac, goldenrod, and the leaves of prairie gentian can be important foods during this period (Jones 1963b).

In New Mexico, Riley et al. (1993) found that the autumn diet was dominated by shinnery oak acorns, and also included grasshoppers, broom grounsel leaves, and insect galls. Western ragweed made up the majority of the fecal matter during autumn in one Oklahoma study (Jones 1963a), and insects can also be a primary lesser prairie chicken food during autumn, particularly in shrubby habitats (Jones 1963b). In their north Texas study area, Crawford and Bolen (1976c) found that grain sorghum was present in 55.6% of the crops of hunted lesser prairie chickens during autumn, while wild flax, acorns, oak leaves, oak galls, beetles, and grasshoppers were also common food items. In New Mexico, Davis et al. (1979) found that in autumn acorns made up 39.2% of the diet, while vegetative material made up 38.7% and insects made up 18.1%. Doerr (1980: 27) found that acorns and galls made up 62.5% of the fall diet. Sunflower seeds can also be an important food on rangelands (Fields 2004: 39). Korean lespedeza, a clover cultivated for livestock silage, is also used as a food by lesser prairie chickens during both summer and winter (Jones 1963b).

Originally, acorns were the key winter food supply for lesser prairie chickens in Texas (Henika 1940: 10-11), and in New Mexico shinnery oak in its various forms makes up one-fourth to three-fourths of the total diet during autumn and winter (Smith 1979). Acorns dominate the winter diet of lesser prairie chickens in New Mexico, comprising 69% of food ingested (Davis et al. 1979, Riley et al. 1992). When natural food sources are diminished by drought or harsh winters, lesser prairie chickens may rely more heavily on waste grains from agricultural fields as a food source (Copelin 1963, Ahlborn 1980: 57). In Kansas, some lesser prairie chickens forage throughout the winter on waste grains in cornfields (Salter et al. 2005). Waste grains, particularly sorghum, can be an important component of the winter diet in some areas (Bent 1932: 283, Copelin 1963, Donaldson 1969: 57, Crawford 1974: 50, Dahlgren et al. 2016: 267). However, the value of this crop to the winter diet was reduced significantly by the advent of combine harvesting, which replaced the stacking and shocking methods that made grain sorghum much more available to lesser prairie chickens (Jackson and DeArment 1963: 733, *and see* Litton 1978: unnumbered 6). In addition, waste grains pose a potential risk to prairie chickens through the potential for contamination with fungus-based biotoxins, which can result in decreased growth, reproductive success, and survival (Peterson 2016: 170). Copelin (1963) found that only one of 16 food plots within lesser prairie chicken range leased for grain production by the Oklahoma Wildlife Conservation Department between 1955 and 1957 was actively used for winter feeding by prairie chickens. In Oklahoma, Jones (1963b) found the winter diet of lesser prairie chickens to be dominated by leaf and flower buds of skunkbush sumac, leaves of sand sagebrush, and leaves of broom snakeweed; grain sorghum was also used as a winter food, but not in habitats where skunkbush sumac was readily available.

Food plots have sometimes been recommended to enhance lesser prairie chicken habitat (*see, e.g.,* Crawford 1974: 50), but these attract other herbivores as well, which may take most of the grain, and food plots may concentrate predator activity and thus turn these sites into a population sink (Bidwell et al. 2002: 6). According to Litton (1978: unnumbered 6), "Small winter food plantings of less than five acres have been attempted but usually are not successful since rabbits, blackbirds, crows, starlings and sparrows denude these areas prior to the critical winter period." Salter et al. (2005) postulated that due to the availability of waste grains in southwestern Kansas, and the limiting nature of sand sage prairie fragments as nesting and brood-rearing habitats for lesser prairie chickens, the conversion of grassland habitat for winter food plots would be counterproductive.

Lesser prairie chickens can meet their water requirements by consuming dew, insects, and succulent vegetation, and do not require open water (Schwilling 1955: 29, Snyder 1967: 123, Bidwell et al. 2002: 6). According to Schwilling (1955: 29),

> Certain flocks at times frequented waterholes with great regularity. However, we have come to believe that water is not a necessity of the birds, but a luxury. Of the flocks kept under daily surveilance [*sic*], many more seemed not to water than those that did.

Johnsgard (2002: 30) suggested that the leaves of sand sage were eaten occasionally by lesser prairie chickens, and that these leaves could serve as a source of free water in this generally arid grassland habitat. The absence of dew during dry years was suggested as a key factor in causing brood failure (Schwilling 1955: 29). Davis et al. (1979) documented prairie chickens visiting stock watering troughs during a very dry spring, but during wet springs the birds made no visits to water facilities. Merchant (1982) documented in his New Mexico study that only one hen drank free-standing water during a drought year, and none did during an ordinary year. Thus, during drought years, the availability of surface water may be a significant factor, while during ordinary years surface water may be unnecessary for prairie chicken survival.

Lesser prairie chickens will use surface water sources, including wildlife-friendly guzzlers (Boal et al. 2014), particularly during periods of drought (Crawford 1974: 41, Crawford and Bolen 1973, Bidwell et al. 2002: 6). Some researchers (*e.g.,* Davis et al. 1979) raised concerns that emplacing new water sources might expand livestock grazing pressure and thereby degrade lesser prairie chicken habitats. Copelin (1963) found that prairie chickens began gathering at surface water sources in September, and Sell (1978) found that hens regularly visited stock tanks during the early stages of incubation. A pilot study used photo-traps on paired guzzler and non-guzzler CRP fields in Kansas, and found frequent mesopredator use of guzzlers but no use by lesser prairie chickens, while a third study showed some guzzler use by lesser prairie chickens (*in* Dahlgren et al. 2016: 269). Grisham et al. (2014: 862) found the lesser prairie chickens in Texas were more likely to nest closer to stock ponds, but conversely Crawford (1974: 37) found that almost all lek sites were more than 0.5 mile distant from stock ponds. These contradictory findings indicate that lesser prairie chickens likely only require surface water during drought conditions (Boal and Haukos 2016).

Lekking. Lesser prairie chickens are polygynous and display and breed at communal display arenas known as 'leks,' which are used year after year (Sharpe 1968). For the closely-related greater prairie chicken, Schroeder and Braun (1992) found that 95.1% of males were documented attending leks in a given day, with yearling males visiting more different leks than adults. Lekking activity may be suppressed by cold and/or windy weather (Suminski 1977).

Adult males almost always breed and display on the same lek year after year, and typically occupy the same territory on the same lek year after year, but on rare occasions may switch territories (Copelin 1963, Campbell 1972: 699). Bouzat and Johnson (2004) found very strong lek fidelity for males, but weaker lek fidelity for females, and found that females at leks tended to be unrelated. Nonetheless, despite their tendency to visit multiple leks, females show fidelity to existing lek sites over new leks sites (Haukos and Smith 1999). In contrast to Copelin (1963), Haukos (1988: 42) found that displaying males frequently switched displaying territories within the lek from day to day, or even between morning and evening. Subadult males moved considerably farther than adult males during the lekking season (Cambell 1972). Jamison (2000: 107) documented that 10 of 48 males (21%) were recaptured at leks other than the lek of their initial capture, and one male was recaptured 13.5 km away. Hagen (2003: 16) found that for his Kansas study area, yearling males showed a 20% chance of switching lek of attendance, while older males showed an 8% chance of switching leks. Hagen et al. (2005: 82) found that adult males had very strong lek fidelity (92%), while yearling males showed slightly lower lek fidelity (80%); among those males that switched leks, distance to the new lek averaged about three km. Kukal (2010: 23) documented strong lek fidelity for males, with no lek switching at all. Lesser prairie chicken leks often contain male relatives, while females are unrelated and tend to be the primary dispersers (Bouzat and Johnson 2004, Corman 2011). Satellite leks may become established in the vicinity of existing leks as populations expand (Hamerstrom and Hamerstrom 1973, Haukos and Smith 1999), and typically are populated by less-dominant males unable to establish territories on previously existing leks (Haukos and Smith 1999).

Timmer et al. (2013: 748) calculated an average lek density of 2.6 leks per 100 km^2 in the Texas panhandle using aerial surveys. Wolfe et al. (2003: 10) documented that leks in Oklahoma averaged 3.8 km apart, while leks in New Mexico averaged 1.5 km apart. Giesen (1994a) found average distance between leks of 1.13 km in the sand sage habitats of southeastern Colorado. Wolfe et al. (2007: 100) found an average distance between leks of 3.77 km in Oklahoma and 1.51 km in New Mexico. Hunt and Best (2004: 73) found that vegetation had little effect on choice of lek sites, and found no difference in the amount of bare ground at leks compared to control points in surrounding habitat. Conservation Reserve Program fields in the Shortgrass/CRP Mosiac region are rarely used as lek sites due to their taller vegetation height and greater density of grasses (Dahlgren et al. 2016: 267).

Lesser prairie chicken males begin showing up on leks and establishing territories, chasing one another frequently, as early as January (Jones 1964). Spring lekking activity by males begins in February and typically peaks in March and early April (Copelin 1963). Cocks may display on the lek until late May (Crawford and Bolen 1975) or even early June (Davis et al. 1979).

Males display most actively between dawn and 105 minutes after sunrise; lekking activity also occurs with fewer birds between 135 minutes before sunset until 30 minutes after sunset (Crawford 1974: 21). Another period of displaying may occur from late afternoon until just after sunset, and some activity may occur at any time during daylight hours (Hunt and Best 2004: 14). In New Mexico, the greatest intensity of lekking activity is during the first three weeks in April, when males may spend the night on the lek (Hunt and Best 2004: 14, *and see* Davis et al. 1979). During the day, males roost near the lek, often in shrub or half-shrub habitats within 0.5 km of the lek, and sometimes in flocks of 10 or 15 birds (Suminski 1977). Males less than one year old visit leks in an attempt to breed, while yearling females tend not to attempt to breed (Wolfe et al. 2007: 100).

Females often visit multiple leks in search of a mate (Haukos 1988: 46, Wolfe et al. 2007: 100). In north Texas, some 82% of females recorded at leks, and 80% of copulations recorded, occurred during the first two weeks of April (Crawford and Bolen 1975). Behney et al. (2012) found that peak female attendance occurred during the week following April 13 during both years of the study. Haukos and Smith (1999) recorded two peaks of female lek attendance in Texas, one during the last week of March and the other during the second week of April. Similarly, in New Mexico, female visitation at leks peaks during the first three weeks of April (Davis et al. 1979, Merchant 1982). Females attending leks after mid-May are likely to be females seeking to re-nest following the failure of the initial nest (Giesen 1998).

Male breeding territories within the lek are typically 12 to 15 feet in diameter, and older, more dominant males show strong fidelity to individual territories (Copelin 1963). Behney et al. (2012) found that all males showed fidelity to the same territory day after day, and the only male documented in two successive lekking seasons occupied the same territory both years. The most advantageous territories are typically located at the center of the lek, and are occupied by the most dominant males (Sharpe 1968, Bidwell et al. 2002: 2), and females visiting leks typically attempt to mate with dominant males at the center of the lek (Bidwell et al. 2002: 2). However, Nooker (2007: 2-14) found no correlation between territory size or position and male breeding success.

Sharpe (1968) labeled the dominant male “the master cock” and found that such birds are typically successful in driving rivals off their territories, often eliciting appeasement responses from the interloper. Nooker (2007: 2-10) found that 18.5% of greater prairie chicken males account for 87.2% of the successful copulations on leks. Behney et al. (2012) recorded that four males engaged in all the copulation attempts on a lek averaging 1.52 males per morning, and two of these males accounted for 82% of the copulation attempts; on a second lek, six males were responsible for all the copulation attempts on a second lek averaging 16.0 males per morning, with one male accounting for 79% of the copulation attempts. Hunt and Best (2004: 15) asserted that the dominant male attacks any other male that attempts to copulate at the lek, but he is never interrupted; Sharpe (1968) also recorded many instances of a rival making a bluff charge at the dominant male during copulation, but also saw such attacks consummated on several occasions. Conversely, less dominant males may signal appeasement by retracting the head, lowering the pinnae feathers, partially retracting the eyecombs, and partially covering the wings with flank feathers (Sharpe 1968). Behney et al. (2012) hypothesized that males crowded successfully copulating males seeking to gain spillover copulations, more so than geographical position on the lek. Males may not be able to establish territories on leks until they are at least two years of age (Sharpe 1968, Jamison 2000: 113).

Aural and visual cues play important roles in the establishment of leks, and provide cues for the duration of lekking activity (McWilliams 2013: 1). The calls of males are variously known as “drumming” (Bent 1932: 281, Davison 1940), “gobbling” (Davison 1940, Baker 1953, Copelin 1963, Bidwell et al. 2002: 2), and “booming” (Donaldson 1969, Bain and Farley 2002). Copelin (1963) characterized the mating vocalizations of the male lesser prairie chicken as a series of two or three syllable gobbles, similar to the gobbling of a turkey, or sometimes similar to air bubbles emerging from water. These vocalizations are audible to the human ear at distances of one mile (Copelin 1963, Beauprez 2011: 11). Bent (1932: 281) described the sound of a large lek as follows: “The drumming of so many cocks would be of such a volume as to sound like distant thunder.” In addition, the males may cackle as part of their breeding vocalizations (Copelin 1963, Bidwell et al. 2002: 2). Giesen (1998) described all of these vocalizations, in addition to a number of others, including whining and soft squeaks. Males also produce sounds by stamping their feet, fluttering their wings, and flicking their tail (Giesen 1998, Bidwell et al. 2002: 2).

When two males face each other in a courtship display, they may alternate gobbles rapidly in such close sequence that the overall effect is that of one continuous gobble (Copelin 1963). Foot stamping starts slowly and builds to a rapid crescendo to create a “drum roll” effect (Sharpe 1968). Males may emit alternating booming calls (Sharpe 1968, Giesen 1998). The head jerks downward such that the pinnae flick down and up as the vocal sacs inflate, and the tail spreads open and closed at peak vocal sac inflation (Sharpe et al. 1968). Short, vertical “flutter jumps” are often performed in association with vocalizations (Copelin 1963, Sharpe 1968, Bidwell and Peoples 1991: 9004.2). These flutter jumps are particularly associated with other groups of lesser prairie chickens flying into sight (Copelin 1963), often involve cackling calls (Giesen 1998), and may serve to recruit additional lesser prairie chickens to the lek. When two evenly matched males face off, displaying may escalate into ritualized fighting and, in rare instances, actual combat in which the wings and beak are the primary weapons (Sharpe 1968).

As a hen walks into a lek, nearby males will begin to display, and may issue a specialized “pike call” that has been compared to the yelp of a turkey (Haukos 1988: 45, *and see* Sharpe 1968). Territorial boundaries may temporarily break down when receptive hens are on the lek (Sharpe 1968). In the presence of a female, the male may perform a “nuptial bow” with wings spread, pinnae erect, and bill lowered to the ground (Bidwell and Peoples 1991: 9004.2). Females signal their readiness for copulation by squatting and drooping their wings so that the primary feathers almost touch the ground, which signals a readiness to copulate (Copelin 1963, Sharpe 1968). In cases where the lek structure is unstable (due to a linear shape or harassment by avian predators, for example), females may lead males into surrounding brush for off-lek copulations (Haukos 1988: 47).

When several females are present on a lek at the same time, a dominant female may emerge who attempts to frustrate the access of other females to breeding males by driving them away or forcing them to congregate (Haukos 1988: 50). The dominant female may make a “clock-clock-clock” vocalization with her esophageal sacs, which may provoke an attack from a neighboring female, but these sounds are thin and not resonant like the booming of the males (Sharpe 1968, Haukos 1988: 50). During such dominance encounters, the dominant hen adopts an aggressive posture with the head and bill extended forward and the tailfeathers erect, while the submissive female adopts an appeasement posture similar to that used by the males (Sharpe 1968).

Males begin to gather at leks once again at dawn in late August for autumn lekking, with strutting commencing in late September and females arrive in October through November to be courted, but without copulations occurring (Copelin 1963). Davis et al. (1979) and Smith (1979), by contrast, documented no females at all in attendance during autumn lekking. Jones (1964) noted closer spacing of males on the lek at this time, and more desultory chasing and fighting than during the spring breeding period. Holt et al. (2010) hypothesized that autumn lekking may establish social structure that is carried through to lek territoriality during the spring breeding season, while Bergerud and Gratson (1988) further elucidated that fall lekking establishes dominance for adult males while yearling males are still too young and small to contest for territories, and that this dominance carries through to spring breeding.

The use of decoys and recorded calls at active lek sites did not increase number of displaying males, but did increase length of time of lek activite, and males displayed toward and attempted copulations with decoys placed on the lek (McWilliams 2013: 7).

Males begin to molt their feathers in early June, during the last week of lekking, while females are believed to delay molting after the nesting and brood-rearing seasons, with nullparous females molting several weeks after the males (Schwilling 1955: 21).

Nesting. The nest is a shallow depression in the soil, sparsely lined with plant material from the nest locale (Coats 1955). Ahlborn (1980: 31) found that 12 of 16 females studied nested near their lek of breeding, while four undertook movements averaging 2.31 km to nest near other leks. In Oklahoma, average distance from lek of capture to nest site was 3.71 km, as compared to 1.31 km (Wolfe et al. 2007: 100) to 3.4 km (Davis et al. 1979) in New Mexico. Wiedenfeld et al. (2001: 36) found that the average distance of a nest site from the lek in their New Mexico study was 1.33 km (0.83 mile), with a maximum distance of 3.25 km (2.02 mile). In southeastern Colorado, hens moved an average of 1.8 km from their lek of capture to their nest site, which was on average 1.04 km distant from the nearest lek (Giesen 1994a). In Kansas, Pitman et al. (2006a) found that hens nested within 0.7 km of a lek on average, but for 80% of hens the closest lek was not the lek where they were captured. Giesen (1998) reported that females may move their nest sites up to one km from year to year.

Average date of nest initiation was May 13 for New Mexico birds and May 23 for Oklahoma prairie chickens (Patten et al. 2005b). The median date for nest initiation in

Texas was May 7 (Grisham et al. 2014: 861, Table 2). The median date of nesting on Kansas CRP lands was May 7 in one year and May 10 in the second year, while median nesting date on grasslands was June 2 (Fields 2004: 37). Average hatch dates in Kansas were June 1 for first nests and June 22 for re-nests (Pitman et al. 2006a).

Eggs are variously described as cream colored to ivory yellow (Bent 1932: 282) or olive to white, with fine brown spots that may be either very faint or absent (Short 1967: 2). Average egg size is 41.9 millimeters (mm) along the long axis (Bent 1932: 282). In Kansas, Pitman et al. (2006a) found a mean clutch size of 12.0 for first nests and 7.6 for re-nests. Lautenbach (2015: 22) reported average clutch sizes of 10.4 eggs and 10.6 eggs in consecutive years in Kansas and Colorado. Patten et al. (2005b: 240, Table 2) found that clutch sizes were significantly larger in Oklahoma lesser prairie chickens (average of 10.8 eggs per nest) than in New Mexico (8.7 eggs per nest), but New Mexico hens tended to nest more consistently from year to year. Grisham et al. (2014: 861, Table 2) found a mean clutch size of 7.4 in Texas, and also noted lower rates of re-nesting. Lautenbach (2015: 26-27) concluded that clutch sizes are typically larger in the northern part of the lesser prairie chicken range than in the southern part.

Wiedenfeld et al. (2001: 37) found an average clutch size in a small New Mexico study site of 10.3 eggs. By contrast, Hagen (2003: 116) found that first nests in Kansas averaged 12.1 eggs per clutch versus 7.7 eggs per clutch for re-nests, and also found that re-nests showed a significantly higher probability of nest failure. Fields (2004: 96) documented an average clutch size of 11.9 and a 54.3% rate of nest success (hatching at least one egg), and a 9.4% re-nesting rate for lesser prairie chickens. Hagen et al. (2002) found nest success rates of 8%, 42%, and 32% during three consecutive years in the late 1990s. Pitman et al. (2005: 1266) documented a 26% nest success rate for lesser prairie chickens in the sand sage region of southwestern Kansas. Lautenbach (2015: 25) found a 38.8% nest survival rate in Kansas and Colorado. Pitman et al. (2006a) documented that nest success in the same region for yearlings (31%) was similar to that for adult hens (27%), but differed marginally between first nests (29%) and re-nesting attempts (14%). In Texas, nest success was documented in one study at 43% (Grisham et al. 2014: 863). Wolfe et al. (2003: 6) found an overall nest success rate of 41.8% in Oklahoma over the course of a five-year study, with a 30% of re-nesting the same year in cases of nest failure. Merchant (1982) found a 64% rate of nest success in New Mexico in one year, but a 0% rate of nest success in the following year, under drought conditions. Patten et al. (2005b: 236) found that lesser prairie chicken hens in Oklahoma were significantly more likely to re-nest than hens in New Mexico if the first nest failed. Unsurprisingly, yearlings show lower nest success than adult hens (Wolfe et al. 2003: 7).

Grisham et al. (2013: 7) postulated that the smaller clutch sizes and fewer re-nest attempts by lesser prairie chickens in New Mexico represent a life history strategy of investing heavily in one nesting attempt. Giesen (1998) reported that hens that re-nest the same year are likely to have smaller clutch sizes. Early nests are generally more successful than later nests (Copelin 1963, Giesen 1998). Pitman et al. (2006a) reported that 31% of hens whose first nest failed attempted to re-nest during the same year.

Following nest failure, hens may attempt to re-nest during the same spring. Augustine and Sandercock (2011: unnumbered 8) found that the closely-related greater prairie chicken clutch sizes averaged 10.9 eggs per nest, but that nest success was low (averaging 7.4% over a 35-day period); similar clutch sizes were reported for re-nest attempts. Wolfe et al. (2003: 10) found that lesser prairie chicken hens moved an average of 3 km from the failed nest site to re-nest.

The incubation period lasts 23 to 28 days (Bidwell et al. 2002: 3). Wiedenfeld et al. (2001: 37) documented an egg hatching success rate of 97.6% in New Mexico, although this was a relatively small study with small sample sizes.

Hagen et al. (2007a) hypothesized that lesser prairie chicken hens selected nest sites to optimize thermoregulation, detect predators, and elude predators during incubation. In southeastern Colorado, hens typically nested beneath sand sage or soapweed shrubs, and the tallest vegetation above nest bowls averaged 50.7 cm (Giesen 1994a). In an ungrazed area of New Mexico, maximum vegetation height at nests averaged 102.2 cm, which was significantly taller than vegetation at control points (Hunt and Best 2004: 15). Pitman et al. (2005: 1259) found that lesser prairie chicken hens selected nest sites that had taller grass, greater density of sand sagebrush, and higher visual obstruction than random points. Patten and Kelly (2010: 2151) found that lesser prairie chickens selected nest sites with higher percent cover (particularly shrub cover and shinnery oak cover), taller canopy height, and greater density of mid-height vegetation. In New Mexico, *Andropogon* grows in thick clumps that often have an opening in the center providing an ideal nesting site for lesser prairie chickens (McWilliams 2013: 50).

In one Texas study, lesser prairie chickens appear selected for nesting habitats with less leaf litter and bare ground (Grisham et al. 2014: 860). In the Shortgrass/CRP Mosaic region of Kansas, which is lacking in shrubs, Conservation Reserve Program lands typified by tall grass height and high stem density are commonly used by lesser prairie chickens for nesting habitat (Dahlgren et al. 2016: 268). For quality nesting habitat, Hagen et al. (2004) recommended providing dense shrubs and residual bunchgrass more than 16 inches tall that provide more than 75% vertical screening in the first 13 inches aboveground and 50% overhead cover, per the findings of Haukos and Smith (1989). Leaving behind at least 10 inches of residual grass height for cover after livestock grazing was also recommended (Hagen et al. 2004: 77).

Brood-rearing. Chicks are ready to begin foraging within a few hours after hatch (Applegate and Riley 1998: 14). Age of first short flights was reported as two weeks by Giesen (1998); Bell (2005) asserted that chicks are ready to begin flying as early as 7-14 days post-hatch. By the age of 34 days, the mobility and independence of chicks increases to the point where they can readily mix with other broods. Ahlborn (1980: 20) found that brood ranges averaged 116 acres (47 hectares) under ideal vegetation conditions.

Broods often seek shade in shinnery oak mottes or under other shrubs where oak is absent during periods of hot weather, but only when soil moisture is low (Copelin 1963). Bell et al. (2010: 484) found that in New Mexico, sand shinnery oak was a "critical component to their population persistence." Hens with broods select microhabitats that are warmer than random during cool weather, and that are cooler than random during warm weather (Bell et al. 2010: 481). The requirement of shade for brood survival during hot weather may explain why lesser prairie chickens appear to be limited to habitats where there is a shrub component (Copelin 1963), or tall grass. Hagen et al. (2004: 77) recommended managing brood-rearing habitat for 20-40% canopy cover of shrubs, forbs, or grasses that are 9.5-12 inches in height. In the Shortgrass/CRP Mosaic region, Conservation Reserve Program lands provide poor brood-rearing habitat due to excessively dense grasses, even though they are often used as nesting habitat (Dahlgren et al. 2016: 268).

The influence of the hen's nutritional plane on the quality of the egg is one of two key factors that influence subsequent chick survival, along with the quality of the chick's diet (Dobson et al. 1988). Patten et al. (2005b: 240) found that prairie chickens in New Mexico fledged significantly fewer chicks per nest attempt (average of 3.66) than Oklahoma birds (4.5 chicks fledged per nest attempt on average). This is perhaps due to lower average clutch sizes and/or poorer nutrition of the hens in these more arid habitats

Movements. Campbell (1972: 698) documented that the longest distance that banded males traveled from their lek of capture was 13 miles. Wiedenfeld (2001: 29) found the maximum distance moved by a lesser prairie chicken hen during the course of their New Mexico study was 7.1 km (4.4 miles); cocks showed even smaller movements, with a maximum distance of 3.5 km (2.2 miles). Toole (2005: 16) recorded smaller individual movements of up to two km. Autumn and spring dispersal of chicks following brood breakup may represent the greatest opportunity for lesser prairie-chicken dispersal and genetic mixing; Pitman et al. (2006c) found that male chicks only dispersed 1.4 km on average from their nest, but female chicks dispersed 1.5 to 26.3 km (0.9 to 16.3 miles) to establish new nests. Some females disperse more than 20 km (12.4 miles) from the lek of capture during the breeding season (Haukos and Zavaleta 2016).

Translocations and lek re-establishment. The lesser prairie chicken is relatively slow to colonize new or formerly occupied habitats (Crawford 1980: 5). McWilliams (2013: 7) had limited success attracting 1 to 3 male lesser prairie chickens to abandoned lek sites using decoys and recorded calls at 6 of 10 sites attempted.

Over the years, some have recommended transplanting lesser prairie chickens into unoccupied range to re-establish extirpated populations (*e.g.,* Copelin 1963: 52). Translocations of greater prairie chickens into a small, isolated, and genetically stressed population in Illinois was able to boost egg hatching success (Westemeier et al. 1998a) and restore historical genetic variation (Bouzat et al. 2009) in the recipient population. After an initial population boost, this population leveled off at a low population density, suggesting that full recovery to population viability remains uncertain (Bouzat et al. 2009).

Transplant efforts for lesser prairie chickens have never met with much success (Snyder 1967: 121, Davis 2005: 10). Ligon (1961) reports several transplant efforts to parts of lesser prairie chicken historic range in New Mexico, but with only limited success as the transplanted birds tended to return to their original home ranges. In Colorado, initial research indicated that many translocations had been attempted with wild-caught birds, but none had been proven successful to date due to an absence of pre-transplant surveys, and a lack of post-transplant monitoring (Davies 1993, Giesen 1994b). Later, all 10 translocation attempts were deemed failures at establishing or increasing populations (Giesen 1998). Duck and Fletcher (1944: 75) reported that when introduced outside their natural range, transplants of lesser prairie chicken are unlikely to be successful, but there was one apparently successful transplant of trapped birds in Oklahoma (p. 76). Coats (1955) reported some success with captive breeding and rearing of lesser prairie chickens, and reported that the most problematic part of the operation was successfully feeding the chicks and raising them to maturity. Captive breeding of greater (Drake 1994) and Attwater's prairie chicken has met with some limited success. Crawford (1980: 5) cautioned that relocations attempted with birds from game farms often fail.

Braun et al. (1994) cautioned that supplementing small populations of prairie grouse through transplants could do more harm than good through reducing desirable or adaptive traits. Oyler-McCance et al. (2016: unnumbered 15) cautioned against lesser prairie chicken translocations between ecoregions, arguing that egoregional genotypes may reflect local adaptations to uniquely different habitat types in each ecoregion, and that mixing them might result in individuals with lower inclusive fitness.

POPULATION STATUS: HISTORIC AND CURRENT

Historic population estimate. Johnsgard (2002: 34) estimated the original population of lesser prairie chickens to be three million rangewide, with two million of those inhabiting Texas just prior to 1900 according to the Texas Game, Fish, and Oyster Commission (*and see* Oberholser 1974: 268, Litton 1978: unnumbered 2), which comprised about two-thirds of the historical range. While some (*e.g.,* Davis et al. 2008) have contested the validity of this estimate because it would require a population density exceeding 8 birds per square kilometer, the density of lesser prairie chickens at the Sandsage Bison Range in southwestern Kansas were estimated at 19.3 birds per square kilometer in the spring of 1980 (Rodgers 2016: 22), so perhaps the original population estimate is not unrealistic after all. Flocks of 500 or more birds once gathered to feed on waste grains in the first agricultural fields created (Bailey and Williams 2000: 157, citing Colvin 1914; Schwilling 1955). Bent (1932: 284) records a 1904 account documenting lesser prairie chicken flocks numbering in the thousands:

> Here, each fall, the chickens gathered by the thousands, and each spring spread out over the vast prairies, nesting and rearing their young. In the fall of 1904 my brother estimated that he saw in a single day, 15,000 to 20,000 chickens in and around this one grain field.

Starting in the 1870s, lesser prairie chicken populations increased and remained high for a period with the assistance of grain cultivation providing additional winter food, a milder climate, and the suppression of natural predators by settlers (Rodgers 2016: 18). Judd (1905: 20) characterized the abundance of lesser prairie chickens in Wheeler County, Texas as follows:

> During severe winters they are so numerous that they become a nuisance. Some idea may be had of their abundance during winter from the information secured by Oberholser [a Biological Survey employee] that one man shipped 20,000 of them from this section in a single season.

Lesser prairie chickens were sufficiently abundant during this period that farmers in the region relied heavily on them for subsistence (Rodgers 2016: 19).

Current population estimate. Lek populations may be connected via female dispersal into larger metapopulations (DeYoung and Williford 2016: 89). Crawford (1980: 3) estimated a rangewide population of between 44,400 and 52,900 birds as of autumn 1979. McDonald et al. (2013: 15, 2014b: 536) estimated a total lesser prairie chicken population across their five-state range of 34,440 birds for 2012 and a total of 17,616 birds in 2013, with a 30% decrease in leks with displaying birds from 2012 to 2013 (*see* Table 2). In 2014, the total population estimate was 22,415 birds (McDonald et al. 2014a: 5). In 2015, the rangewide population stood at 29,162 birds (McDonald et al. 2015: 16). The most recent rangewide estimate is 25,651 birds across the 5-state area of occupied habitat (McDonald et al. 2016: 13). Using the historic population estimate of three million birds furnished by Johnsgard (2002: 34), the current population of lesser prairie chickens represents less than 1% of the original total.

However, an examination of population trends for the different ecoregional populations tells a different story. While there was a modest overall population rebound from 2013 to 2015, driven by increases in the Mixed Grass Prairie and Shortgrass/CRP Mosaic ecoregions, the Shinnery Oak Prairie and Sand Sage Prairie populations continued to decline substantially in 2014 and the Shinnery Oak Prairie population continued its decline in 2015. Several of these populations remain below the minimum viable population size of 5,000 birds.

Region	2012[1]	2013[2]	2014[2]	2015[3]	2016[4]
Shinnery Oak Prairie	2,946	1,967	1,292	814	3,255
Sand Sage Prairie	3,005	1,802	477	881	1,479
Mixed Grass Prairie	8,076	3,567	7,372	10,019	6,891
Shortgrass/CRP Mosaic	20,413	10,279	13,273	17,448	14,025
Total	34,440	17, 615	22,414	29,162	25,651

Table 2. Annual total population estimates for the four ecoregions inhabited by lesser prairie chickens.

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[1] McDonald et al. (2013), Table 4

[2] McDonald et al. (2013), Table 5

[2] McDonald et al. (2014a), Table 7

[3] McDonald et al. (2015), Table 8

[4] McDonald et al. (2016), Table 8

Reliance on lek counts to establish absolute population numbers for grouse has been criticized, but they do provide a useful index to population size and trend (Johnson and Rowland 2007: 20). McRoberts et al. (2011a: 775) found detectability of lesser prairie chicken leks to range from 72.3% to 89.9% using helicopter-based aerial surveys. Timmer (2012: 36) found that detectability of lesser prairie chicken leks using helicopter surveys was 51%, while Timmer et al. (2013: 747) recorded a detectability rate of 45.7%. Recent rangewide population estimates are based on aerial surveys that entail lek counts of a random subsample of lesser prairie chicken range, together with ground-truthing (McDonald et al. 2011: 5).

Population trends. Crawford (1980: 2) reported that the population size of the lesser prairie chicken declined by 97% over the previous 100 years. Garton et al. (2016: 49) used population data through 2012 to project a rangewide population of 200,000 birds in the late 1960s through population reconstructions, decreasing to about 25,000 birds in the late 1980s to mid-1990s, and increasing to an estimated 80,000 birds in 2008.

Kansas. In Kansas, Baker (1953) asserted that lesser prairie chickens were abundant prior to the Dust Bowl drought of the 1930s, which decimated populations. The combination of overgrazing, conversion of grassland to cropland, and severe drought decimated lesser prairie chickens in other states as well during the 1930s (Crawford 1980: 2). According to Schwilling (1955: 5), "During this drought period, which apparently almost eliminated the lesser prairie chicken in Kansas, there was little water, food, or cover available over most of their range.... Prairie chickens were reported found dead in large numbers with their throat and nostrils clogged with dust." In 1951, there were an estimated 40 lesser prairie chickens using five active leks in the state (*id.*). Sands (1968: 454) published a 1963 population estimate for lesser prairie chickens in Kansas of 10,000 to 15,000 birds.

Texas. According to Lyons et al. (2009: 94), "it is likely that current populations are not sustainable, thus without immediate attention focused on large-scale habitat restoration, the future of lesser prairie-chickens in Texas is bleak." Henika (1940: 5) reported that in Texas, the overwintering population of lesser prairie chickens was estimated at 2,000 birds in 1940, and stated, "[throughout] the present occupied range prairie chicken exist in thin density by comparison with populations of ten years ago." There was a further 50% decline in lesser prairie chickens between 1942 and 1953; there was no hunting of the species during this time (Crawford 1974: 3). Jackson and DeArment (1963: 735) reported that severe drought from 1952 through 1956 caused additional major population declines for lesser prairie chickens, and population recovery was prevented by changing land-use practices such as overgrazing and widespread herbicide spraying for brush control. These researchers estimated the Texas population at the time at "not much greater than 3,000 birds." Hughes and Mote (1997: 2) reported a steady decrease in males per active lek between 1969 and 1997.

Colorado. Lesser prairie chickens were apparently abundant in southeastern Colorado during pre-settlement times, with flocks of over 100 birds common prior to the 1930s (Hoffman 1963: 727), but the population crashed to a low during the Dust Bowl of the 1930s (Giesen 2000: 137). The birds were presumed extirpated during the 1950s, but in

1959 a total of six males were recorded at three lek sites; by 1962 the count had grown to 104 males on 13 active leks based on an increase in surveying effort (Hoffman 1963: 731). The statewide population in 1980 was estimated at 400 to 500 birds between two populations (Taylor and Guthery 1980a: 2). Based on surveys in Colorado between 1986 and 1990, the state population of lesser prairie chickens was estimated at 1,200-1,800 birds (Davies 1993). In 2000, the statewide population was estimated at less than 1,500 breeding birds (Giesen 2000: 137). As of 2013, Colorado Parks and Wildlife estimated a statewide population of 200-400 birds based on lek counts (CPW 2013: 1).

New Mexico. Bailey and Williams (2000: 158) estimated a pre-settlement population of 125,000 lesser prairie chickens in New Mexico. Snyder (1967: 121) reported that the lesser prairie chicken population began to increase in 1956, peaking in 1959 when the bird had re-occupied much of its original range. Sands (1968: 456), using unknown techniques but perhaps informed by hunter harvest figures, estimated the statewide population of 8,000 to 10,000 birds at that time, down from a peak population years of 1949 and 1961, when populations were estimated at 40,000 to 50,000 birds.

Best et al. (2003: 231) reported detections of lesser prairie chickens in 2000 and 2001 at 3 of 4,419 survey locations, and that "few encounters of this species in this survey indicates the current population is small." For southeastern New Mexico, Best et al. (2003: 232) concluded, "It is possible that normal environmental extremes or human-induced disturbances have rendered [this] region inhospitable for the long-term survival of the lesser prairie chicken." Hunt and Best (2004: 3) found only one active lek in southeast New Mexico, near Eunice, south of U.S. Highway 380 and east of the Pecos River. Davis (2005: 112) asserted the existence of a single active lek in Lea County at that time. McWilliams (2013: 69, 70) documented lekking activity near Eunice in 2008, but documented only a handful lesser prairie chickens in her study area in 2009, and no lesser prairie chickens at all in 2010 and 2011. Beauprez (2009: unnumbered 2) hypothesized that a 47% population decrease in New Mexico from 2008 to 2009 was attributable to a large May hailstorm in May of 2008 and dry spring and summer conditions. In 2009, the New Mexico breeding population was estimated at a minimum of 4,968 birds using 125 leks, with an average of 7.57 birds per lek (Beauprez 2009: unnumbered 2). In 2011, New Mexico populations were estimated at 6,130 birds; over the previous ten-year periond, the high was an estimated 9,443 birds in 2008 and the low was an estimated 3,013 birds in 2010 (Beauprez 2011: 22). Based on genetic testing, Pruett et al. (2011: 1212) postulated a declining population in New Mexico at that time. McWilliams (2013: 32) documented a non-lekking, scarce population in Eddy and Lea Counties of southeastern New Mexico, some 12 to 19 years after the last recorded lekking activity had been documented.

Oklahoma. Duck and Fletcher (1944: 71, Table X) estimated a total population of 14,914 birds in Oklahoma at that time. Copelin (1963: 49) estimated a total Oklahoma population of 15,000 birds and found a 52% decline in population density between the 1930s and 1960s in one Oklahoma test area; Cannon and Knopf (1980: 71) estimated a total state population of 7,500, a decline of almost 72% in Oklahoma lesser prairie populations between the 1940s and 1980. By 1980, the range of lesser prairie chickens in Oklahoma was becoming increasingly fragmented, with isolated remnant populations

(Cannon and Knopf 1980: 73). By 2000, the estimated statewide population was less than 3,000 birds (Horton 2000). Patten et al. (2005b: 246, Figure 6) modeled population persistence for lesser prairie chickens in Oklahoma, and starting with a population of 1,000 females, predicted a 50% chance of extinction within 17 years (by 2022) and a 90% probability of extinction by year 23, which would be 2028. Based on genetic testing, Pruett et al. (2011: 1212) postulated a stable population in Oklahoma at that time. Haufler et al. (2012: ii, 6) recommended a minimum population target of 5,000 birds in Oklahoma, representing "the current estimate of the minimum number necessary to maintain a viable population of [lesser prairie chicken] in Oklahoma."

Population Dynamics. Lesser prairie chickens are subject to naturally-occurring population fluctuations (Applegate and Riley 1998: 13, Massey 2001: 12). In other species of prairie grouse, variations in weather explain a significant amount of population variation (Flanders-Wanner et al. 2004: 23). Garton et al. (2016: 73) found that lesser prairie chicken populations consistently showed density dependence, but with geographic variation in the trends of carrying capacity and abundance. As a species of fragmented habitats with varying patch sizes and levels of isolation from one another, lesser prairie chicken population dynamics can also usefully be classified as four different metapopulations (Shinnery Oak Prairie, Sand Sage Prairie, Mixed Grass Prairie, and Shortgrass/CRP Reserve) each of which is made up of smaller populations occupying remnant habitat fragments of varying sizes. For each patch fragment, probability of extinction increases with decreasing patch size, while probability of recolonization increases with connectivity with other populations (a factor of both distance and permeability of the intervening habitat), for an overall metapopulation dynamics that reflects the changing balance of local extinctions and recolonizations (*after* Hanski 1998).

While the relatively long-lived greater sage grouse shows time lags of 2-10 years between habitat degradation and population response (Harju et al. 2010, entire), the shorter-lived lesser prairie chicken is not known to experience such time lags.

Fecundity. Hagen (2003: 124) proposed "a life history strategy of 'boom and bust' fecundity" driving lesser prairie chicken population dynamics. For all grouse, nest success is believed to be the most variable parameter influencing population dynamics, contributing more to changes in population size than any other parameter (Bergerud 1988: 681). The findings of Jamison (2000: 44, 61) support the idea that recruitment rather than adult survival determines population trends for this bird. Hagen (2003: unnumbered 3) and Hagen et al. (2009: 1329) modeled all demographic factors for lesser prairie chickens, and found that nest success and chick survival had the greatest effects on population trend. Wisdom and Mills (1997: 308) modeled the impact of all life stages on population parameters and determined conclusively that nest success and brood survival dominate the population changes for lesser prairie chickens.

Pitman et al. (2005: 1259) found in southwestern Kansas that nest success was most closely correlated with grass height (but not grass cover), sand sagebrush density, and sagebrush height. Grisham et al. (2014: 862) found that nest survival is positively correlated with visual obstruction, even though hens apparently did not select nest sites for visual obstruction. Patten et al. (2006: 15) confirmed that concealment was a critical determining factor for nest survival. Nests in hay meadows or cropland may be destroyed by harvesting or cultivation during May and June (Bidwell et al. 2002: 11), further reducing fecundity. Dahlgren et al. (2016: 268) pointed out that the quantity of suitable nesting habitat in the region may be the most influential factor in increasing population abundance and range in Kansas.

Females often re-nest if their first nest fails, but re-nesting contributes little to overall population trends (Hagen et al. 2009: 1328). In a New Mexico study, Patten et al. (2006: 15) found that less than 10% of females re-nested after their first nest failed. There seems to be a difference in life history strategy between Oklahoma and New Mexico birds in this regard.

Brood survival. Brood survival has been postulated as the single most important demographic parameter associated with population fluctuations of lesser prairie chickens (Wisdom and Mills 1998: 308, Hagen 2003: 125). In contrast to researchers who viewed nest success as the primary population driver, Fields et al. (2009: 937) argued that brood survival may be the most critical factor driving lesser prairie chicken population dynamics.

Brood survival increases with chick age, indicating an increasing ability to escape predation over time and with growth and fledging (Fields 2004: 6, Pitman et al. 2006b: 678, Fields et al. 2009: 931). Pitman et al. (2006b: 677) found that 33% of all broods were lost completely prior to 14 days post-hatching, and only 48% of all chicks survived this period. In one Kansas study, nearly half of all broods were completely wiped out prior to fledging (Jamison 2000: 61). Fields (2004: 89) found a 16.1% rate of chick survival to fledging, while Jamison (2000: 55) estimated chick survival at 19% for the first 60 days of life. In Kansas, Pitman et al. (2006b: 679) found an average juvenile survival rate 17.7% over the first 60 days and of 12% over the first year of life. Overwinter survival rate for chicks was 70%, with most mortality occurring during the dispersal period following the breakup of broods; body mass was the most important predictor of survival, with heavier chicks having a significantly greater chance of survival (Pitman et al. 2006b: 679).

Predators such as coyotes, hawks, owls, bobcats, raccoons, and foxes, as well as smaller predators, likely are the largest single source of chick mortality (Bidwell et al. 2002: 6). Broods may also be killed by hay harvesting equipment during the pre-fledgling period (Bidwell et al. 2002: 6).

Wet weather may also affect brood survival. Fleharty (1995: 43-44) excerpted a news story from the Osborne County Farmer indicating that in 1877, thousands of prairie chicken young were drowned or so weakened by the pervasive wet weather that they died before reaching maturity. Duck and Fletcher (1944: 73) reported that heavy summer rains in 1941 were associated with very poor brood survival. An 1879 account indicated that hundreds of prairie chickens had been killed by large hail near Kirwin (Fleharty 1995: 241). Hannon and Martin (2006: 423) found that the primary causes of early juvenile mortality in grouse were cold wet weather, predation, lack of food, and poor physical condition of the hen; cold, wet weather is particularly significant during the first 8 to 10 days of life when chicks are unable to thermoregulate on their own.

Hagen et al. (2009: 1328) found that nest success and female survival was greatest in the two pastures in their study area with the greatest amount of shrub cover, while brood survival was greatest in shrubby areas of intermediate shrub cover; however, chick growth and survival also were greater in areas with more forbs and less shrub cover in this study.

Adult survival. Lesser prairie chickens have relatively short lifespans. Campbell (1972: 689) found that populations of adult male prairie chickens on leks in New Mexico experienced complete turnover in about five years. Patten et al. (2006: 12) characterized most lesser prairie chickens as living about two years, and in their study a hen that achieved a four-year lifespan was nicknamed "Methuselah."

Hagen (2003: 176) found that 54% of mortality in his Kansas study area was attributable to mammalian predation, versus 16% for raptor predation, 5% for powerline collisions, and 5% for recreational hunting. Further extension and refinement of this dataset yielded 59% of hen mortality due to mammalian predators and attributed 11% of mortality to raptors. However, lekking males pay little attention to coyotes when the two are observed together at leks, suggesting that coyotes are little threat to adult birds (Duck and Fletcher 1944: 73).

Hagen et al. (2005: 82) found that the apparent survival rates (incorporating both mortality and emigration) of adult and yearling males varied greatly from year to year. Paradoxically, Nooker (2007: 2-14) found no correlation between mating success and survival for male greater prairie chickens, indicating that successful males were not more susceptible to predation or other mortality factors despite spending greater time and energy in displaying on leks where they are obvious to predators. Patten et al. (2006: 13) found that male lesser prairie chickens were more vulnerable to death by predation, whereas females had a greater risk of collision mortality from fences and vehicles, and ultimately were killed at nearly twice the rate of males.

Augustine and Sandercock (2011: unnumbered 1) found that for greater prairie chickens, annual survival averaged 27.7% during the year after capture, and 42.4% thereafter. This difference in survival during year after capture and subsequent years has not been tested for lesser prairie chickens, making this a candidate for additional study. For lesser prairie chickens, Jamison (2000: 146) estimated annual survival at 57% for adults. Hagen (2003: 174) documented age-specific annual survival probabilities as 62% for yearlings, 49% for adults, and 35% for older adults. Lyons et al. (2009: 93) found a 52% annual survival rate in the Sand Sage Prairie Region and a 31% annual survival rate in the Shinnery Oak Prairie Region during the same period of years. Fields (2004: 90) found that the overall probability of hens surviving the nesting and brood-rearing seasons was 62% during the first year of the study and 66% during the second year. In northeast Texas, Toole (2005: 12) found combined survival rates for both sexes through the breeding and nesting seasons ranging from 62.7% to 70.5%. Haukos (1988: 13) extrapolated survival rates for lesser prairie chicken hens during the breeding and pre-incubating periods and projected an impossibly low annual survival rate of 4.1% if the breeding and pre-incubating mortality rate was sustained throughout the year.

Survival for females is higher outside the nesting and brood-rearing seasons, presumably because these activities render females more susceptible to predation (Hagen 2003: 175, Lyons et al. 2009: 93). In Kansas, Robinson (2015: 82) found that survival over the 25-week nonbreeding season (mid-September to mid-March) ranged from 68% to 83% between three study sites, while Plumb (2015: unnumbered 4) found an average survival rate during the breeding season of 45.5% in the same study area. Hagen et al. (2007a) concluded that females engaged in nesting and/or brood-rearing had lower daily survival rates than hens not engaged in these activities, indicating the nesting and brood-rearing places adult hens at greater predation risk. In the northeastern panhandle of Texas, Kukal (2010: 54) documented a 62.6% probability of overwinter survival for lesser prairie chickens. Also in Texas, Boal and Pirius (2012: Discussion 8) found an average survival rate in the nonbreeding season of 72.1%. However, severe winter weather can cause major die-offs; during the winter of 2006-2007, a severe blizzard is credited with 75% mortality in the populaton of lesser prairie chickens (J. Reitz, unpubl., *as cited in* Haukos et al. 2016b: 285).

Hagen (2003: 174, 175) found that male and female survival rates were similar, but that female mortality rates were greater during the nesting season, and survival rate was higher for yearlings (which do not breed). Patten et al. (2005b: 240) found that female mortality was concentrated in May and June, corresponding to the period of movements from leks to nesting areas, while male mortality was highest from March through May, during the lekking season.

Male local survival rates (which incorporate emigration and mortality) found by Hagen (2003) in Kansas averaged 61.5% for yearlings, 48.5% for adults, and 34.7% for older adults. Campbell (1972: 694) calculated male mortality rates at 64.2% per year based on a life-table analysis, and postulated a 5-10% overestimate of mortality rates in that study due due to inefficiencies in the recapture method.

Shrub cover is critical to lesser prairie chicken survival in New Mexico and western Oklahoma; Patten et al. (2005a: 1275) found that survivorship was significantly greater in habitats with more than 20% shrub cover than in habitats with 10-20% shrub cover, and these latter habitats in turn showed greater prairie chicken survivorship than habitats with less than 10% shrub cover. Survival time increases with increasing shrub cover and grass cover (Patten et al. 2005a: 1275, 2006). By contrast, Kukal (2010: 55) found (with relatively small sample sizes) that overwinter survival decreased as patch size of oak mottes increased.

Patten (2005b: 243) found that lesser prairie chicken hens had significantly higher rates of mortality in the highly-fragmented Oklahoma habitats versus the less-fragmented New Mexico habitats due to greater propensity for collisions with fences, powerlines, and vehicles, but that male mortality rates were similar in both states. Fragmented populations may be maintained in part by immigration (Hagen 2003: 177).

Population distribution. The occupied range of the lesser prairie chicken has decreased 92% since the 1800s, which incorporates a 78% decrease in range since 1963 (Taylor and Guthery 1980a: 4). The current and historical range of the lesser prairie chicken have been mapped in great detail using GIS mapping technology by a number of researchers, most recently by the Playa Lakes Joint Venture (Bartuszevige and Daniels 2013: 5, Figure 2), which documented a 90% reduction in occupied range for this species from its original historical range. During the Pleistocene, the lesser prairie chicken may have had a very expansive range, as bones from this period have been found as far away as Oregon (Crawford 1974: 1).

Many recent studies have modeled remaining suitable habitat for lesser prairie chickens (*e.g.,* Dusang 2011, Jarnevich et al. 2016). Jarnevich et al. (2016: unnumbered 9) found that more than 50% of the lesser prairie chicken's historic range is now unsuitable as habitat for these birds. Much of the remaining suitable habitat (when considering natural features and anthropogenic impacts, *see* Figure 8(b) and (c) below) is badly fragmented.

Texas. The Texas population of lesser prairie chickens experienced a 78% range contraction between 1963 and 1980, and estimated lesser prairie chicken habitat in Texas at 1.3 million acres by 1989 (Sullivan et al. 2000: 179). In Texas, the 1940 range was estimated at 3.4 million acres, which was reduced to 1.4 million acres by 1990 due largely to conversion to cropland (Hughes and Mote 1997: 1). The species now occurs primarily in six of the original 14 Texas counties of its native range, almost entirely on private lands (Seyffert 2001: 108). Johnsgard (2002: 35) pointed out that the human population of seven Texas panhandle counties dropped by 1% per year over the last years of the 20th Century, reducing pressure on lesser prairie chicken habitats, and the Ogallala aquifer responsible for irrigated agriculture in the region was rapidly being depleted, stating that "When the Texas aquifer finally runs dry, perhaps in less than a hundred years, the land might revert to prairie-chicken habitat even if no prairie-chickens are there to reclaim it." Groundwater depletion for irrigation and municipal use already outpaces recharge, and in some parts of Oklahoma, Kansas, and the Texas panhandle, the Ogallala aquifer has already been drawn down between 100 and more than 250 feet (Karl 2009: 124).

Kansas. In Kansas, an original 19 million acres of occupied lesser prairie chicken range decreased to 2.5 million acres in the 1950s, rebounding somewhat to 7.2 million acres at present (Channell 2010: 27). Jensen et al. (2000: 171) found that lesser prairie chickens were present in 31 of 39 Kansas counties where they are believed to have occurred historically, but that the population was declining steadily. Spencer (2014: 24) reported an increase in grassland (including CRP lands) from 50% of the former range in 1950 to 53.9% in 2013.

Colorado. Originally, lesser prairie chickens were common south of the Arkansas River in the southeastern corner of the state (Lincoln 1918: 236), and had an original range spanning six Colorado counties – Lincon, Cheyenne, Kiowa, Bent, Prowers, and Baca (Giesen 2000: 140, Figure 1). Taylor and Guthery (1980a: 2, Figure 1) reported occupied range only for Prowers and Baca Counties in 1978. Small and isolated populations remain in Kiowa and Cheyenne Counties, and larger populations currently occur in Baca and Prowers Counties, contiguous with Kansas and Oklahoma; populations in Lincoln and Bent Counties may not currently occur (Giesen 2000: 140, Figure 1). Van Pelt et al. (2013: 78) estimated the current occupied range in Colorado at about 1.1 million acres.

Oklahoma. Cannon and Knopf (1980: 71,72) reported that by that time the range in Oklahoma had shrunk from 13 counties to small and isolated patches of occupied habitat in Beaver, Texas, Harper, Woodward, Ellis, and Roger Mills Counties, representing a range contraction of 55% between 1960 and 1980. The Oklahoma range of the lesser prairie chicken contracted by 55% between 1960 and 1980 (*id.*: 74, *and see* Figure 1). In Oklahoma, by 2000 the lesser prairie chicken was known to occur in 8 of the 22 counties where it is known to have occurred historically, an areal decrease of 63.6% (Horton 2000, *and see* Haufler et al. 2012: 2). Van Pelt et al. (2013: 78) estimated the current occupied range in Oklahoma at about 4 million acres.

New Mexico. As shown in Figure 4 of this Petition, the range of lesser prairie chickens in New Mexico has contracted markedly over the course of the recorded history. Sands (1968: 454) reported the possibility of a small remnant population in eastern Harding County in northeastern New Mexico, and the last record of lesser prairie chickens in this area was in 1993 (Massey 2001: 7). McWilliams (2013: 96) reported the occupied range of this bird was limited to portions of Curry, De Baca, Roosevelt, Chavez, and Lea Counties (*see* Figure 4). Van Pelt et al. (2013: 78) estimated the current occupied range in New Mexico at about 2 million acres.

Outside historic range. Lesser prairie chickens were introduced to the high, grassy plateaus on the eastern end of the island of Niihau in Hawaii in 1934 (Fisher 1951). This population was still believed to be in existence as late as 1980 (Taylor 1980), but was believed to be extirpated as of 1998 (Giesen 1998).

IDENTIFIED THREATS TO THE PETITIONED SPECIES: CRITERIA FOR LISTING

The Service must evaluate whether a species is "threatened" or "endangered" as a result of any of the five listing factors set forth in 16 U.S.C. § 1533(a)(1):

> A. The present or threatened destruction, modification, or curtailment of its habitat or range;
> B. Overutilization for commercial, recreational, scientific, or educational purposes;
> C. Disease or predation;
> D. The inadequacy of existing regulatory mechanisms; or
> E. Other natural or manmade factors affecting its continued existence.

In the current spate of global human-caused extinctions, habitat destruction and invasive species are the primary culprits worldwide; overexploitation and alien diseases are additional contributors (Wilcove et al. 1998: 607). Grassland bird assemblages are declining markedly as a result of habitat fragmentation; rangeland degradation as a result of overgrazing, invasive weeds, and lack of fire; and other factors affecting seasonal habitats beyond grasslands (Brennan and Kuvlesky 2005: 5). In fact, endemic grassland birds have declined more than any other group of birds during the latter part of the 20th century (Knopf 1994: 251, 1996: 142). Remaining expanses of grassland may too small and degraded by livestock grazing to support viable populations of grassland birds over the long term (With et al. 2008: 3163).

The lesser prairie chicken is considered an "umbrella species" (Pruett et al. 2009a: 1254, Pruett et al. 2009b: 257), a species that requires sufficiently large and unfragmented native habitat that its conservation effectively provides for the conservation of a number of other sensitive species. It has also been recognized as an indicator species (Ross et al. 2016: 2 termed it a "sentinel species"), acting as the "canary in the coal mine" to signal ecological distress at an ecosystem scale. According to Partners in Flight, "Within the range of Lesser Prairie-Chicken, the needs of this species should drive grassland bird conservation" (Rich et al. 2004: 62).

Mote et al. (1999: 16) asserted that the lesser prairie chicken is an indicator of ecosystem health, and that "Maintenance of viable populations of [lesser prairie chickens] would indicate that the southern Great Plains ecosystem, including its many species and their interactions, is being maintained." Because the lesser prairie chicken does not belong to a monotypic genus (a genus that includes only one species), the highest possible Listing Priority Number is 2. First Declaration of Michelle Shaughnessy, Case No. 7:14-CV-00050-RAJ, at ¶2. The U.S. Fish and Wildlife Service elevated the Listing Priority Number from 8 to 2 in 2008. 73 Fed. Reg. 75176, 75179-80.

(Factor A) The Present or Threatened Destruction, Modification, or Curtailment of the Species' Habitat or Range

Habitat fragmentation. The state of habitat fragmentation is the discontinuity in the spatial distribution of resources and conditions that affects occupancy, reproduction, or survival of a particular species, and the process of habitat fragmentation is the set of mechanisms leading to that state (Franklin et al. 2002: 27). The impacts of habitat fragmentation are inevitably confounded with the impacts of direct habitat loss, which occurs simultaneously (Harrison and Bruna 1999: 227). The process of habitat fragmentation, in addition to the subtraction and isolation of available habitat, can result in building up populations of harmful species in the matrix between suitable habitats, which then extend a negative influence into the remaining pockets of suitable habitat (Wilcove et al. 1986: 248).

According to island biogeography theory, smaller "islands" of habitat have greater rates of extinction, while distance to the next nearest island determines rate of recolonization and population rescue via immigration; thus, both patch size and degree of connectivity with other patches determine the persistence of populations in fragmented environments (Hunter and Gibbs 2007: 183). Samson (1980: 294) found that grassland islands occupied by greater prairie chickens were significantly larger than unoccupied patches, averaging 424 acres in size while unoccupied islands of grassland averaged 81 acres. Fahrig (1997: 607) argued based on modeling that habitat loss itself has a greater impact on the probability of population extinction than does habitat fragmentation.

Habitat fragmentation increases the probability of population extinctions, and also places a premium on maintaining sufficient connectivity to allow recolonization through dispersal of areas where populations were previously extirpated (Fahrig and Merriam 1994: 54). Thus, habitat fragmentation leads to the biological impoverishment of resulting fragments of habitat (Harrison and Bruna 1999: 229). Coppedge et al. (2001: 56, 57) found that increasing juniper expansion and habitat fragmentation due to conversion to cropland resulted in fewer grassland specialist birds, while large core areas of grassland with little tree encroachment held the most abundant assemblages of grassland birds. Populations in fragmented habitats can become more susceptible to inbreeding depression (Keller and Waller 2002: 240).

Habitat fragmentation is a process that encompasses the impacts from a number of human activities, including construction of roads and powerlines, energy development, cropland cultivation, and urbane or rural sprawl. Grisham et al. (2016a: 227) pointed to projected increases in oil and natural gas drilling in lesser prairie chicken range, stating,

> Energy development and agricultural practices have the greatest potential to impact Lesser Prairie-Chickens because [these] types of land use tend to occur in rural areas and influence large expanses of habitat. Energy development will increase in the future because of increases in population and per capita energy demands.

According to Davies (1993: 13):

> The primary threat to lesser prairie chickens is habitat alteration and loss. Development of oil and gas resources, overgrazing, and conversion of grasslands to croplands are major threats. Poor growing conditions and improper livestock stocking rates resulting in inadequate nesting and winter cover are of concern.

Human developments that fragment habitats can result in both displacement of sensitive species from preferred habitats as well as stress to individuals that remain in close proximity. Fuhlendorf et al. (2002: 626) found that the decrease in large patches of unfragmented habitats was correlated with declining prairie chicken populations. Bartuszevige and Daniels (2016: 212) found in a rangewide analysis that active leks were positively correlated at the 3,000 m and 5,000 m buffer distances with large patches of habitat that were outside the impact buffers for anthropogenic features like roads, powerlines, and oil and gas wells. Hagen (2003: 156-157) found that the study area with comparatively greater habitat fragmentation had lower survival and fecundity than a less

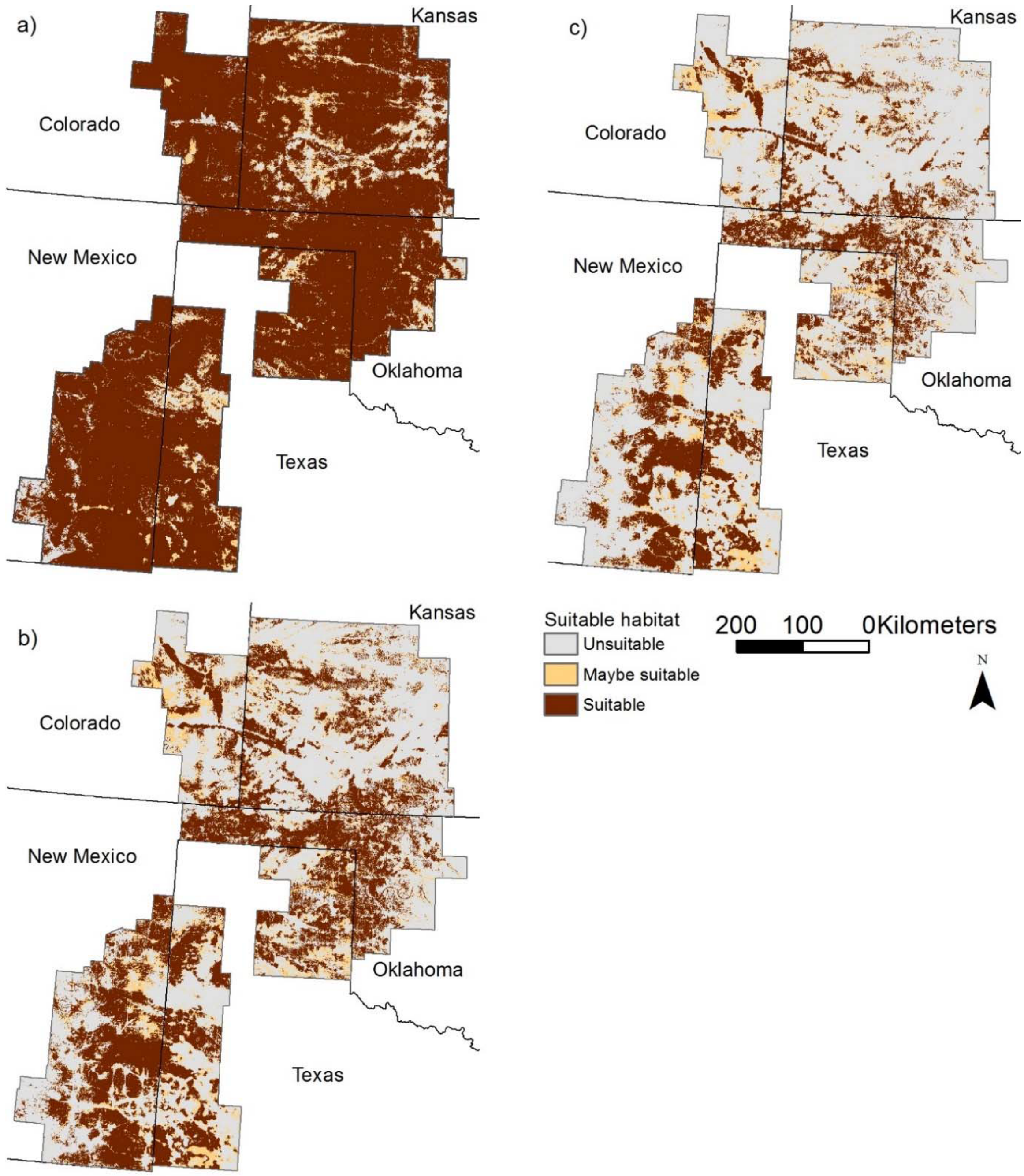

Figure 9. Lesser prairie-chicken remaining habitat as mapped according to lek suitability agreement between models including and excluding state as a categorical variable, including agreement between a) the minimum training presence threshold, b) the five percentile threshold, and c) the ten percentile threshold. The 'maybe suitable' category indicates locations where one model classified a location as suitable while the other classified it as unsuitable. Excerpted from Jarnevich et al. (2016: unnumbered 7).

fragmented study area, and that prairie chickens avoided powerlines, wells, and buildings. Pitman et al. (2005: 1267) calculated that anthropogenic features effectively eliminated 53% of the nesting habitat in their southwest Kansas study area. Jarnevich et al. (2016: unnumbered 9) found that habitat suitability increased with distance from anthropogenic features throughout the range of the lesser prairie chicken. *See* Figure 9.

Jarnevich and Laubhan (2011: 932) found that distance from roads, oil and gas wells, and powerlines increased lek habitat suitability, and that sensitivity to these anthropogenic features is increasing with time; density of oil and gas wells is also becoming an increasingly important factor which is negatively correlated with active leks. Fuhlendorf et al. (2002: 623) found that changes in land cover over decades showed a stronger relationship to lesser prairie chicken population trend than did current land cover status, and attributed this to the time lags in population responses to land cover alteration. Hagen et al. (2011: 73) and Grisham et al. (2014: 864) found that lesser prairie chicken habitat use showed significant avoidance of improved roads, powerlines, buildings, and oil and gas wells. Dusang (2011: 5) concluded that "nesting habitat was impacted most severely by avoidance of man-made structures."

Cushman et al. (2010: 25) identified key fracture zones and connecting corridors between lesser prairie chicken populations important for maintaining regional connectivity, noting that habitat restoration and/or the establishment of stepping-stone populations may be necessary for these corridors to be effective. On the other hand, Wilcove et al. (1986: 255) argued in a broader ecological context that maintaining at least marginally suitable habitats in the lands surrounding habitat fragments may contribute more to the survival of fragmented populations than providing habitat linkages between fragments.

According to the U.S. Fish and Wildlife Service, "On these facts, the loss and fragmentation of even relatively small amounts of existing and suitable habitat can easily put the species on a path towards a 'death spiral' from which it cannot recover, as the Service has seen for similar prairie grouse species such as the now-extinct heath hen and endangered Attwater's prairie-chicken." Defendant's Additional Filing in Support of their Opposed Motion to Amend the Judgment, Case No. 7:14-CV-00050-RAJ at 7. A ranking official with the Service has testified that "[a]lthough restoring habitat that is already fragmented will be essential for conserving the species, the majority of the existing conservation efforts for the lesser prairie-chicken, with the exception of the RWP, focus primarily on protecting existing suitable habitat, rather than restoration of fragmented habitat." Declaration of Jennifer Norris, Case No. 7:14-CV-00050-RAJ Document 115-1 at 4.

<u>Edge effects.</u> Habitat fragmentation results in the creation of "edge effects" along the boundaries of remaining native habitat, where negative impacts extend for varying distances from the margins into the remaining fragments of native habitat; in many cases multiple edge effects create amplified levels of impact (Wilcove et al. 1986: 249, Fletcher 2005: 348). Mesopredators like foxes and skunks concentrate their activities near roads and other linear, human-caused features (Frey and Conover 2006: 1115). Forman (2000:

35) estimated that about one-fifth of the United States is directly affected ecologically by the system of public roads. The edge effect principle can be related to patch size through comparing the "core area" of habitat fragments (the areas more than 100 m from an edge), in effect the acreage of habitat that is unaffected by edge effect (Sisk and Battin 2002: 40). These edge effects may be far more important than spatial arrangement or connectivity among fragments, as the presence of corridors is incapable of ameliorating edge effects (Harrison and Bruna 1999: 229). This assertion is consistent with the findings of Helzer and Jelinski (1999: 1451), that perimeter-area ratio of grassland patches (an index of edge effect) was negatively correlated with the probability of occurrence of grassland passerines, and that edge effect was stronger than the influence of relative patch size.

Fuhlendorf et al. (2002: 623) found that increasing edge density (an index of habitat fragmentation) was correlated with declining populations of lesser prairie chicken at small geographic scales.

Lessons from other grouse species. DeYoung and Williford (2016: 78) argued that scientific knowledge pertaining to other prairie grouse is often applicable to lesser prairie chickens. Habitat fragmentation is correlated with population declines and/or extirpations for many grouse species, including Gunnison sage grouse (Oyler-McCance et al. 2001: 328, Wisdom et al. 2011: 464) and greater sage grouse (Knick et al. 2013: 1539, Wisdom et al. 2011: 464). Knick et al. (2013: 1544) found that 99% of active sage grouse leks were surrounded by habitats with less than 3% disturbance, while Kirol (2012: 15) found that surface disturbance exceeding 4% had a significant negative effect on sage grouse brood-rearing habitat. Winter and Faaborg (1999: Appendix) found that greater prairie chickens were entirely absent from small prairie fragments (less than 321 acres), requiring larger expanses of prairie to persist. The response of nest predators appears to be strongest to fragmentation at the landscape scale, rather than the edge or patch scales, and thus avian nest success also shows the greatest response to fragmentation at the landscape scale (Chalfoun et al. 2002: 311, Stephens et al. 2003: 104). Aldridge et al. (2012: 405) examined Gunnison sage grouse nesting habits and recommended that roads and residential developments be sited more than 1.5 miles from crucial nesting habitat. The increase in nest predation due to habitat fragmentation appears to be even greater for agricultural landscapes than for predominantly forested landscapes (Chalfoun et al. 2002: 312). As a result of all types of energy development, habitat loss in United States temperate grasslands by 2030 is estimated to be 65,000-191,000 km^2, and for all ecosystems types the amount of new land lost to energy development sprawl will be 206,000 km^2 nationwide by 2030 (McDonald et al. 2009: 5, 6). For greater and Attwater's prairie chickens, habitat fragmentation has been implicated in causing genetic bottlenecks that reduce genetic diversity in the resulting fragmented populations (Johnson et al. 2007: 2219).

Oklahoma. Lesser prairie chicken habitats in rural western Oklahoma are typically divided into square-mile (640-acre) sections, which are often further fenced into 160-acre pastures or crop fields (Patten et al. 2005b: 244). In the highly fragmented habitats of western Oklahoma, collisions with fences, vehicles, or powerlines accounted for 42.4%

of all lesser prairie chicken mortality, versus 14.3% of mortality in the less-fragmented habitats of New Mexico, where parcel size of private lands is ten times larger, and roads, fences and powerlines are one-half to one-third as dense (Patten et al. 2005b: 240). For Oklahoma alone, Dusang (2011: 31, 32) estimated that 2.4 million acres of suitable nesting habitat (or 43.5% of modeled habitat of this type) is lost to current oil and gas development and planned wind development, while 620,511 acres of lek habitat (or 5% of modeled habitat) is lost to current oil and gas development and planned wind development.

Kansas. Robel et al. (2004) found that in their Kansas study area, 58% of the available grassland habitat remaining in 2001 was negatively affected by infrastructure and industrial features. Pitman et al. (2005: 1268) found that nesting birds avoided habitats within one km of buildings. Hagen (2010: 100) performed a meta-analysis of multiple studies on the impacts of development (including wind, oil and gas, and transmission) on prairie grouse, and found moderate to large displacement effects and small to moderate demographic effects.

In some ways, total patch size can be an index of fragmentation, although it may not account for all types of anthropogenic linear disturbances. In Kansas, Spencer (2014: 43) documented a slight increase of 7.7% in mean patch size, indicating that increasing enrollment of CRP lands was reducing habitat fragmentation; an increase in edge for the same period provides a contradictory perspective, indicating that habitat fragmentation is continuing.

New Mexico. In New Mexico, only four habitat patches exceeded the 17,885-acre threshold necessary to maintain lesser prairie chickens over the long term (Johnson et al. 2006: 3). Thus, only 26% of suitable habitat occurred in patches large enough to support lesser prairie chickens, 74% of the "suitable" habitat (including most high-quality habitat) was in patches too small to support lesser prairie chickens (*id.*).

Texas. Agricultural conversion has played a major role in eliminating and fragmenting lesser prairie chicken habitats (Hagen et al. 2010: 30). Fossil fuels development is prevalent across a large acreage of remaining occupied habitat in Texas (Haukos 2011: 110, Ungerer and Hagen 2012: 29, 30, *see esp.* Figure 9 this petition), and further contributes to the fragmentation of remaining grassland. Habitat fragmentation in Texas also includes over a million acres of shinnery oak elimination (Bell et al. 2010: 484). Future habitat fragmentation in Texas from wind power generation is likely to accelerate due to the magnitude of projected future wind power development in lesser prairie chicken occupied range (*see* ERCOT 2006: ES-1, Timmer 2012: 61, Timmer et al. 2013: 741) and the absence of permitting regulations protecting lesser prairie chicken habitats from the construction of new powerlines and wind farms (Brennan et al. 2009: 181).

Colorado. Human settlement and habitat fragmentation from the cultivation of row crops are the primary form of habitat fragmentation in Colorado (Giesen 1994b: 180). Parts of the remaining range in Colorado have potential for further fragmentation through oil and gas development (Copeland et al. 2009: 3).

Oil and gas development. Oil and gas development is currently one of the major ongoing causes of habitat loss and fragmentation for lesser prairie chickens. Oil and gas development was recognized as a major factor in reducing lesser prairie chicken range and population densities as early as 1940 (Henika 1940: 3). The Permian Basin oil and gas deposits are 250 miles in width and 300 miles in length, overlapping much of the Llano Estacado which provides habitat for the lesser prairie chicken; Rodgers (2016: 22) stated, "Nowhere within the range of the species is the impact of oil and gas infrastructure more evident than in the Permian Basin of Texas and adjacent New Mexico." Major oil and gas activity also occurs throughoput Oklahoma and Kansas. Oil and gas drilling activity fluctuates with market prices, peaking during "boom" periods when crude oil or natural gas prices are high (Boyd 2007: 1). Some 38.4% of the current lesser prairie chicken habitat rangewide has one or more oil and gas wells per square mile, and 12.1% of the range has a density of four or more wells per square mile (Ungerer and Hagen 2012: 29). Areas of greatest intensity of development include the Permian Basin affecting the Shinnery Oak Prairie population of Texas and New Mexico, as well as northeast Texas and parts of Oklahoma and Kansas that are part of the Mixed-Grass Prairie and Shortgrass/CRP Mosaic populations (*see* Figure 10). As of 2013, there were 4,212 oil and gas wells within the range of the lesser prairie chicken that had remained inactive for ten years or more (and therefore are required to be shut in and have equipment removed) in Texas alone (Van Pelt et al. 2013: 11). Oil and gas development has expanded into most of the remaining range of the lesser prairie chicken in New Mexico (Massey 2001: 16). According to Rodgers (2016: 27),

> New technologies include improvements in seismic detection of oil-bearing formations, carbon dioxide injection into older oil fields, the development of horizontal drilling techniques, and hydraulic fracturing. New oil and gas infrastructure has sprung up in many parts of the remaining range of Lesser Prairie-Chickens, but this boom has been particularly intense in the species' remaining range in the northeast Texas Panhandle and adjacent northwest Oklahoma.

Copeland et al. (2009: 3) mapped several areas that overlap with lesser prairie chicken occupied range in Colorado and New Mexico that have moderate to high potential for oil and gas development.

A major driver of habitat fragmentation, oil and gas infrastructure development within wellfields can result in nearly 100% affected habitat using a quarter-mile zone of influence (Weller et al. 2002: 11, Figure 4). Characterizing the findings of Pitman et al. (2005), Rodgers (2016: 22) described the potential impacts of full-field oil and gas development as follows:

> The field project, combined with earlier studies, demonstrated how Lesser Prairie-Chicken populations could be completely lost from intensive oil and gas production fields, even though much of the original vegetation remains. Project results also revealed how even widely scattered oil and

> gas infrastructure can still have negative impacts on Lesser Prairie-Chicken populations.

The amount of land actually converted to roads and wellpads reflects only a small minority of the total impact of oil and gas development. The direct footprint of oil, gas, and geothermal development represents only 5% of the total habitat negatively affected, while the impacts of habitat fragmentation and species avoidance behavior accounts for 95% of the habitat impacted by oil and gas development (McDonald et al. 2009: 4). Thus, while only a small proportion of the habitat is directly disturbed, the entire land area encompassed by an oil and gas field is typically degraded as habitat.

Lessons from other grouse species. While experiments, including those employing a Before-After-Control Investigation (BACI) design, have not been attempted for prairie grouse response to oil and gas development, numerous observational and correlative studies have been completed in varying habitats and circumstances. All yield similar results, suggest that the impacts of oil and gas development on prairie grouse are now well-understood and not artifacts of study design, methods, investigators, or other bias (Beck 2009: 68).

The impacts of oil and gas development on the related greater sage grouse are well-documented. Sage grouse are negatively impacted by oil and gas development, and lek populations decline when wells are drilled within 3.1 miles of leks, when producing wells occur within 1.9 miles of leks, and when overall wellsite density is greater than one well per square mile (Holloran 2005: 50, *and see* Walker et al. 2007: 2652). In some cases, sage grouse numbers have not recovered even after the oil and gas facilities were fully reclaimed (Braun et al. 2002: 339). Scientific research has determined that one energy site per square mile is the density threshold at which significant impacts to sage grouse populations begin to be measured (Doherty 2008, Taylor et al. 2012: 23, Copeland et al. 2013: 5, Figure 4). Tack (2009: 43, Figure 9) found that in a study in Montana's Milk River Basin, well densities of one per square mile were correlated with a very low probability of a lek being large. Copeland et al. (2013: 7, Table 1) found that a statewide analysis of well densities revealed population decline curves very close to the earlier studies by Holloran (2005), but also noted that a one wellpad per square mile density of development correlated to an approximately 18% decline in sage grouse lek population (*see* Holloran 2005: 91, Figure 4). So one wellpad per square mile is definitely not a zero-impact threshold. It is important to make the greatest possible attempt to maintain small, isolated populations of prairie grouse within the matrix of developed areas wherever possible to serve as seed stock for repopulation once the development is fully reclaimed, because transplanting these species is so fraught with difficulty (Doherty et al. 2010: 8).

Impacts on lesser prairie chickens. Habitats near oil and gas wells are avoided by lesser prairie chickens (e.g., Pitman et al. 2005: 1268, Hagen et al. 2011: 73, Timmer 2012: 72). Hagen (2010: 100) pointed out that while lesser prairie chickens show a smaller radius of avoidance for energy production facilities than sage grouse, habitats impacted by such facilities may become population sinks where prairie chickens can survive but are constrained by long-term negative population trends.

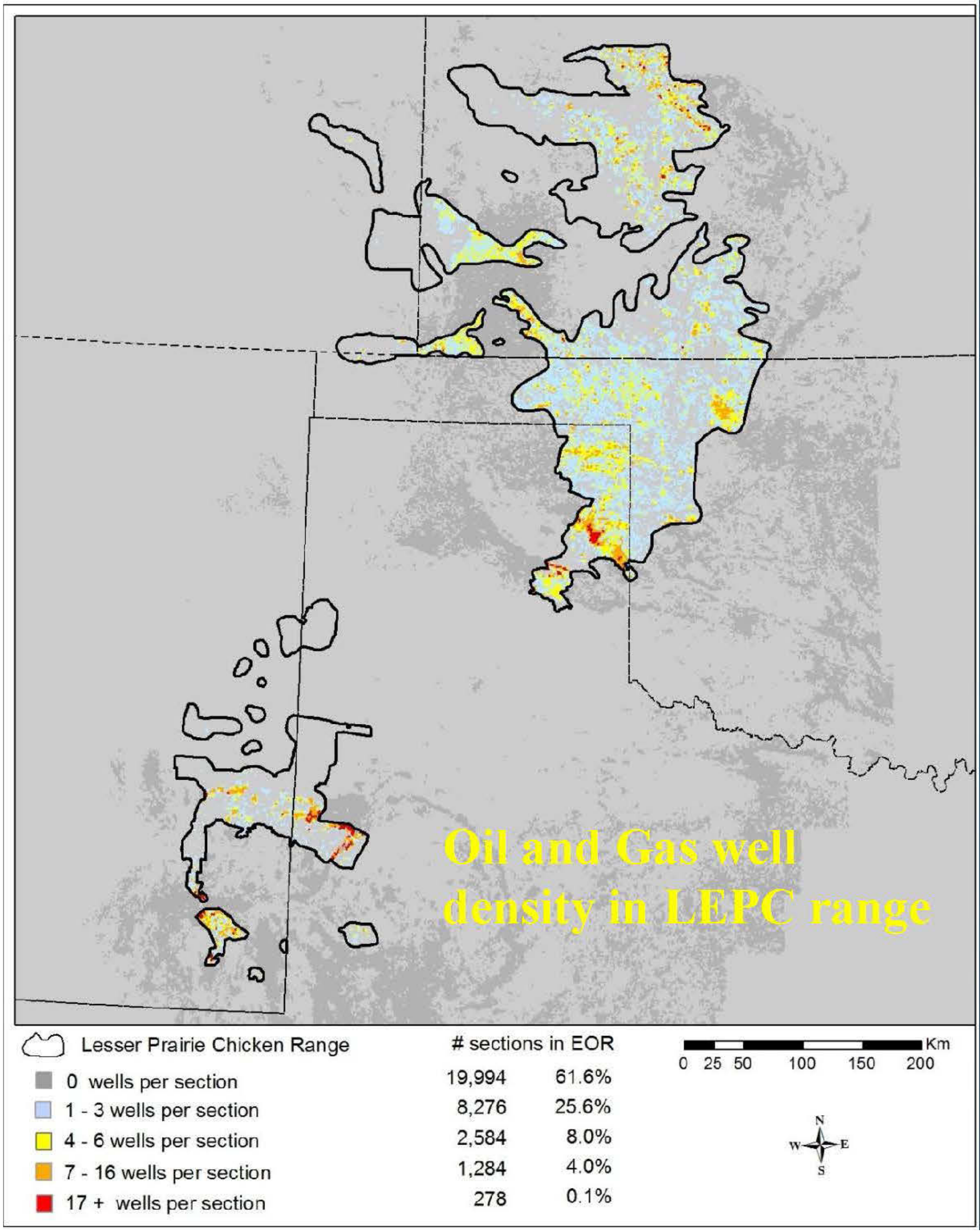

Figure 10. Oil and gas development density across currently occupied lesser prairie chicken range (reproduced from Ungerer and Hagen 2012: 29).

Timmer et al. (2014: 147) found that the density of active lesser prairie chicken leks was inversely related to the density of active oil and gas wellsites. In New Mexico, Hunt and Best (2004: 99, 122) determined that differences in level of oil and gas development accounted for 31.5% of the variation in whether lesser prairie chicken leks were active or abandoned; active leks averaged one well within one mile, while abandoned leks averaged 8 wells within one mile during their last year of lek activity. Plumb (2015: 116, 118) recorded that hens avoided habitats with high densities of oil and gas wells in Kansas, and recommended a limit of 60-acre well spacing to achieve more than a 10% probability of habitat use by lesser prairie chickens. Jarnevich and Laubhan (2011: 930) found that density of oil and gas wells was the most important predictor of active lek occurrence at the 3,000-meter scale. Hunt and Best (2004: 99) found that numbers of active oil and gas wells and total wells were greater within 1.6 km of abandoned leks versus active leks. In a multi-species study that includes lesser prairie chickens, Hovick et al. (2014) found that oil and gas structures and roads had statistically significant effects and caused displacement of grouse species.

In addition to habitat fragmentation and destruction, disturbance and displacement as a result of wellfield noise and human activities contributes to habitat loss. Hagen et al. (2011: 73) documented avoidance of oil and gas wells by lesser prairie chickens, and recommended new wells be sited 300 m or more from occupied breeding and summer habitats. According to Smith et al. (1998: 6),

> Perturbance by un-muffled pump jacks is only one form of disturbance attributable to oil and gas development. Habitat fragmentation, road construction, vehicle traffic, and oil-well-wastewater sites may also impact the [lesser prairie chickens] of this region.

Timmer (2012: 75) found only a modest relationship between oil and gas well density and lesser prairie chicken lek density, postulating that lesser prairie chicken avoidance of oil and gas fields was driven more by disturbance from oil and gas vehicle traffic rather than the wells themselves.

Oilfield pollution has also been a problem in New Mexico, and lesser prairie chicken mortality from sludge pits and poisonous gases, as well as powerlines, has been documented (Massey 2001: 16).

For nesting birds, Pitman et al. (2005: 1259) found that nesting prairie chickens avoided siting their nests in habitats within 80m of oil and gas well sites. The State of Colorado recommends the following management: "Avoid oil and gas operations within 2.2 miles of active leks and within [lesser prairie chicken] nesting and early brood-rearing habitat outside the 2.2 mile buffer" (Van Pelt et al. 2013: 6). Hunt and Best (2004: 2) concluded, "Petroleum development at intensive levels probably is not compatible with populations of lesser prairie-chickens."

Roads. Roads not only result in collision mortality, but also are vectors of noxious weed invasion (Gelbard and Belnap 2003: 424), and cause the avoidance of nearby habitats as a result of noise and movement of vehicles along the roadway (Forman and Alexander 1998: 214). Timmer et al. (2014: 147) found that lesser prairie chicken lek density increased with decreasing density of paved roads. Lek habitat suitability increases with increasing distance from highways (Jarnevich and Laubhan 2011: 931). Robel et al. (2004) documented lesser prairie chicken avoidance of habitats within 785 m of roads.

Hagen et al. (2011: 73) documented avoidance of paved roads by lesser prairie chickens and recommended new roads be sited 850 m or more from occupied breeding and summer habitats.

Hunt and Best (2004: 99) found that miles of road within 1.6 km of abandoned leks was greater than for active leks. Timmer (2012: 75) found that habitats with the greatest lek density had lower densities of paved roads and of unpaved roads, with paved roads having the stronger negative influence. Pruett et al. (2009a: 1256) found that lesser prairie chickens avoided one of two highways in their study by 100m, but that the highway did not appear to be a barrier to movement. Pitman et al. (2005: 1267) found that nest success increased with distance from unimproved roads.

Patten et al. (2005b: 242, Figure 3) documented that 4% of lesser prairie chicken mortality was from vehicle collisions in Oklahoma, while New Mexico populations failed to show a measurable effect from vehicle-related mortality.

Lessons from other grouse species. For other prairie grouse, the negative impacts of roads are well-documented. Holloran (2005: 50) found that siting an improved gravel road that accesses five or more oil and gas wellsites within 1.9 miles of a lek results in a significant decline in sage grouse numbers at that lek, regardless of whether or not the road is visible from the lek. Wisdom et al. (2011: 462) found that increasing road density was correlated with population extirpations for greater and Gunnison sage grouse. Braun (1986) also found a significant negative effect of mining haul roads on sage grouse leks within 1.9 miles of the road. Aldridge et al. (2012: 400) found that Gunnison sage grouse avoided habitats with a road density greater than 0.5 linear mile per square mile, and recommended that roads be sited more than 1.5 miles from nesting habitat.

Noise disturbance. Noise can negatively influence bird populations and communities, and acoustic masking may be a dominant mechanism precluding many birds from breeding in noisy habitats (Francis et al. 2009: 1418).

Blickley et al. (2012a: 467) played back recorded continuous and intermittent anthropogenic sounds associated with natural gas drilling and roads at leks. For three breeding seasons, they monitored sage grouse abundance at leks with and without noise. Peak male attendance (i.e., abundance) at leks experimentally treated with noise from natural gas drilling and roads decreased 29% and 73%, respectively, relative to paired controls. Decreases in abundance at leks treated with noise occurred in the first year of the study and continued throughout the experiment. Intermittent noise had a greater effect than continuous noise. Female attendance averaged a decrease of 48%; male attendance averaged a decrease of 51%. Road noise leks decreased by 73% versus control leks; drilling noise leks decreased 29% versus control leks. There were residual effects of noise after the treatment ceased. These researchers concluded that sage grouse do not habituate to noise impacts over time.

According to Blickley and Patricelli (2010: 280), "The cumulative impacts of noise on individuals can manifest at the population level in various ways that can potentially range from population declines up to regional extinction. If species already threatened or endangered due to habitat loss avoid noisy areas and abandon otherwise suitable habitat because of a particular sensitivity to noise, their status becomes even more critical."

Patricelli et al. (2013: 235) reviewed the scientific literature on noise impacts to sage grouse and recommended that noise be limited to 10 A-weighted decibels above the ambient noise level, but points out that 39 decibels is not the appropriate ambient noise level for undisturbed habitats, but instead that 16 to 20 decibels is the natural background noise level measured at sage grouse leks. "Therefore to avoid disruptive activity in areas crucial to mating, nesting and brood-rearing activities, we recommend that roads should be sited (or traffic should be seasonally limited) within 0.7-0.8 miles from the edge of these areas" (Patricelli et al. 2012: unnumbered 3).

Lesser prairie chicken vulnerability to noise disturbance. Butler et al. (2010: 1161) measured the booming sounds of lesser prairie chickens, found that they averaged 106 dB, and estimated that this sound would be about 30 dB at a distance of 0.65 km. Pitman et al. (2005: 1267) reported sound levels 100 m from center-pivots ranged from 60–80 dB, those from compressor stations were 80–100 dB, and the sound level 100m from the power plant was >100 dB when precipitators and scrubbers were operating; low-frequency sounds from these sources were audible to the human ear at distances greater than 2 km. Robel et al. (2004) reported that noise from center pivots was audible at a distance of 0.6 mile, gas compressor stations were audible at a distance of over 2 miles, and power plant noise could be heard for a distance of 1 to 2 miles. Truck traffic was audible for 1.5 miles, and farther if an incline or curve is present that requires drivers to gear down.

Smith et al. (1998: 3) found that 21 of 29 historic lek sites in southeastern New Mexico were significantly impacted by noise from oil and gas operations, and 10 of the sites had high noise levels. Hunt and Best (2004: 142) found that sound levels were four dB greater at abandoned lesser prairie chicken leks than at active leks, a statistically significant difference. According to Smith et al. (1998: 6), "The observed high fidelity to display grounds by [lesser prairie chickens] means that sound disturbance at traditional lek sites could be devastating to breeding efforts."

Lessons from the greater sage grouse. The greater sage grouse has shown similar sensitivity to industrial structures and activity, and the impacts of noise on this related grouse species are much more thoroughly developed than for lesser prairie chickens. Blickley and Patricelli (2012: 23) found that low-frequency noise from oil and gas development can interfere with the audibility of male sage grouse vocalizations:

> We found that noise produced by natural gas infrastructure was dominated by low frequencies, with substantial overlap in frequency with Greater Sage-Grouse acoustic displays. Such overlap predicted substantial masking, reducing the active space of detection and discrimination of all vocalization components, and particularly affecting low-frequency and low-amplitude notes. Such masking could increase the difficulty of mate assessment for lekking Greater Sage-Grouse.

These researchers went on to state, "Ultimately, increased difficulty in finding leks or assessing males on the leks may lead to lower female attendance on noisy leks compared with quieter locations. Males may also avoid leks with high levels of noise if they perceive that their vocalizations are masked" (*id.*: 32). Noise also causes stress to sage grouse. According to Blickley et al. (2012b: 1),

> We found strong support for an impact of noise playback on stress levels, with 16.7% higher mean FCM [fecal corticoids, an index of stress] levels in samples from noise leks compared with samples from paired control leks. Taken together with results from a previous study finding declines in male lek attendance in response to noise playbacks, these results suggest that chronic noise pollution can cause greater sage-grouse to avoid otherwise suitable habitat, and can cause elevated stress levels in the birds who remain in noisy areas.

These researchers also noted that "Noise at energy development sites is less seasonal and more widespread and may thus affect birds at all life stages, with a potentially greater impact on stress levels" (*id.*: 6).

Overhead powerlines. Robel et al. (2004) and Pitman et al. (2005: 1267) found that lesser prairie chickens were rarely found within 0.4 km of powerlines, even if the habitat was otherwise suitable for nesting. Pruett et al. (2009a: 1258) documented avoidance of transmission lines for both nests and leks, and reported that few nest sites were located within 2 km of transmission lines. Hagen et al. (2011: 70) documented minimum avoidance distances of 662 to 702 m for transmission lines. The same study included a Before-After-Control Investigation (BACI) study on construction of a new 138 kilovolt (kV) powerline, and found that there was no immediate avoidance of the line, suggesting strong site fidelity of individuals to their habitats in the face of new disturbance, and consistency with other studies that show a time lag in abandonment of impacted habitat over time for prairie grouse. Plumb (2015: 117) found that females avoided habitats closer to electrical distribution lines during the nesting season, and recommended that powerlines be located more than 5 km away from leks.

Transmission lines have been found to have a negative relationship with lek density for lesser prairie chickens (Timmer 2012: 76). Hunt and Best (2004: 99) documented that the distance to the nearest powerline was greater for active lesser prairie chicken leks than for abandoned leks. Timmer (2012: 72) found that lek density decreased as transmission line density increased. Lautenbach (2015: 30) also observed avoidance of overhead powerlines. Pruett et al. (2009a: 1258) documented that lesser prairie chickens avoided powerlines by 100m and that transmission lines appeared to be a partial barrier to movements and dispersal. Based on these findings, Hagen et al. (2011: 73) recommended that powerlines be sited 700 m or more from occupied breeding and summer habitats.

The documented avoidance of power lines may also serve as a movement barrier to lesser prairie chickens, further fragmenting habitats (Hagen et al. 2011: 72). Hagen et al. (2004: 74) documented previously unpublished data indicating that placement of powerlines near leks may negatively affect the breeding activities of males.

Overhead power and telephone lines were a source of collision mortality for lesser prairie chickens in Oklahoma and New Mexico, leading researchers to recommend the burial of overhead lines in lesser prairie chicken habitat (Wolfe et al. 2007: 102). Hagen (2003: 81) documented that 5% of lesser prairie chicken mortality in southwestern Kansas was the result of collisions with powerlines. Patten et al. (2005b: 242, Figure 3) found that powerline collisions accounted for 6.1% of lesser prairie chicken deaths in Oklahoma, but only 1% of mortalities in the less-fragmented habitats of New Mexico. Thus, transmission lines sited in lesser prairie chicken habitat are known to have a variety of important impacts.

Overhead electrical transmission lines also emit electric and magnetic fields (EMFs) that can change the behavior, reproductive success, growth and development, physiology and endocrinology, and oxidative stress of wild birds in ways that vary by species (Fernie and Reynolds 2005, entire). To the best of our knowledge, experiments involving lesser prairie chickens have yet to be undertaken.

Increased predator habitat. Raptors hunt from perches, and the introduction of manmade perches can increase raptor hunting effectiveness, particularly in habitats where natural perches are limited (Reinart 1984: 28). Steenhof et al. (1993: 275) documented that raptors and common ravens nest on transmission towers, particularly those with denser latticework, with 133 pairs of ravens colonizing transmission towers on a single stretch of powerline in Idaho during its first 10 years of existence. Gilmer and Wiehe (1977: 5) found that ferruginous hawks tended to nest in clusters on powerline towers, with as many as 5 active nests on one ten-mile stretch of transmission line. In North Dakota, Gilmer and Stewart (1983: 151) found that ferruginous hawk nest success was highest for powerline towers and lowest for nests in hardwood trees. Nonne et al. (2011: 2) found that raven abundance increased along the Falcon-Gondor powerline corridor in Nevada both during the construction period, and long-term after powerline construction activities had ceased. These increases were documented to be long-term increases by a subsequent report on the same powerline (Gibson et al. 2013). The increased predator presence along powerlines can lead to behavioral avoidance of these structures, increased stress for birds that remain nearby, and increased risk of predation for lesser prairie chickens.

Lessons from other grouse species. Impacts of transmission lines on populations, including displacement from habitats, has been shown for many species of grouse. For Gunnison and greater sage grouse, increasing distance from transmission lines was a significant predictor for population persistence, while closer proximity was associated with extirpated populations (Wisdom et al. 2011: 462). Raptors perching have an increased impact on nesting birds at least 0.25 mile from the structure (Braun et al. 2002: 344, Hanser et al. 2011: 130, Dinkins 2013: 80). Braun et al. (2002: 344) reported that 40 greater sage grouse leks with a power line within 0.25 mile of the lek site had significantly slower population growth rates than unaffected leks, which was attributed to increased raptor predation. Dinkins (2013: 80) documented greater sage grouse avoidance of powerlines not just during the nesting period but also during early and late brood-rearing. Gibson et al. (2013: 27) reported significantly lower nest success and female survival near the Falcon-Gondor powerline, an impact that was greatest closest to the powerline but was still measurable out to 20 km (12.4 miles) away from the powerline. These researchers concluded:

> Published results suggest that population growth in sage-grouse is highly sensitive to variation in female survival and nest survival (Taylor et al. 2011); therefore we urge caution when placing transmission lines within sage-grouse habitat. Additionally, placement of the Falcon-Gondor transmission line was selected specifically to minimize the disturbance to sage-grouse (M. Podborny, NDOW, personal communication), therefore our results may underestimate the influence of transmission lines in general on sage-grouse demographic rates, depending on line placement.

Within the range of the Gunnison sage grouse, Prather (2010: 89) empirically found perch inhibitors to be ineffective at preventing raptor perching on distribution powerlines, and Lammers and Collopy (2007: 2756) found a similar result for major transmission lines. Coates et al. (2013: 9) recommended a 4.66-mile buffer for active leks as the appropriate area of protection for greater sage grouse key habitats (at least breeding, nesting, and early brood-rearing habitats); Peck et al. (2012: 430) recommended a 10-km buffer for nesting habitat in Utah.

Wind energy development. Wind energy development is believed to pose a significant threat to lesser prairie chicken habitats and populations. As of the spring quarter of 2016, there are 74,512 MW of installed wind-power generation capacity in the United States, with an additional 15,200 MW of wind farms under construction or in the advanced stages of development (AWEA 2016: 3, *and see* Figure 11). This is up from 48,611 MW of installed capacity in 2012 (AWEA 2012a: 3). A number of these new projects appear to be within the range of the lesser prairie chicken (AWEA 2016: 10). In order to meet 20% of the increase in electricity demand projected between 2005 and 2030, there would need to be an additional 290,000 MW of wind power projects built by the year 2030 (USDOE 2008: 65).

Stewart et al. (2007: 5) found that wind farms could result in declines in avian abundance, although these results were highly dependent on species and location, and it is not always clear whether the mechanism for the decline is displacement to other habitats or outright population decline. Leddy et al. (1999: 101) found a lower density of grassland birds on lands with wind turbines than on lands without them. Stewart et al. (2007: 6) performed a meta-analysis of multiple studies on the impact of wind farms, and found that declines in avian abundance increased the longer the wind power facility was in place, suggesting that birds displaced or reduced in number buy the construction of wind farms do not acclimate to the presence of wind turbines over time.

The potential for turbine-strike mortality among bird species is well known (Erickson et al. 2001, Manville 2005: 1058). A number of different species are considered vulnerable to wind turbine collision mortality because they commonly fly between 32 and 124 m above ground level, the rotor-swept area for commercial wind turbines (Wulff et al.

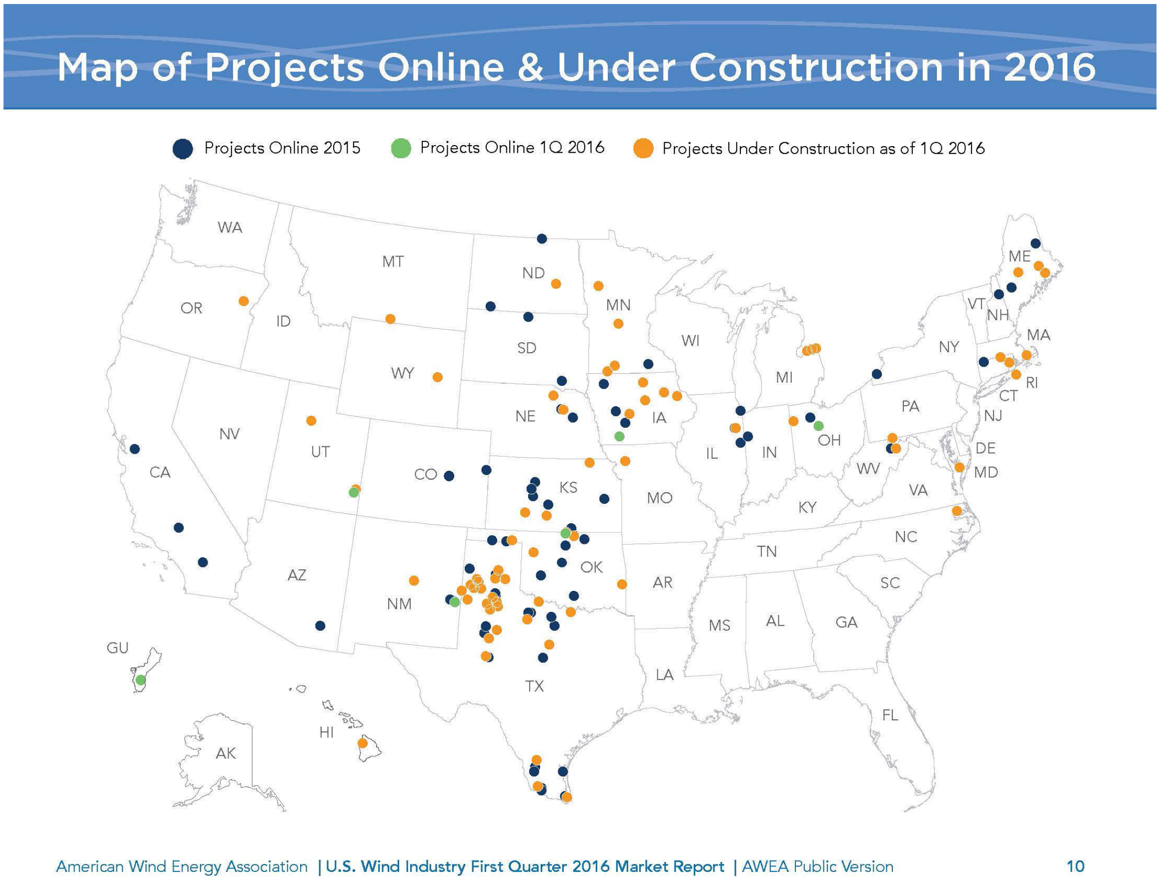

Figure 11. Wind energy projects built prior to and including 2015 ("online") and under construction in 2016.

2016). The lesser prairie chicken is presumed to be less vulnerable to turbine-strike mortality because it seldom flies this high above the ground. Giesen (1998) reported that most flights are confined to altitudes above ground of less than 100 m. Pruett et al. (2006b: 259) argued that turbine-strike mortality is unlikely to be a major issue for lesser prairie chickens because they rarely fly higher than six m above the ground, and seldom fly at night. Habitat loss and fragmentation due to wind farm development, and its associated disturbance and displacement of bird species, likely represents a greater impact to birds than does turbine collision mortality (Kuvlesky et al. 2007).

The direct habitat disturbance impacts from wind power projects represent only 3-5% of the habitat acres affected, while 95-97% of their impact area is the result of habitat fragmentation, species avoidance behavior, and bird and bat mortality issues (McDonald et al. 2009: 4). Grouse species that inhabit non-forested ecosystems (such as the lesser prairie chicken) are particularly susceptible to indirect impacts from wind power development, because they evolved in habitats devoid of tall vertical structures (Hovick et al. 2014). However, Walters et al. (2014: 6) were unable to corroborate that the observed avoidance of tall structures by grouse was in any way related to structure height itself. In a multi-species study, Hovick et al. (2014) found that anthropogenic structures negatively affect both lek attendance and annual adult grouse survival rates. Anecdotal observations report both the presence of birds in close proximity to wind energy facilities as well as abandonment of areas where major wind facilities have been constructed (Haufler et al. 2012: 13).

Brennan et al. (2009: 180) pointed out the lack of empirical studies of the impacts of wind power development on lesser prairie chickens, but still concluded that wind farms are likely to have dire consequences for this species due to their intolerance of habitat fragmentation. Hagen et al. (2011: 73) documented avoidance of overhead powerlines by lesser prairie chickens, and hypothesized that avoidance of wind turbines (which also are tall structures) would be similar; these researchers recommended a 1.4 km setback for wind turbines from occupied breeding and summer habitats. Pruett et al. (2009b: 259) postulated that wind farms could be impassable barriers to lesser prairie chicken movements if birds avoided tall turbine towers and associated transmission lines. Pruett et al. (2009a: 1258) found that lesser prairie chickens exhibited stronger avoidance for overhead transmission lines than for heavily travelled roads, and concluded that wind turbine facilities, which also feature tall structures, would pose barriers that isolate and further fragment lesser prairie chicken habitat.

Pruett et al. (2009b: 260) point out that lesser prairie chicken states are ranked highly for wind power potential and that much of the new and proposed wind power development is proposed within the historic range of lesser prairie chickens. Wolfe et al. (2016: 308) concluded, “It will be imperative that wind turbines and associated high-voltage transmission lines are located in sites that will avoid direct and indirect impacts to mixed-grass prairie occupied by Lesser Prairie-Chickens.”

Oklahoma. In Oklahoma, 53.1% of known lesser prairie chicken leks are within one mile of lands classifed as having excellent wind power potential, and 90.6% of known leks are within five miles of lands classified as “excellent” for wind power potential (O’Meila 2005: 2, *and see* USDOE 2010). Oklahoma had 250 existing wind turbines within lesser prairie chicken range and an additional 1,300 more proposed at the time. Since the court order vacating the “threatened species” listing for lesser prairie chicken, four additional wind energy projects in Oklahoma that had been deferred were fast-tracked for permitting, two of them in lesser prairie chicken Focal Areas under the Range-Wide Plan, and two of them in Connectivity Areas. Second Declaration of Michelle Shaughnessy, Case No. 7:14-CV-00050-RAJ, at ¶3(b).

Dusang (2011: 69) found that in western Oklahoma, wind turbines did not overlap a large amount of predicted habitat at the time of the study. However, future developments could pose a significant threat in this area.

New Mexico. As of 2015, the Roosevelt Wind Farm project by EDF Renewable Energy in Roosevelt County, New Mexico is slated to be built on approximately 62,000 acres of occupied lesser prairie chicken habitat. First Declaration of Michelle Shaughnessy, Case No. 7:14-CV-00050-RAJ, at ¶19(e). This is an enormous area of remaining habitat. Subsequently, the Broadview Wind Project was proposed by Pattern Energy, entailing

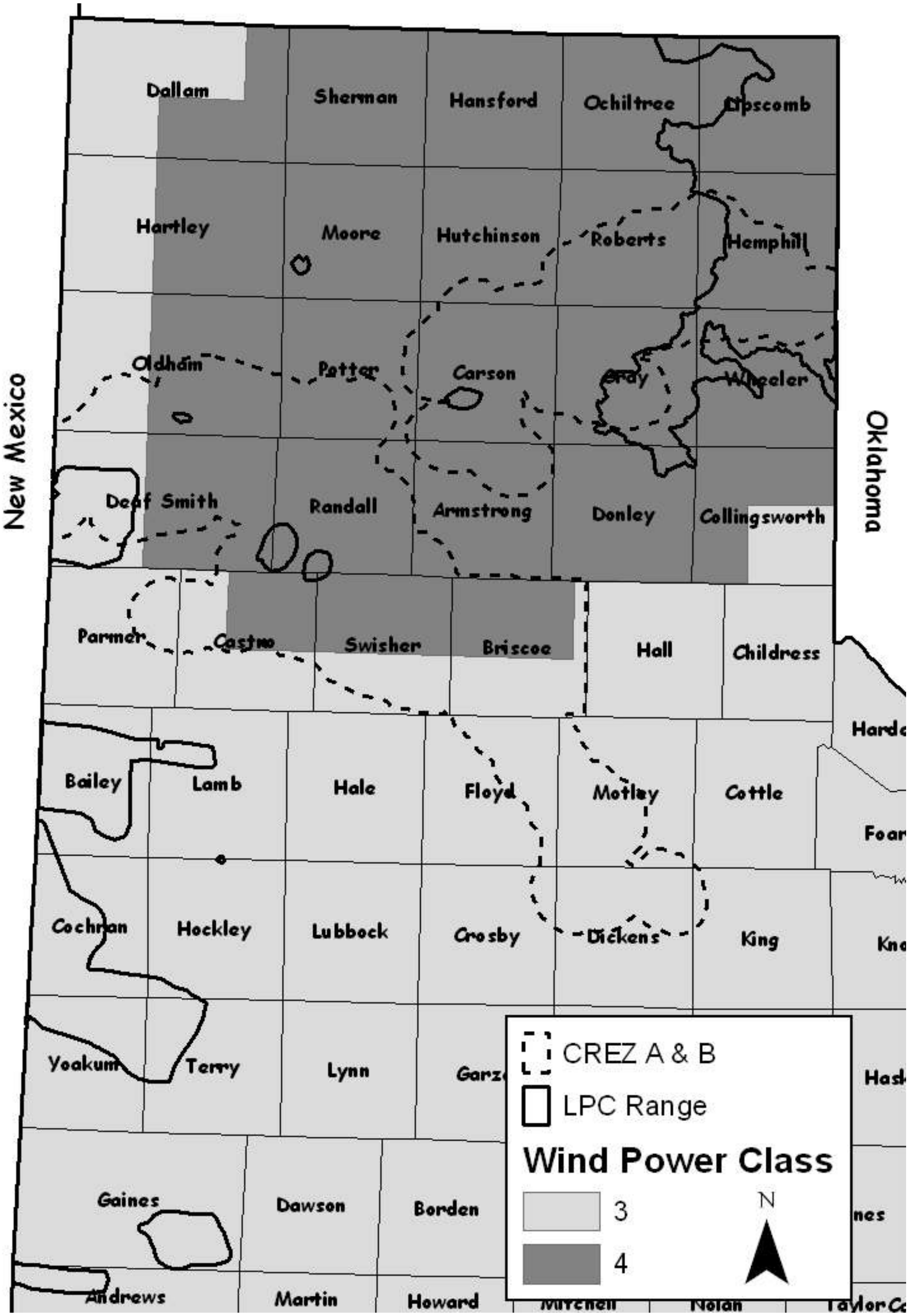

Figure 12. Lesser prairie chicken range in Texas relative to wind power classes and Competitive Renewable Energy Zones (reproduced from Timmer 2012: 22).

237 turbines of which at least 30 are located in lesser prairie chicken occupied habitat. Second Declaration of Michelle Shaughnessy, Case No. 7:14-CV-00050-RAJ, at ¶3(a).

Texas. Texas is the nationwide leader in utility-scale wind development (AWEA 2016: 3). In 2006, a six-fold increase in wind turbine deployment was projected across Texas, with a projected 9,600 megawatts of new installed capacity occurring in the Texas panhandle (ERCOT 2006: ES-5, Figure ES-3).

Five Competitive Renewable Energy Zones (CREZs) were established in Texas to encourage wind energy development (ERCOT 2006: 2, *and see* Figure 12). Two of these CREZs overlap with 27% of the remaining lesser prairie chicken habitat in Texas (Timmer 2012: 4, *and see* Figure 11). Timmer et al. (2013: 745) surveyed lesser prairie chicken habitats in Texas, and found that 13 of the 66 groups of lesser prairie chickens in the northeast Texas panhandle and 10 of 109 lesser prairie chicken groups in the southwestern panhandle were within CREZs. Based on ERCOT (2006: 40), approximately 4,800 new turbines are expected to be installed in the Texas panhandle, plus up to two additional 345-kV transmission lines to transport the electricity to load customers in the Dallas area.

Kansas. Jarnevich and Laubhan (2011: 927) reported six wind farms in operation in Kansas at that time, with an additional 44 wind power projects proposed.

Lessons from other grouse species. While empirical studies of the direct impacts of wind farms on lesser prairie chickens have yet to be completed, before-after-control investigations have been undertaken to examine the effects of wind farm construction on the closely-related greater prairie chickens (Winder et al. 2014a, b, McNew et al. 2014, Winder et al. 2015). Winder et al. (2014b: 399) found no negative impact of wind farm construction on survival of greater prairie chickens, and McNew et al. (2014: 1094, 1095) found no impact of wind farms on greater prairie chicken nest survival or habitat use. However, Winder et al. (2014a: 11) found that home range size expanded markedly following wind farm construction, and that female greater prairie chickens avoided habitats near wind turbines during the breeding season. And Winder et al. (2015: 288) found that greater prairie chicken lek persistence within 8 km of wind turbines was significantly lower, supporting the USFWS recommendation to provide an 8-km turbine-free buffer around leks. Hovick et al. (2015: 1) recommended concentrating energy development impacts in lands of lower conservation concern and avoiding habitats important to greater prairie chickens for the purpose of siting energy developments.

Impacts of wind power development have also been demonstrated for greater sage grouse. Wind farm development results in a significant decrease in nest and brood survival within 5 km of wind turbines (LeBeau 2012: 79, *and see* LeBeau et al. 2012). Risk of sage grouse nest failure declined by 7.1%, and risk of brood failure decreased by 38.1%, for every kilometer in distance from the nearest wind turbine (LeBeau et al. 2014: 527). It is reasonable to expect similar outcomes for lesser prairie chickens as for these two grouse species that also evolved in open, treeless, unfragmented country.

Several researchers (*e.g.,* Leddy et al. 1999: 103) have recommended locating wind turbines within cropland areas to minimize impacts to grassland birds. Jarnevich and Laubhan (2011: 934) recommended siting wind power facilities in areas that already possess low habitat suitability for lesser prairie chickens. Hagen et al. (2004: 79) recommended siting wind farms more than 2 km (1.2 miles) from the nearest occupied lesser prairie chicken habitat. The U.S. Fish and Wildlife Service recommended siting wind turbines at least 5 miles (8 km) from prairie grouse leks to protect both important breeding and nesting habitats and connecting corridors, based on a minimum 5-mile buffer around lesser prairie chicken leks (Manville 2004: 4).

Habitat conversion to cropland. McLachlan et al. (2010: 8) found that 43% of native habitats have been converted to cropland in the western half of the region inhabited by the lesser prairie chicken, while 54% of the grasslands have been converted to cropland in the eastern half. According to U.S. Fish and Wildlife Service estimates, some 27.1% of the estimated historical range and 27.7% of the occupied range were in cultivated crop fields as of 2006, while grasslands comprised 34.9% of the historical range and 60.5% of the occupied lesser prairie chicken range. 79 Fed. Reg. 20025. According to Crawford (1974: 50), "The greatest potential threat to the lesser prairie chicken in West Texas is breaking remaining rangeland for cultivation." Conversely, Haukos and Zavaleta (2016: 126) observed, "Restoration of sand shinnery oak and sand sagebrush prairie in semiarid regions is expensive and time-consuming under the best possible environmental conditions, and protection and conservation of extant habitats may be the most effective and economic approach to habitat conservation."

Hexem and Krupa (1987: 4) estimated that 35 million acres of current pasture and rangeland in the five lesser prairie chicken states had a high or medium potential for conversion to cropland. Woodward et al. (2001: 267) reported a 1.2% rate of landscape change per decade within 4.8 km of lesser prairie chicken leks in New Mexico, versus 2.8% rate of change per decade in Texas and an 11.2% rate of change per decade in Oklahoma. According to Robel et al. (2004), most of the large-scale conversion of grassland to cropland in the lesser prairie chicken range ceased in the mid-1980s. However, Wright and Wimberly (2013: 4135) reported a major increase in long-term conversion of grassland to corn and soybean fields to the north and west of the current lesser prairie chicken range, indicating that conversion of grassland to cropland in lesser prairie chicken occupied range may not be a merely historical occurrence.

Bartuszevige and Daniels (2016: 212) found in a rangewide GIS study that land cover in Grassland plus CRP (the inverse of cropland) was positively correlated at the 3,000 m lek buffer distance with the presence of active lek sites, demonstrating that croplands have a negative impact on the ability of lesser prairie chickens to maintain active breeding populations.

Crawford and Bolen (1976a: 102) found that landscapes with more than 63% cultivated cropland were no longer capable of maintaining lesser prairie chicken populations; Hagen et al. (2004:74) contended that landscapes with 5-37% cropland supported the maximum numbers of lesser prairie chickens. Fuhlendorf et al. (2002: 626) found that declining populations of lesser prairie chickens had significantly greater proportions of cropland at large scales than did stable populations. However, most agricultural conversion to cropland happened prior to 2002, and recently cropland cover may actually be decreasing due to enrollment in the Conservation Reserve Program (*id.*: 624). Crawford (1974: 38) found the largest populations of lesser prairie chickens in north Texas on areas possessing limited cultivation, with 63 to 95% native rangeland. Woodward et al. (2001: 261) found that landscapes with greater rates of overall landscape change and shrubland loss were correlated with population declines for lesser prairie chickens; however, this study found no correlation between amount of cultivation and population trends.

The negative effects of cropland conversion on lesser prairie chickens are well-documented. Robinson (2015: 97) found in Kansas that lesser prairie chicken survival increased in landscapes with more grassland and less cropland. Jarnevich and Laubhan (2011: 930) found that percent grassland or percent grassland plus CRP land was positively correlated with active leks. Pitman et al. (2005: 1265) found that nest success was greater with distance from center-pivot irrigation. Irrigated center-pivot fields in southwestern Kansas are bare or have little vegetation before irrigation begins in late April or early May, and lesser prairie chicken hens avoid nesting near these fields (Pitman et al. 2005: 1264). Fields (2004: 37) and Patten et al. (2006: 10) documented that lesser prairie chickens disproportionately avoid cropland, and these researchers also documented an avoidance of CRP fields in New Mexico. Wolfe et al. (2003: 8) found that only one of 67 lesser prairie chicken nests in their Oklahoma study area was located in an agricultural field (alfalfa, in this case), and that nest failed to produce any chicks; nine nests were located in fallow fields, and showed a 33.3% nest success rate, lower than for grassland habitats.

Aerial spraying of insecticides and herbicides near cropfields could potentially affect lesser prairie chickens (Peterson 2016: 170). Cropland agriculture is typically associated with the aerial spraying of insecticides, herbicides, and/or fertilizers. For example, cotton growers have been encouraged to spray insecticides over shinnery oak habitats and Conservation Reserve Program lands in an effort to kill overwintering boll weevils (Slosser et al. 1985, Plains Cotton Growers 1998: 3). Arthropods important in the diet of lesser prairie chickens may be negatively affected by herbicide spraying targeting exotic grasses (Wolfe et al. 2016: 307-308). Applegate and Riley (1998: 15) recommended,

> Minimize herbicide and insecticide use. These are particularly detrimental because they will reduce insect populations and insect-producing shrubs and forbs.

Blus et al. (1989: 1142) found that aerial spraying of organophosphide insecticides resulted in the deaths of scores of greater sage grouse present in multiple incidents of aerial spraying in Idaho. Peterson (2016: 171) noted that no studies have specifically documented lesser prairie chicken exposure to environmental contaminants, but these species are presumably vulnerable to poisoning by aerially sprayed insecticides and herbicides as well as spills or emissions of contaminants at oil and gas production facilities. In addition, herbicides, insecticides, pesticides, plasticizers, and resins could be harmful to lesser prairie chicken reproduction at levels far lower than those that are lethal (Peterson 2016: 175).

In addition, the use of poisons to eradicate black-tailed prairie dogs poses a potential threat to lesser prairie chickens. Lesser prairie chickens use black-tailed prairie dog colonies as lek sites (Bidwell et al. 2002: 1). Grains with Rozol or zinc phosphide are often used as toxic baits to kill prairie dogs through internal hemhorraging. While proper application involves dropping poison baits more than 15 cm down into burrows, even proper application of these poisons in accordance with their label can lead to deaths in ground-foraging birds. Vyas et al. (2013: 98-99) documented one poisoning death of a meadowlark from Rozol, and detected Rozol in the droppings of several other birds.

Oklahoma. In Oklahoma, tillage agriculture began in 1890, greatly reducing the range of the lesser prairie chicken (Copelin 1963); land runs between 1889 and 1895 took place, particularly in Oklahoma, when lands not assigned to Indian tribes were opened for settlement (Rodgers 2016: 18). Further sodbusting during the World War I era brought about further habitat destruction (Duck and Fletcher 1944: 70, Copelin 1959). At the height of the land rush, "practically every quarter section of prairie chicken range in western Oklahoma supported a family, even if only for a few months" (Duck and Fletcher 1944: 70). The subsequent abandonment of Oklahoma and neighboring Plains states, with an exodus of about 70,000 residents during the Dust Bowl years of the 1930s, allowed much of this land to return to grassland (Duck and Fletcher 1944: 70).

Texas. Wheat and cotton farming did not take hold in the Texas panhandle until the early 1900s, during an unusually wet series of years (Rodgers 2016: 18). Toole (2005: 26) reported that in the northeast Texas panhandle, agricultural practices prior to the 1970s were more conducive to prairie chicken habitat needs, and birds commonly fed in grain fields and nested in alfalfa fields; as agricultural practices changed, lesser prairie chickens shifted their habitat use almost entirely to native rangelands. The practice of fall tilling eliminates waste grain as a food source for lesser prairie chickens (Crawford 1974: 40).

In the Texas panhandle, large reservoirs were created during starting in the 1920s, and aquifer-based irrigation permitted the rapid spread of conversion of grasslands to farming for cotton, sorghum, and other crops (Oberholser 1974: 268). Vast areas in the center of the lesser prairie chicken's range, including much of the Texas panhandle, have been lost due to conversion to cropland and are no longer suitable for the species (Hagen et al. 2010: 30). Sodbusting began in earnest in the Texas panhandle by 1910, and conversion began to push prairie chickens out of areas with deeper soils (Henika 1940: 3). Silvy et al. (2004: 19, citing Bidwell n.d.) argued that the lesser prairie chicken cannot survive in landscapes comprised of more than 30% croplands, and pointed out that of the lesser prairie chicken historic range in Texas, some 34% of the Rolling Plains region and 76% of the High Plains region have been converted to cropland.

New Mexico. Laycock (1987: 4) reported that in New Mexico the greatest expansion in tillage agriculture occurred between 1915 and 1925 to grow wheat to support the demand brought about by World War I and the economic expansion that followed. In New Mexico, conversion to irrigated cropland has been a smaller scale issue than elsewhere, although the rapid growth of the dairy industry in this area in the early 2000s has resulted in plowing up grassland habitats to grow forage crops for dairy cows (Davis 2005: 18). Merchant (1982: 3, 12) reported that winter wheat and grain sorghum were major agricultural crops, comprising 3% of the surface area in his east-central New Mexico study area.

Kansas. Farming began in Kansas in 1854, but met with little success until Mennonite immigrants from Russia introduced wheat to the region (Rodgers 2016: 17). In southwestern Kansas, the spread of center-pivot irrigation systems tapping the Ogallala aquifer began near Garden City in 1965 and rapidly spread throughout the sand sage grasslands, previously unsuitable for agriculture due to sandy soils, which was reduced by more than half from an estimated 1,353,000 acres to 512,547 acres (Sexson 1980: 114). Sand prairie in south-central Kansas was being lost to center-pivot irrigation at a rate of 5% per year in the early 1970s, and only the designation of an Intensive Groundwater Use Area by the Kansas Division of Water Resources in 1986 put a halt to the expansion of irrigation and allowed 20% of the sand sagebrush prairie to survive in south-central Kansas (Rodgers 2016: 21). This agricultural conversion ultimately resulted in a 53% decrease in area-weighted mean patch size of grassland habitat in western Kansas since the 1950s (Spencer 2014: 49).

Colorado. While there is little expansion of agricultural cropland at present in southeastern Colorado, there is some ongoing loss of grassland habitats. "The Service has also recently confirmed, through a communication between a Service employee and the project consultant, that the dairy farm in Prowers County, Colorado — previously identified in Defendants' briefs as a prospective project in occupied lesser prairie-chicken habitat — in fact went forward, resulting in the removal or loss of that habitat for the species." Defendant's Additional Filing in Support of their Opposed Motion to Amend the Judgment, Case No. 7:14-CV-00050-RAJ at 4.

Rural development. Urban growth and rural housing sprawl have had a relatively small but locally significant impact on lesser prairie chicken populations across the range of the species. The net human population growth throughout the historical range of the lesser prairie chicken by 2060 is estimated at 569,326 people, a net increase of 3.2 individuals per square mile, while the occupied range is expected to see a net increase of 188,770 people at an average growth of 6.04 individuals per square mile (*see* 79 Fed. Reg 20019), although a significant portion of this population growth will likely be in urban areas. Hagen et al. (2011: 73) documented avoidance of buildings by lesser prairie chickens and recommended new wells be sited 1.4 km or more from occupied breeding and summer habitats.

Livestock grazing. Permanent cattle ranching began in Oklahoma about 1870 (Duck and Fletcher 1944: 70) and in New Mexico by 1875 (Massey 2001: 13). Between 1870 and 1880, the number of cattle on the Great Plains quadrupled to 4.4 million, almost doubling again by 1886 (Laycock 1987: 4). According to Henika (1940: 4), "Under the present system of land use the pasture land is with a few exceptions heavily overstocked with livestock." The impacts of livestock grazing and drought are synergistic, multiplying impacts on lesser prairie chicken habitats. Copelin (1959: 159) reported that overgrazing was exceptionally severe in Oklahoma during the 1952-1953 drought, coinciding with a lesser prairie chicken population crash in that state. The shift from heavy but infrequent grazing by bison to heavy and constant grazing pressure by domestic livestock has contributed to the spread of shrubs and trees, and has reduced the prevalence of native perennial grasses (Patten et al. 2005a: 1277). Bidwell and Peoples (1991: 9004.1) blamed the loss of high-quality prairie chicken habitat in Oklahoma on overstocking by cattle and the prevention of widespread prairie fires.

Today, the vast majority of western federally managed lands are commercially grazed by domestic livestock (Fleischner 1994: 630). Because lesser prairie chickens are dependent on medium to tall grasses in a region of low rainfall, their habitat is very sensitive to overgrazing (Hamerstrom and Hamerstrom 1961: 290). According to Wisdom (1980: 33),

> Where sand bluestem is abundant and lightly grazed or ungrazed within the shinnery oak plant community…, nesting success is high. Conversely, areas of shinnery-dominated rangeland that are devoid of sand bluestem due to heavy livestock grazing…are not conducive to nesting success; females in these areas use nest cover provided by a variety of plants that are unpalatable to livestock, but these plants do not provide the superior concealment afforded by sand bluestem.

However, at the date of this study, such lightly grazed habitats made up only 5% of the potential habitat in New Mexico and an even lesser proportion of habitat in the Texas panhandle (*id.*). At the same time, some (*e.g.,* Haufler 2012, Grisham et al. 2016b) have asserted that grazing by native wildlife or domestic livestock can be sustainable or is even essential to maintain healthy grasslands and shrublands on the Great Plains.

Impacts on grass cover. With heavy cattle grazing on the Southern Plains, tall species of grass important to lesser priairie chickens as cover such as big and little bluestem, switchgrass, and Indiangrass decreased, short grasses like blue and sideoats grama, sand dropseed, and buffalograss increased, and exotic species like cheatgrass invaded (Johnsgard 2002: 132). Melcher (2015: 168) stated, "Inappropriate livestock grazing practices, including a lack of (or too little) pasture rotation, have greatly degraded LPC habitat in portions of the LPC's range." According to Davies (1993: 8), in the northwestern part of the lesser prairie chicken range, most public domain lands were homesteaded by the early 1900s, and "grasslands were converted to cropland and a shortgrass range disclimax maintained by livestock grazing." This heavy grazing resulted in conversion from taller bluestems to low-growing grama and buffalograss (*id.*). Jackson and DeArment (1963: 736) pointed to the "increased grazing loads placed on cattle ranges since World War II, resulting in displacement of tallgrasses in the plant community by shorter species" as one of the three most important factors preventing lesser prairie chicken population rebounds following drought. Hoffman (1963: 728-729) also noted this livestock-caused disclimax state of low-growing grasses on grasslands that naturally would be dominated by taller mixed-grass species.

Prolonged livestock grazing can decrease the capacity of native grasses to competitively exclude trees and shrubs, while at the same time reducing fine fuels that support natural fires (Archer and Smeins 1991). Heavy grazing by domestic livestock is responsible for reducing or removing native midgrass species such as little bluestem and sideoats grama from many areas where these plants were once prevalent (Dahlgren et al. 2016: 266). The loss of grasses during springtime, when prairie chickens are nesting and grasses are most palatable to livestock, removes nesting cover required by nesting hens (Toole 2005: 27-28). Heavier grazing ultimately causes diversity to decline as short grasses increasingly dominate the plant community (Archer and Smeins 1991).

Grass height is important for providing cover for lesser prairie chickens. Because vertical visual obstruction is the single most important habitat characteristic for nest site selection (Lautenbach 2015: 29), moderate to heavy grazing can have a severe impact on hiding cover. Leonard (2008: 29, 30) found that most prairie chicken hens in his study nested in ungrazed habitats with high levels of visual obstruction, and most overall prairie chicken habitat use was on ungrazed grassland not treated with herbicides. Low-growing grasses are poor habitat for lesser prairie chickens, and they are believed to be a limiting factor preventing population increase and range expansion in Colorado (Giesen 1994b: 180). Wisdom (1980: 14) found that average grass height within nine meters of nests was more than seven inches, and that there was a strong preference for nesting in areas with more than 12 inches of grass height, associated with 31.5% utilization of bluestem by grazing livestock. Lautenbach (2015: 29) reported that hens select nest sites with 7.9 to 11.8 inches of visual cover. Giesen (1994a) recommended that livestock grazing should maintain sufficient cover of tall (>40 cm/15.7 inches) bunchgrasses within 1.8 km (1.1 miles) of leks to provide adequate nesting cover. Pitman et al. (2005: 1268) recommended leaving behind more than 9.8 inches of grass height during the nesting season.

McWilliams (2013: 69) documented a decline in rangeland condition in 16 of 17 BLM Habitat Evaluation Areas between 2007 and 2012, based on declining prevalence of *Andropogon*, a climax grass associated with good range condition. This decline in range condition was associated with drought conditions compounded with moderate to low levels of livestock grazing.

Collins et al. (1987: 89, 97) found that livestock grazing reduced perennial grasses relative to one ungrazed plot, and that low-growing and grazing-tolerant grama grass tended to increase with livestock grazing. Patten et al. (2005a: 1273) did not detect differences in grass cover between grazed and ungrazed sites in their study. In New Mexico, Hunt and Best (2004: 122) found livestock overgrazing to be the second most important factor in determining cause of lek abandonment, accounting for 18.6% of the variation in the dataset. Active leks had five times as much *Andropogon* as abandoned leks, leading Hunt and Best (2004: 74) to conclude that heavy grazing has a negative impact on both lekking and nesting for lesser prairie chickens. Hunt and Best (2010: 481) further elaborated that while *Andropogon* was more abundant around active leks, abandoned leks had more *Sporobolus*; *Andropogon* decreases with grazing pressure while *Sporobolus* increases, indicating that heavy livestock grazing is a primary driver of lek abandonment in New Mexico. McWilliams (2013: 70, 72) also documented a shift from *Andropogon* in active lek areas to *Sporobolus* in grazed areas with no lek activity, and likewise concluded that heavy grazing was a major impact on lesser prairie chickens.

In contrast to most other researchers, Bidwell and Peoples (1991: 9004.2) argued that light to moderate grazing could benefit lesser prairie chickens by promoting a mosaic of different habitat types. Merchant (1982: 33, 35) found that lightly grazed habitats are particularly important for nesting during times of drought. Elmore et al. (2009: 13) argued that light stocking rates not only benefit lesser prairie chickens, but also provide the best long-term economic return and lowest risk at times of economic uncertainty or drought.

Short-duration grazing regimes make it easier to mimic natural patch dynamics in shinnery oak systems than season-long grazing (Haukos 2011: 114). Some authors (*e.g.,* Litton 1978: unnumbered 6, Grisham et al. 2016b: 330) have recommended rotational grazing practices as a method to allow overgrazed grassland to recover or reduce overall grazing pressure, and some studies (*e.g.,* McIlvain and Savage 1951: 45) reported that rotational grazing increases taller grasses favorable to lesser prairie chickens, such as bluestem species, while continuous grazing increases low-growing gramas. However, Dickerson (1985: 47) found that short-term, rotational grazing did not yield consistent increases in forage production or forage quality over continuous grazing from year to year in shinnery oak grasslands of Texas. These grazing systems also result in uniform grazing of grasses, which suppresses patch heterogeneity (Fuhlendorf and Engle 2001: 631). Such grazing systems also require multiple paddocks and a great deal of cross-fencing, which is deadly to lesser prairie chickens (Elmore et al. 2009: 10). Elmore et al. (2009: 13) argued, "Short-duration grazing, as it is commonly practiced with multiple paddocks and frequent moves, will not provide the landscape diversity necessary for healthy [lesser prairie chicken] populations." Patch burning can create patch heterogeneity that is sustained through livestock grazing (Fuhlendorf and Engle 2001: 628, Elmore et al. 2009: 5), to the benefit of lesser prairie chickens.

Ahlborn (1980: 60) recommended that efforts to optimize nesting and brood-rearing habitat should focus on restoring grassland-shinnery oak plan communities to near-climax state through reduction in livestock grazing pressure. Riley (1978: 53) also flagged reductions in livestock grazing as a central tenet of lesser prairie chicken conservation. Hagen et al. (2004: 78) recommended limiting livestock grazing to light to moderate levels that retain 60-70% of residual grasses and herbaceous vegetation for nesting cover for prairie chickens, and recommended resting 20-30% of a pasture on a 3-5 year rotation. Bailey et al. (2000: 149) surveyed the quality of nesting habitat in New Mexico; these researchers found that 80% of nesting habitat was in poor condition as a result of grazing and drought, and that the poor quality of nesting habitat was likely a limiting factor on lesser prairie chicken numbers that contributes to population declines. Hens with broods preferred ungrazed habitats with no herbicide treatments, with grazed sites without herbicides selected second-highest; ungrazed sites subjected to herbicide were avoided (Bell et al. 2010: 482). Bailey and Williams (2000: 164) asserted that grazing impacts to lesser prairie chicken habitat could be ameliorated by a prompt reduction in stocking rates during drought.

Impacts on shrub cover. Livestock grazing contributes to the spread of shrubs. Heavy livestock grazing may also lead to the spread of shinnery oak, through relieving the shrubs from competition with grasses for moisture and nutrients (Weidemen 1960). Bell et al. (2010: 482) found that sand shinnery oak canopy height was greatest in areas with no livestock grazing and no herbicide treatment; however grazing increased oak stem density. Wright et al. (1976: 470) reported. "Where sites are heavily grazed, honey mesquite invasion is inevitable during opportune years and fire may not be a realistic tool to kill honey mesquite seedlings." However, Gillen and Sims (2006: 148) found no relationship between livestock grazing instensity and sand sagebrush cover in a multi-decadal study.

Livestock grazing increases the level of phenolics in shinnery oak buds and catkins, reducing their digestibility and forage value (Boyd et al. 2001: 297). In addition, overgrazing and fire suppression has reduced the grass and forb component of shinnery oak prairies (Haukos 2011: 110), fostering the expansion of shinnery oak in these habitats. In sand sagebrush grasslands, livestock grazing causes a temporary expansion of shrub cover, which returns to original conditions within 15 years (Collins et al. 1987: 94).

Lessons from other grouse species. For the greater sage grouse, the best available science has established that at least seven inches of residual stubble height needs to be provided in nesting and brood-rearing habitats throughout their season of use. According to Gregg et al. (1994: 165), "Land management practices that decrease tall grass and medium height shrub cover at potential nest sites may be detrimental to sage grouse populations because of increased nest predation… Grazing of tall grasses to <18 cm would decrease their value for nest concealment… Management activities should allow for maintenance of tall, residual grasses or, where necessary, restoration of grass cover within these stands." Connelly et al. (2000: 977) reviewed the science of that time and recommended an 18-cm residual stubble height standard. Hagen et al. (2007b: 47) analyzed all scientific datasets up to that time and concluded that the 7-inch threshold was the threshold below which significant impacts to sage grouse occurred (*see also* Herman-Brunson et al. 2009). Prather (2010: 69) found for the related Gunnison sage grouse that occupied habitats averaged more than seven inches of grass stubble height in Utah, while unoccupied habitats averaged less than the seven-inch threshold.

Fences. A collateral impact of livestock grazing is the proliferation of barbed-wire fences to divide pastures and land ownerships. Collisions with fences were the second-highest cause of mortality for radio-collared lesser prairie chickens in Oklahoma and New Mexico, killing 86 of 322 birds, versus 91 mortalities from raptor predation, the leading cause of mortality (Wolfe et al. 2007: 95). In New Mexico, 26.5% of prairie chicken mortalities were the result of fence collisions (Wolfe et al. 2007: 99). Oklahoma had greater habitat fragmentation than New Mexico lesser prairie chicken habitat, and as a result fence collision mortalities were higher there, comprising 39.8% of all lesser prairie chicken mortality (*id*.). Patten et al. (2005b: 242, Figure 3) also found high rates of fence collision mortality, accounting for 32.3% of all deaths in Oklahoma and 13.3% of all mortality in New Mexico. In Kansas, Plumb (2015: 69) attributed 7.2% of hen mortalities during the breeding season to either fence collisions or fatal encounters with agricultural equipment. Robinson et al. (2016: 7) reported that fence collisions were uncommon in northern Kansas and southeast Colorado. Lesser prairie chickens also avoid fences during the nesting season, perhaps because they provide perch sites for raptors (Lautenbach 2015: 30).

Fence collisions are also a major problem for other grouse species. Stevens et al. (2013: 411) found that fence collisions are an important source of greater sage grouse mortality, and fences on flat areas near leks were a particularly high risk for causing sage grouse fatalities. Christiansen (2009: 1) documented 146 sage grouse collision mortalities along a 4.7-mile stretch of fence in western Wyoming over a 2.5-year period. Moss (2001: 255) projected that fence mortality for the capercaillie in Scotland is sufficiently high to drive the species to extinction, when in the absence of fence mortality hen populations would increase by 6% annually. Robinson (2015: 96, 102) found higher mortality rates for lesser prairie chickens near fencelines, which attenuates at 1 km from the fence, and recommended removing or preventing fence construction in key habitats, but her study attributed the increase in mortality rates to predator activity rather than collisions.

The use of Savery-style grazing systems involving short-duration, high-intensity livestock grazing in a number of small fenced paddocks also may result in greater lesser prairie chicken exposure to fences and fence collision mortality (Wolfe et al. 2007: 102). Wolfe et al. (2003: 18) recommended against cross-fencing of pastures and the use of cell-type grazing systems.

Marking fences to reduce grouse collision mortalities is only partially effective, reducing but not eliminating this source of mortality. In Wyoming, marking of fences in open sagebrush steppe reduced greater sage grouse collision mortalities by 61% (Christiansen 2009: 2). In Europe, marking of fences in woodland habitats reduced collision mortalities for capercaillies by 64%, for black grouse by 91%, and for red grouse by 49% (Baines and Andrew 2003: 169). Fence marking for lesser prairie chickens has also reduced collision mortality, although data are sparse and fence removal is the biologically preferable (although potentially expensive) option (Wolfe et al. 2009: 142).

Vegetation treatments and herbicides. Ranchers and managers of federal rangelands have for decades pursued large-scale shrub eradication programs with the goal of increasing forage for domestic livestock. Oberholser (1974: 268) characterized the result as follows: “Nowadays (1960s into 1970s), summertime motorists in the Panhandle drive for mile after mile through chemically deadened shrubland—a January-in-June landscape.” In New Mexico, the Bureau of Land Management abandoned herbicidal shrub control in 1990, but the practice has continued on private rangelands (Johnson et al. 2004: 342). Mechanical treatments of shinnery oak are rarely undertaken because they result in an increase in shinnery oak stems growing from buds on the rhizomes (Wiedeman 1960). Tebuthiuron is used in conjunction with prescribed fire in an effort to eliminate honey mesquite (Wright et al. 1976: 471). The removal of shinnery oak and sand sagebrush through vegetation treatments is a threat to the persistence of lesser prairie chickens.

Tebuthiuron. Tebuthiuron is a urea-based pelletized herbicide that is absorbed by the roots and travels to the leaves, where it inhibits photosynthesis (Scifres et al. 1987: 4). Sand shinnery oak may occur in dense stands, representing 80% of the annual plant yield, and is highly competitive with grasses and forbs for water and nutrients, and is the primary target for this herbicide (Pettit 1986: unnumbered 1). Livestock operators have often targeted shinnery oak for a 50-80% reduction in density to stimulate increased grass production for their livestock (Copelin 1963: 51). Pettit (1986: unnumbered 3) asserted that a three- to seven-fold increase in forage yields for livestock could be achieved in this way. Cotton farmers also target shinnery oak for tebuthiuron treatment and burning out of fear that it provides winter habitat for the boll weevil (Slosser et al. 1985, Prairie Cotton Growers 1998: 3, Johnsgard et al. 2002: 127).

Shinnery oak is seasonally toxic to livestock due to poisonous spring buds (Duck and Fletcher 1944: 73), which causes ulceration of the rumen and subsequent destruction of the liver and kidneys. The abomasum and small intestines may be inflamed or ruptured as well, due to excessive levels of tannin (Vermeire and Wester 2001: 19). Application of the herbicide tebuthiuron and land conversion via deep-plowing have been widely used to reduce or eliminate this shrub and increase the production of forage grasses used by livestock, and both can permanently eliminate sand shinnery oak (Jones and Pettit 1984: 488). However, during drought, shinnery oak provides one of the few available livestock forages and may therefore become valuable (Peterson and Boyd 1998: 24). Pasture-scale applications of tebuthiuron occurred on BLM lands during the 1980s and 1990s, and continue to occur on private ranch lands today (Johnson et al. 2006: 6).

Some researchers (*e.g.,* Doerr 1980: iv, Doerr and Guthery 1983: 1138) recommended targeted tebuthiuron treatments to enhance prairie chicken habitat, and others (*e.g.,* Donaldson 1966: 223) expressed ambivalence regarding the potential benefits versus drawbacks of shinnery oak herbicide treatments. However, according to Peterson and Boyd (1998: 29), "There is no evidence from Texas or New Mexico indicating that shin-oak treatment with tebuthiuron benefits prairie-chickens." Jackson and DeArment (1963: 736) argued that "the accelerating program of brush and weed control by aerial application of herbicides" was one of the three most important factors preventing lesser prairie chicken population rebounds following drought. Tebuthiuron also kills non-target plant species, including forbs and sand sagebrush (Pettit 1979, Doerr and Guthery 1983: 1139, 1141). Forbs recover quickly following tebuthiuron applications, increasing within several years after treatment (Olawsky 1987: 17). Loss of sand shinnery oak habitats as a result of treatment with tebuthiuron and other herbicides is a major cause of habitat degradation for lesser prairie chickens (Johnsgard 2002: 127, Bell et al. 2010: 484). In Texas alone, over 405,000 hectares (1 million acres) have been converted from sand shinnery oak habitat (Bell et al. 2010: 484). Removal or loss of shinnery oak on sandy soils also can lead to severe wind erosion (Moldenhauer et al. 1958: 5).

Haukos (2011: 114) concluded that modest levels of tebuthiuron treatment, coupled with long periods of rest from livestock grazing (7 years' rest before, 3 years rest after treatment) could result in an increase in grass cover and return toward historical patch diversity. However, this researcher also noted that higher application rates desired by livestock producers may be harmful rather than beneficial to grassland birds, particularly when shinnery oak communities are in poor condition. Olawsky (1987: 64) recommended a patchy pattern of application to maintain a mosaic of habitat types. Crawford (1974: 45) found that a single spraying of herbicide was correlated with improved lesser prairie chicken population performance, but lands subjected to two sprayings had much lower forb cover and were correlated with smaller prairie chicken populations.

Doerr (1980: iv) found that tebuthiuron treatment increased grass coverage and density, improving nesting and winter cover, but decreased shinnery oak cover by at least 84%, eliminating thermal cover and important foods. Olawski (1987: 64) and Patten and Kelly (2010: 2152) also found that tebuthiuron reduced oak cover, but increased grass cover.

Olawsky (1987: 60) determined that acorns from shinnery oak were a major component of lesser prairie chicken diet in untreated shinnery oak habitats, while acorns were absent in the diets of prairie chickens in habitats that had been treated with tebuthiuron; these dietary differences even correlated with differences in gizzard weights and caecal lengths in birds from treated versus untreated areas. More definitively, Olawski (1987: 60, 61) found that birds in untreated pastured had higher protein and lipid levels than birds in treated pastures, indicating superior health and body condition, due to increased acorn consumption (fat) and greater availability of insects in shinnery oak left untreated by herbicide (protein). Litton (1978: unnumbered 10) recommended limiting spraying to once every four years, and avoiding spraying the same area in consecutive years. The negative effects of tebuthiuron spraying on shinnery oak habitats are detectable 20 years or more post-treatment (Johnson et al. 2006: 6). According to Riley et al. (1993: 188), "Because of the importance of shinnery oak grassland to prairie-chickens for both food and cover, broad-scale eradication of this community should be avoided."

Olawski and Smith (1991: 366) found no difference in lesser prairie chicken numbers on lands treated with tebuthiuron and untreated habitats, and suggested that treated areas provided greater concealment from tall grasses in winter, when shinnery oak shrubs have dropped their leaves. Smythe and Haukos (2009: 142) similarly found no difference in nest site selection in treated and untreated areas. Patten et al. (2006: 18) found no difference in nest survival between treated and untreated pasturelands, and found a slight (but non-significant) reduction in overall fledgling production in treated habitats. Wiedenfeld et al. (2001: 56) also detected no difference between habitat use and nest success on treated and untreated plots, but cautioned that the effects of tebuthiuron effects on vegetation the year before did not become apparent until very late in their study, perhaps masking significant effects.

Johnson et al. (2004: 339) found that hens selected untreated shinnery oak habitats heavily over treated habitats. Overall, lesser prairie chickens avoided tebuthiuron-treated habitats for nesting but those hens which did nest in these habitats showed similar fledgling production to those that nested in untreated habitats (Patten and Kelly 2010: 2153). Avoidance of treated habitats increased over time, with 25.3% of birds nesting in treated areas the first year post-treatment (when the full effect of the herbicide had yet to be fully visible), declining to 1.2% of birds nesting in treated areas three years post-treatment. Thus, tebuthiuron has a negative impact on lesser prairie chicken reproduction as a result of avoidance of these habitats by nesting birds, rather than by directly depressing the nest success or chick survival for birds that do nest in treated habitats.

Furthermore, because lesser prairie chicken survival is positively correlated with shrub cover and density, the use of tebuthiuron potentially results in lower adult survival rates for lesser prairie chickens using treated habitats (Patten et al. 2005a: 1276). However, Smythe and Haukos (2009: 142) found low nest success rates for a variety of grassland birds across all types of treated and untreated habitats during their study due to drought conditions, and could not detect significant differences in nest survival. Haukos (2011: 113) pointed out that intensive livestock grazing in tebuthiuron-treated areas resulted in lesser prairie chickens abandoning these areas in favor of untreated habitats. Doerr (1980: 49) warned that sand dunes should not be treated with tebuthiuron so that shinnery oak could be maintained for summer thermal cover and for production of catkins, galls, and acorns important for food for lesser prairie chickens. Jackson and DeArment (1963: 737) documented a two-year loss of acorn production from aerial spraying that resulted in a 25% kill of shinnery oak in the affected area, which resulted in a lower prairie chicken population count in 1958. Hagen et al. (2004: 78) recommended that managers should minimize the use of herbicides, except where they are needed to control invasive weeds.

Similar to tebuthiuron use in shinnery oak grasslands, the herbicide 2,4-D is used to manipulate sand sagebrush grasslands (Bovey 1964, Donaldson 1969: 9). On the Cimarron National Grassland, about 10,000 acres of sand sagebrush were treated annually from 1979 through 1984 in large, continuous blocks (Rodgers and Sexson 1990: 494). In 1978, the Forest Service initiated 2,900 acres of tebuthiuron treatments on the Cimarron National Grasslands in small blocks and strips in accordance with a wildlife management plan, but unsatisfied with the results the agency departed from the plan and treated an additional 36,500 acres of sand sagebrush, causing extensive habitat damage and long-lasting lesser prairie chicken population decline (Rodgers 2016: 23). The use of this herbicide reduces sand sagebrush, increases grasses and forbs, and increases overall plant diversity over untreated sand sage grasslands (Donaldson 1969: 41); sagebrush losses may be near total following aerial spraying (Rodgers and Sexson 1990: 495). Bovey (1964) found that the first aerial herbicide application resulted in 50-90% reduction in sand sagebrush, while a second application was necessary to eliminate sand sagebrush entirely; McIlvain and Savage (1949: 47) reported lethal rates of 25-86% from a single spraying.

According to Jackson and DeArment (1963: 737), “The elimination of sand sagebrush, shin oak, and other woody cover, if concurrent with or followed by heavy grazing, results in plant communities to which the lesser prairie chicken does not readily adjust.” Songbird counts in treated pastures showed major declines in years 4 and 5 post-spraying (Rodgers and Sexson 1990: 496). Thacker et al. (2012: 520) found that aerial spraying of sand sagebrush reduced shrubs and visual cover significantly for 20+ years, without meaningfully increasing forb production or grasshopper abundance, and therefore cautioned that this technique is not an appropriate habitat treatment to benefit lesser prairie chickens in cases where cover is limited. The spraying of sand sagebrush habitats is known to cause lek abandonment and displacement of lesser prairie chickens to marginal unsprayed habitats (Jackson and DeArment 1963: 736).

In sum, the broad-scale application of herbicides has had a negative impact on lesser prairie chickens in the past, and represents a continuing threat to the species and its habitats, particularly on privately-owned rangelands.

Prescribed fire. Some researchers (*e.g.,* Bidwell and Peoples 1991: 9004.3, Dahlgren et al. 2016: 271) have suggested that prescribed fire can be a cost-effective method for improving nesting and brood-rearing habitats for lesser prairie chickens. Prescribed fire has also been recommended in shinnery oak grasslands and Conservation Reserve Program lands for the control of overwintering boll weevils, for the benefit of cotton farmers (Plains Cotton Growers 1998: 3). Bidwell et al. (2002: 3) and Elmore et al. (2009: 13) went so far as to assert that periodic fires are necessary in Oklahoma to maintain the proper shrub height and canopy cover for optimal prairie chicken habitat. The human-caused alternation of natural fire regimes results in suboptimal habitat for lesser prairie chickens and in a secondary threat to their survival; human-driven prescribed fire programs do not at this time recreate natural fire patterns across most of the species' range.

Haufler et al. (2012: 14) pointed out that the patchy distribution of burned landscapes attracted heavier grazing pressure by native ungulates, creating a shifting mosaic of grass heights that included high-grass areas for nesting habitat and low-grass, high forb and insect areas preferred by brood-rearing lesser prairie chickens. Vermeire (2002) likewise found that burned areas experienced much stronger grazing pressure by domestic livestock. However, Pillsbury et al. (2011) experimentally examined patch-burning followed by grazing, and found that patch burning did not create structural heterogeneity (due to livestock grazing that was apparently too heavy) and generally resulted in lower grass height (and the presence of birds that preferred these habitats), while large-scale burning resulted in tall, dense grasses. Winter et al. (2011) also found that patch burning followed by herbivory reduced grass heights versus unburned sites. Bidwell et al. (2002: 9) cautioned that it is very important to retain unburned areas of dense grass within one mile of lek sites. Cannon and Knopf (1979) recommended early spring burns as a means of attracting lesser prairie chickens to breed at new, recently burned locations.

Boyd and Bidwell (2001) examined the effect of prescribed fire in spring, fall, and winter, and found an immediate loss of mast crop and oak bud and catkin production, neutral to positive response of grasses and grasshoppers, and a longer-term reduction in nesting habitat quality due to reduction in shrub cover. Vermeire et al. (2004b) found that prescribed fire followed by livestock herbivory negatively affected several species of grasshoppers, but overall abundance and biomass were unchanged from pre-burn levels. Doxon et al. (2011) performed a more broad-based survey of insects following prescribed fire followed by livestock grazing, and similarly found only minor differences in abundance and diversity between burned and unburned plots. Elmore et al. (2009: 13) recommended burning private rangelands every three to five years, constraining burns to 20 to 30 percent of the land in any given year. Prescribed burns during late summer, fall, and winter promote a higher proportion of forbs, an important prairie chicken food source (Bidwell et al. 2002: 9). Hagen et al. (2004: 78) recommended a very cautious approach to prescribed burning in lesser prairie-chicken habitat, and recommended mechanical treatments as preferable for juniper removal.

Fire topkills shinnery oak, and following a burn or mechanical cutting, it re-sprouts from underground buds located along the rhizomes (Wiedeman 1960, Boyd et al. 2001). Shinnery oak is fire-tolerant, returning its former abundance and stature within four years after a fire (Harrell et al. 2001), or even increasing in abundance (Pettit 1986).

Prescribed fire has been recommended as a means of increasing grasses in sand sagebrush grasslands (Vermeire et al. 2001). Vermeire (2002) found that prescribed fire applied between maturity of stem growth and dormancy removed decadent material without long-term damage to sand sagebrush stands, as sand sagebrush sprouts strongly following fire, whereas burning or mechanical treatment during stem elongation (prior to July) was damaging to the shrubs. Patch burning in sand sagebrush prairie creates areas that strongly attract domestic livestock when they are allowed access to the burned area in the immediate wake of the fire, leading some researchers to recommend this method as a tool to manage livestock grazing distribution (Vermeire et al. 2004a). However, allowing livestock immediate access to burned sites reduces the standing crop of grasses on these sites by roughly half (Vermeiere et al. 2005). Autumn burning accelerates wind erosion by denuding the soil during the dormant season; spring burns showed no increase in wind erosion of the soil (Vermeire et al. 2005).

Grazing by large herbivores decreases fire frequency, which increases the rate of spread of woody trees and shrubs and the loss of grassland habitats (Briggs et al. 2002b). While fire may be effective in eliminating juniper encroachment at the stage when a significant component of grassland remains, once juniper woodlands reach a closed-canopy condition the herbaceous understory is eliminated and they lack sufficient fuels to carry prescribed fire (Briggs et al. 2002a). Historically, natural fires limited the invasion of trees on Kansas grasslands (Bragg and Hulbert 1976, Briggs et al. 2002b). Waddell and Hanzlick (1978) suggested that deep, sandy soils prevented enough rainfall from staying within the rooting zone of trees to permit tree growth in sand sagebrush habitats. In addition, plantings of trees at homesteads, in cemeteries, and in shelterbelts between cropfields facilitated its spread onto the Great Plains (Stritzke and Bidwell 1989). However, livestock grazing significantly reduced fuel loads, reducing the fires that kept red-cedar in check and fostering its expansion (Van Auken 2000, Briggs et al. 2002a, b), and the same is true for common hackberry (*Celtis occidentalis*, Briggs et al. 2002b). However, Owensby et al. (1973) found that juniper invasion rate declined as grazing intensified. Honey mesquite appears to be difficult to reduce using fire, and only partial exclusion of this shrub can be achieved even with repeated burning (Wright et al. 1976: 470).

Tree invasion. According to LPCI (2016), more than 675,000 acres of occupied lesser prairie chicken habitat are now impacted by red-cedar encroachment about two-thirds (441,020 acres) of which are currently at low density of tree cover. In 1873, the Federal Timber Culture Act offered 160 acres of land to any claimant who would plant 40 acres of trees; this resulted in plantings in the eastern parts of lesser prairie chicken range that would ultimately lead to tree invasion (Rodgers 2016: 23). In the tallgrass prairie of northeastern Kansas, redcedar (*Juniperus virginiana*) encroachment can convert grassland to closed-canopy woodland in as little as 40 years (Briggs et al. 2002a). In Oklahoma, this species is known to have slower growth rates in the western parts of the state than in the wetter eastern parts (Engle and Kulbeth 1992). The creep of junipers into grassland is also a large-scale issue in Oklahoma (Drake and Todd 2002). Van Auken (2000) argued that the expansion of woodlands into the Great Plains is the result of expansion of tree species that were already present at low densities expanding in response to heavy livestock grazing and the suppression of natural fire.

Fuhlendorf et al. (2002: 625) found that increasing tree cover at large scales was correlated with declining populations of lesser prairie chicken. Lautenbach (2015: 118) found a strong negative relationship between juniper density and lesser prairie chicken habitat use, and once woodland density reaches two trees per 5 acres, hens will no longer nest there. LPCI (2016) found that densities greater than one tree per acre nullified habitat value for lesser prairie chickens. The expansion of woodlands, particularly junipers, could be leading to the isolation of lesser prairie chicken populations that were formerly connected in larger-scale metapopulations (Fuhlendorf et al. 2002: 625). LPCI (2016) noted that redcedar encroachment is a significant issue in grasslands on the eastern part of the lesser prairie chicken range, and that redcedar expansion is correlated with ecological conversion from warm-season C3 grasses to cool-season C4 grasses. Together, excessive livestock grazing and this expansion of redcedar are deemed "the largest threat to existing [lesser prairie chicken] populations" in Oklahoma (Bidwell et al. 2002: 3).

Tree removal projects are currently popular, and landowners are often willing to participate, because they can result in increased forage for domestic livestock on treated rangelands (Elmore and Dahlgren 2016: 196). In eastern Kansas, woodland expansion can be curbed with regular fire, maintaining tree and grassland distribution at pre-settlement levels (Bragg and Hulbert 1976). Elmore et al. (2009: 13) recommended burning prairie on a 7-year rotation to suppress the invasion of junipers. When juniper stands become mature, prescribed fire is no longer a safe option, and mechanical removal through cutting, pushing, chaining, or grinding is recommended if grassland restoration is the goal (Elmore et al. 2009: 15). However, LPCI (2015) cautioned that the effectiveness of redcedar removal at improving lesser prairie chicken habitat has never been directly tested and demonstrated.

Archer et al. (1988) documented the expansion of honey mesquite, which dies back at the end of droughts but expands during wet periods, over time on the Rio Grande Plains. That expansion was attributed largely to domestic livestock, which are excellent vectors of mesquite seed dispersal, leading to conversion from grassland to woodland (*id*., *and see* Van Auken 2000). As noted above, the use of prescribed fire for control of honey mesquite is not effective.

Invasive weeds. Wolfe et al. (2016: 307) pointed out, "invasive grasses have often outcompeted native vegetation to create exotic monocultures with little ecological value." Some CRP lands in Colorado, particularly those managed for permanent wildlife habitat, had major components of cheatgrass or squirreltail (Ripper et al. 2008: 216). According to Bidwell et al. (2002: 11), non-native invasive plants such as Bermuda grass, Old World bluestem, Russian olive, autumn olive, and osage orange are of no value to the lesser prairie chicken. According to Rodgers (2016: 26), "Wherever exotic bluestems have been established, they have been nearly impossible to eliminate and proven to be aggressive invaders that are likely to further diminish the habitat quality of remaining native grasslands." Roads are a conduit for the spread of invasive weeds along roadways and in adjacent habitats, as disturbance of soils and vegetation during road construction provides ideal habitat for weed establishment, and construction equipment and subsequent vehicle use transports weed seeds into the road corridor (Gelbard and Belnap 2003). Invasive weeds represent a significant and potentially growing threat that would potentially be exacerbated by additional development and/or climate change in lesser prairie chicken occupied habitat.

Threats by DPS

Shinnery Oak Prairie DPS. The Shinnery Oak Prairie DPS is impacted by agricultural conversion to cropland (Patten et al. 2006: 10) often to support dairy farms (Davis 2005: 18), livestock grazing (Wisdom 1980: 33, Hunt and Best 2010: 481, McWilliams 2013: iii, 73), non-native grasses (Davis 2005: 13, Rodgers and Huffman 2005, Patten 2006), oil and gas development (Massey 2001: 16, Hunt and Best 2004, Ungerer and Hagen 2012: 29), and transmission lines (Timmer 2012: 72). Hunt and Best (2004: 130) concluded that while both overgazing and petroleum development are having negative effects on lesser prairie chickens in New Mexico, oil and gas development has the stronger negative effect.

Grisham et al. (2016b: 315) stated, "In addition to the universal threats throughout the species distribution, populations in sand shinnery oak are susceptible to a changing climate in an ecoregion that is already an extreme environment for ground-nesting birds." Wolfe et al. (2016: 306, citing Grisham et al. 2013 and 2016a) added, "models of climate change in [the] Sand Shinnery Oak Ecoregion predict that nest survival will fall below the threshold for population persistence."

Conservation Reserve Program lands in Texas and New Mexico (many of which were planted decades ago) are dominated by non-native plantings of weeping lovegrass and Old World bluestem, which have little if any value as prairie chicken habitat (Davis 2005: 13, Rodgers and Huffman 2005, Patten 2006). Efforts to rehabilitate monocultures of non-native grass on CRP lands have largely failed (Haufler et al. 2012).Toole (2005: 29) reported that native rangelands had 32 times more inverebrates, an important lesser prairie chicken dietary component, than CRP fields planted in lovegrass. Conservation Reserve Program lands in New Mexico were also deficient in shrub cover, with the vast majority showing no shrub component, and of those that had shrub growth, none exceeded 10% shrub cover (Ripper et al. 2008: 210-211). For these reasons, Conservation Reserve Program lands have added little to prairie chicken conservation efforts.

Sand Sage Prairie DPS. The Sand Sage Prairie DPS is impacted by agricultural conversion to cropland (Davies 1993, Sullivan et al. 2000: 178, Robel et al. 2004), livestock grazing (Hoffman 1963: 728, Davies 1993, Giesen 1994b: 180, Sullivan et al.: 178), sand sagebrush “control” programs (Rodgers and Sexson 1990: 494, Rodgers 2016: 23, Sullivan et al. 2000: 178), and transmission lines (Lautenbach 2015: 30).

Cannon and Knopf (1980: 74) found that most lesser prairie chicken populations in Oklahoma occupied private native rangelands and remarked, “The future status of lesser prairie chickens in Oklahoma will reflect the practices of individual landowners, since few scattered populations remain on public lands.” Dryland farming in this area largely failed during the Dust Bowl of the 1930s, and many croplands had reverted back to grassland by the 1960s, when irrigated center-pivot farming intiated a new round of habitat loss, the primary cause of lesser prairie chicken declines in this ecoregion (Haukos et al. 2016b: 283). Anthropogenic structures related to energy development and infrastructure have also had a major negative effect in this ecoregion. Robel et al. (2004) reported that only 26% of the native grassland habitat remained available for nesting in the Sand Sage Prairie ecoregion as a result of the combined effects of agricultural crop conversion and avoidance of anthropogenic structures.

In many cases, croplands have been enrolled in the Conservation Reserve Program to convert them back to grassland. In addition, a large proportion of cropland in this ecoregion is highly erodible, elevating its potential for enrollment in the CRP Highly Erodible Land Initiative (Haukos et al. 2016b: 294). However, Conservation Reserve Program lands in Colorado were deficient in shrub cover, the vast majority of CRP fields having no shrubs, and none of those that had shrubs reached 10% shrub cover (Ripper et al. 2008: 210-211). These lands were dominated by plantings of grama grass, which is low-growing and provides insufficient cover for lesser prairie chicken habitat needs (Rodgers and Huffman 2005, Ripper and Vercauteren 2007: 10). CRP lands in Colorado also had limited forb production and were dominated by low-growing grasses, with 50% of all lands sampled having grasses <35 cm in height (Ripper et al. 2008: 216). For these reasons, CRP lands in the Colorado portion of the Sand Sage Prairie ecoregion have limited value as lesser prairie chicken habitat.

Mixed-Grass Prairie and Shortgrass Prairie/CRP Mosaic DPS. The Mixed-Grass Prairie and Shortgrass Prairie/CRP Mosaic DPS is impacted by cropland conversion (Copelin 1959: 158, Copelin 1963, Sexson 1980: 114, Toole 2005: 20, Pitman et al. 2005: 1259, Hagen et al. 2010: 30, Robinson 2015: 38), livestock grazing (Copelin 1959: 159, Jackson and DeArment 1963: 736, Collins et al. 1987: 89, Bidwell and Peoples 1991: 9004.1, Patten et al. 2005a: 1277, Melcher 2015: 168), herbicide “treatment” of shinnery oak habitats (Jackson and DeArment 1963: 736, Olawsky 1987: 62, Bell et al.

2010: 484), fencing of small pastures and small pasture size (Patten et al. 2005b: 244, Wolfe et al. 2007: 102), infrastructure and industrial features (Hagen 2003: 156, Robel et al. 2004, Pitman et al. 2005: 1259, Hagen et al. 2011: 73, Timmer 2012: 72, Plumb 2015: 116, Lautenbach 2015: 30), rural sprawl in the form of buildings (Pitman et al. 2005: 1267), energy development (Dusang 2011: 31, Jarnevich and Laubhan 2011: 930, Hagen et al. 2011: 73, Ungerer and Hagen 2012: 29, Hovick et al. 2014), and tree invasion of grassland habitats (Drake and Todd 2002, LPCI 2016).

Over 50% of the southern mixed-grass prairie has already been lost (Samson et al. 2004). According to Wolfe et al. (2016: 299), "Much of the mixed-grass prairie was severely fragmented by homesteading over a century ago, and fragmentation is ongoing due to oil and gas development, wind power development, transmission lines, highways, and expansion of invasive plants such as eastern red-cedar (*Juniperus virginiana*)." Oil and gas well densities in the Mixed Grass Prairie Ecoregion already average 4 to 12 wellsites per square mile (Wolfe et al. 2016: 302), and additional development is ongoing. Density of fences, which result in collision mortalities, in the Mixed Grass Prairie Ecoregion can reach as much as 8.8 linear miles of fencing per square mile of habitat, and 6 miles of fencing per square mile is prevalent (Wolfe et al. 2016: 305). In addition, estimates of genetic effective population size (N_e) for the Mixed Grass Prairie Ecoregion are low, suggesting that the maintenance of genetic diversity may be compromised for this population (Corman 2011, Pruett et al. 2011: 1212).

(Factor B) Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Hunting. Hunting is widely viewed today as being of negligible significance to the decline of lesser prairie chicken populations. Haukos et al. (2016a: 142) found sport hunting "fairly minor source or mortality" over the past century. However, sport hunting can have a significant local impact on populations (*see, e.g.,* 1933 data presented in Davison 1940), and market hunting for the species resulted in heavy mortality in the late 1800s (Haukos et al. 2016a). Hagen (2003: 119) found that in his population dynamics modeling, population change responded poorly to reductions in harvest and other efforts intended to increase adult survival rates. This researcher concluded that "increases in adult survivorship or post-brood survival by eliminating hunting (<5% of all current mortality) would do little to stabilize these populations" (Hagen 2003: 126). Interestingly, hunting harvest does not seem to be correlated with overall population (Snyder 1967: 126). In Kansas, the economic impact of lesser prairie chicken hunting was estimated at $182,250 annually, while the economic impact of birdwatching as a whole (including lesser prairie chicken) in the Cimarron National Grassland, Pratt Sandhills, and Finney Refuge by themselves was estimated at $629,300 annually (Mote et al. 1999).

Heavy sport hunting occurred during the 1800s, when parties of prairie chicken shooters went out on the prairies by the wagonload and often returned with dozens of birds each; early game laws allowed prairie chickens to be hunted throughout the year (Fleharty 1995: 38). Around 1900, railways ran specials for sportsmen to the Texas panhandle and placed ice cars on sidings for preservation of the kill (Jackson and DeArment 1963: 733). Ligon (1927) reported that lesser prairie chickens became subject to significant illegal hunting in New Mexico when they gathered in flocks and visited croplands during autumn and winter.

Kansas first regulated lesser prairie chicken hunting in 1861, but other states did not initiate limits or seasons until the early 1900s (Haukos et al. 2016a). The hunter harvest in Kansas peaked above 6,000 birds in 1979 (Haukos et al. 2016a). In Oklahoma, a two- to four-month season was set for lesser prairie chicken hunting beginning in 1890, with no bag limit until 1909, when a limit of 15 birds per day and 100 per year was established (Copelin 1959: 158). Lesser prairie chicken hunting was discontinued in Oklahoma in 1915 due to scarcity of prairie chickens, although hunting was reinstated in 1929, 1931, and 1933; additional open seasons occurred in 1950 and 1951 (Copelin 1963). In Colorado, hunting of lesser prairie chickens was discontinued in the early 1900s (Giesen 1998). Lesser prairie chicken hunting was ended in Texas in 1937 (Jackson and DeArment 1963: 733), and did not resume until a two-day season was opened in 1967 (Johnsgard 2002: 34). In 1987, nearly 1,400 birds were shot in Texas, a high point over the last 30 years (Haukos et al. 2016a). The hunting season in Texas was ultimately closed in 1998 and has not reopened (Haukos et al. 2016a). As of 1998, only Kansas and Texas had open hunting seasons, and these were limited, with an annual harvest of less than 500 birds in each state (Giesen 1998).

New Mexico closed its hunting season in 1935, re-opening it in 1948; at least 962 birds were killed in 1949 (Lee 1950). Massey (2001: 18) reported that a hunting season was also permitted in 1948 and 1949, 1958 and from 1960 to 1995. Campbell (1972: 689) studied lesser prairie chicken population dynamics in New Mexico, and found that the removal of 1,100 birds per year by hunting had no apparent effect on the overall population from year to year. Davis (2005: 7) found that hunter harvest in recent times peaked at 4,000 birds in 1988 before declining abruptly, resulting in the permanent closure of the hunting season in 1996. A planned hunt in 2008, which would have allowed 100 birds to be taken, was suspended due to the impending prospect of federal Endangered Species Act listing.[5]

Game wardens are unable to comprehensively patrol all lesser prairie chicken habitat, and as a result incidental take of lesser prairie chickens during the quail hunting season has been documented (Duck and Fletcher 1944: 73). Overall, hunting of lesser prairie chickens was likely a heavy cause of mortality during the late 1800s and into the early 1900s, and potentially played an important role in early population declines. However, the low levels of hunting mortality in recent decades ranks this as a secondary threat to population persistence today. Hunting is currently not occurring in any state (Elmore and Dahlgren 2016: 199), but could start again since the 2016 removal of the lesser prairie chicken from the "threatened species" list.

Scientific use. Scientific studies can result in small-scale mortality, disturbance, and

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[5] Romo, Rene. State puts prairie chicken hunt on hold. Santa Fe New Mexican, August 8, 2008. Online at http://abqjournal.com/news/state/081140454008newsstate08-08-08.htm; last viewed 7/18.16.

displacement of lesser prairie chickens. Haukos (1988: 3) noted that the presence of radio transmitters on lesser prairie chickens might make them more visible and/or vulnerable to predators. Hagen (2003) found no difference in survival rates between lesser prairie chickens fitted with radio transmitters and banded birds. Wolfe et al. (2003: 14) documented four birds in their study that died of undetermined causes, but the deaths were thought to be the result of stress during capture and handling. Jamison (2000: 53) documented that 5 of 71 chicks (7%) and 12 of 350 adults (3.4%, p. 153) marked in his Kansas study died as a result of handling during initial capture.

McRoberts et al. (2011b) found that lesser prairie chickens flushed on 38.5-50% of aircraft passes durial aerial population surveys, depending on type of aircraft used; birds returned to lekking in an average of seven minutes on 14 of 19 instances. These researchers concluded that aerial survey disturbance did not negatively impact lesser prairie chickens, but did note the “troubling” potential loss of reproductive opportunities in cases where birds did not return to a disturbed lek within the one-hour observation window.

Disturbance of prairie chickens for scientific purposes is not likely to rise to a population-level threat, but the Service should consider the potential impacts of scientific studies on lesser prairie chicken populations.

Wildlife viewing. There is increasing public interest in viewing the courtship rituals of the lesser prairie chicken, as evidenced by the establishment of the High Plains Prairie Chicken Festival in Milnesand, New Mexico in 2004 (Robb and Schroeder 2005). In addition to New Mexico, Oklahoma also has a lesser prairie chicken festival that includes viewing (Elmore and Dahlgren 2016: 199). Extreme drought led to the Milnesand Lesser Prairie Chicken Festival being canceled in 2013 and 2014 (McDaniel and Williamson 2016). Johnsgard (2002: 133) documented a decline in male attendance at a popular greater prairie chicken viewing lek in Nebraska, which he attributed to human disturbance of the birds. Thus, birdwatching is likely to have a local-scale impact on the lesser prairie chicken.

<u>(Factor C) Disease or Predation</u>

Predation. Overall, predators are the single greatest cause of lesser prairie chicken mortality. However, predation is a normal part of lesser prairie chicken life history, and according to Wolfe et al. (2007: 101), “We have no reason to believe that lesser prairie chicken populations are being impacted severely by predation.” Snyder (1967: 124) added, “Predation is not a major factor in limiting prairie chickens in New Mexico…” Combined raptor and mammal predation accounted for 85.7% of lesser prairie chicken mortality in New Mexico (Patten et al. 2005b: 244, Figure 3), and in a Kansas study predation from all species coincidentally made up 85.7% of the total mortality (Plumb 2015: 69). Winter may be the period of greatest predator-related mortality due to a lesser availability of grass for hiding cover during that season (Davis et al. 1979). Wolfe et al. (2007: 96) pointed out that changes in predation rates on lesser prairie chickens over time have not been detected.

Haukos (1988) found that the peak of raptor migration in Texas corresponded to the period just prior to when lesser prairie chicken hens arrive on the lek. While lesser prairie chickens are highly visible during courtship displays on leks, Behney et al. (2011) found that raptors sighted during lekking activity only attempted an attack 25% of the time, and prairie chickens responded by flushing or squatting, resuming their breeding activity within an average of 4.2 minutes of the event. These researchers concluded that raptor predation on lesser prairie chickens during lekking is uncommon; Davis et al. (1979) reported similar results. Cooper's hawks and sharp-shinned hawks are believed to be the lesser prairie chicken's most effective avian predators, while crows and ravens are significant nest predators (Duck and Fletcher 1944: 72, 73). Haukos and Broda (1989) found that northern harriers commonly visited leks, causing birds to flush and occasionally taking a bird at a location away from the lek.

Predation by coyotes and snakes was found to be the leading cause of nest failure in southwestern Kansas, although 2% of nests were lost as a result of trampling by cattle (Pitman et al. 2005: 1262). Crows, ravens, opossums, skunks, terrapins, and bull snakes may also be effective nest predators (Duck and Fletcher 1944: 73, Leonard 2008). Foxes, including red and swift foxes, are known to predate upon lesser prairie chickens (Boal 2016). In one Kansas study, 63.5% of lesser prairie chicken nests were known to be depredated (Jamison 2000: 79). Pitman et al. (2006a) found that coyotes and gopher snakes were the leading nest predators in their southwest Kansas study, and ground squirrels were also documented as nest predators. Humans and cattle have also been documented to destroy lesser prairie chicken nests (Haukos 1988: 9).

Predator control has not been applied for lesser prairie chicken management due to the difficulty in determining the relative importance of various predator species and whether or not their predation is having a population-level effect (Boal 2016). In addition, predator control programs to benefit grouse can be counterproductive. According to Wolfe et al. (2007: 95), "in cases where top predators reduce mesopredator population densities, for example those of red foxes *Vulpes vulpes*, indiscriminate removal of predators may hasten the decline of grouse populations." For greater sage grouse, Mezquida et al. (2006) confirmed that coyote control programs could result in increased predation and nest failure for greater sage grouse as smaller predators increase in population as a result.

Boal (2016: 146) asserted, "Concerns about predation are "due to impacts of human activities on biotic communities and landscapes and to management goals for sustainable harvest of the population surplus." The most appropriate method for minimizing predation mortality is to provide adequate habitat including sufficient grass cover and an absence of perches (such as transmission lines, fences, and structures) for avian predators in and near occupied habitats. Augustine and Sandercock (2011: unnumbered 15) found that for greater prairie chickens inhabiting unfragmented grasslands, predation pressure was high on nests, chicks, and adults, and recommended investigating rangeland practices that increase residual nesting cover or reduce predator impacts. Unimproved roads, transmission line right-of-ways, and field edges may serve as predator travel lanes, and debris around buildings may provide foraging sites for predators (Pitman et al. 2005:

1268). Atwood et al. (2004) found that coyotes preferentially used fencelines and roadside ditches as travel corridors, enabling them to hunt more efficiently in fragmented landscapes. Hagen et al. (2007a) recommended that managers focus on creating suitable habitat that minimizes loss of females to mammalian predators rather than direct predator-killing programs, which may cost-prohibitive over the long term (*see also* Plumb 2015: 77).

Parasites and Diseases. According to Peterson et al. (2002: 834), "Although habitat loss and degradation are likely ultimate causes for this decline, infectious agents, particularly microparasites, could be proximate contributors." Heavy burdens of parasites can lead to a poor nutritional plane for nesting hens, and through the influence of hen nutrition on egg quality, this can have a significant influence on chick survival (Dobson et al. 1988). Epidemics of microparasites such as *Pasteurella multicida* could result in extirpation of small local populations of lesser prairie chickens if they were to spill over from other host species (Peterson 2016: 174). Peterson (2004) asserted that macroparasites are more likely to regulate populations of grouse, because impacts to fecundity tend to outweigh impacts to survivorship in the population dynamics of these birds. Peterson (2016: 166, 176) listed a number of microbial parasites that have the potential to regulate lesser prairie chicken populations, and further noted that genetic drift and bottlenecking in prairie chicken populations could amplify their vulnerability to disease outbreaks.

The lice *Goniodes cupido* and *Lagopoecus* spp. have been documented infesting the lesser prairie chicken (Emerson 1951). The worm *Oxyspirura lumsdeni* (now *O. petrowi*) has been documented in the ocular orbits of lesser prairie chickens and other Tetraonids (Addison and Anderson 1969, Pence and Sell 1979, Robel et al. 2003); Pence and Sell (1979) characterized this worm as a widespread parasite of ground-dwelling or ground-feeding birds in North America. Pence and Sell (1979) documented one flatworm (*Rhabdometra odiosa*) and a caecal threadworm (*Heterakis isolonche*) in lesser prairie chicken; *H. isolonche* was was noted as the most common helminth parasite for this bird in the Texas panhandle, and several birds had heavy (> 200 worms) infections without suffering apparent ill effects. Helminth parasites have been implicated as a cause of mortality in young ruffed grouse, and may have contributed to the extinction of the heath hen (*Tympanuchus cupido cupido*); a related worm (Heterakas gallinarium) is known to transmit the protozoan *Histomonas meleagridis*, which causes blackhead disease resulting in fatalities in greater prairie chickens and heath hens (Peterson 1996, *and see* Snyder 1967: 125). In Kansas, Robel et al. (2003) documented that the majority of lesser prairie chickens studied were infected by a stomach worm (*Tetrameres* sp.) and a caecal worm (*Subulura* sp.), but no adverse impacts of these parasites was documented when comparing the behavior and survival of heavily infested versus uninfested individuals. High parasite loads of worms could increase susceptibility to predation and to bacterial or viral infections (Peterson 2016: 175).

Mycoplasma and *Salmonella* species of bacteria have been isolated from the trachea and kidneys, respectively, of lesser prairie chickens that appear to be healthy (Peterson 2004). Hagen et al. (2002) found several lesser prairie chickens in Kansas seropositive for infections of three different species of *Mycoplasma* bacteria. Peterson et al. (2002)

documented two strains of infectious bronchitis virus in lesser prairie chickens from Texas. Stable (1979) first documented a 10.8% incidence of the malarial parasite *Plasmodium pedioecietii* in lesser prairie chickens from New Mexico. Also in New Mexico, Smith et al. (2003) found that 13% of lesser prairie chickens in their study tested seropositive for *P. pedioecietii*. Kansas researchers isolated the bacterium *Pasteurella multocida* from the lung, liver, and spleen of two lesser prairie chickens with clinical signs of cholera (Peterson 2004). Lesser prairie chicken mortality from avian cholera has been documented (Hagen et al. 2007a). Smith et al. (2003) also documented a new species of microbe parasite, *Eimeria tympanuchi,* in the feces of lesser prairie chickens; this microbe potentially causes coccidiosis, which compromises the digestion in fowl. Intestinal coccidiosis caused by *Eimeria* pathogens and avian malaria caused by *P. pedioecetii* have the greatest potential for population-level effects through affecting growth and survival of young birds, while West Nile virus also has the potential for large-scale population impacts but thus far is rare within the range of the lesser prairie chicken (Peterson 2016).

West Nile virus was first documented in North American birds in 1999 (Bernard et al. 2001). A recent survey of blood sera from lesser prairie chickens from the southwestern Texas panhandle documented one adult male that showed presumptive evidence of exposure to West Nile virus (Peterson 2016: 169). Peterson (2004) noted that microbial diseases pose a significant danger of extirpation for small, isolated populations of grouse, and that disease outbreaks have resulted in 75% rangewide reductions in turkey, bobwhite, and ruffed grouse populations in the past. Climate change could bring the lesser prairie chicken into grater contact with arthropod-borne viruses like West Nile in the future (Peterson 2016: 176). Thus, this disease poses a major potential future threat to lesser prairie chicken persistence.

Reticuloendotheliosis virus is known to cause mortality in Attwater's and greater prairie chickens through lesions on the internal organs (Drew et al. 1998). Wiedenfeld et al. (2002) found that this virus is uncommon in greater prairie chickens, but an investigation of 184 lesser prairie chickens in Kansas, Oklahoma, and New Mexico turned up no evidence of this pathogen in lesser prairie chickens. This virus remains an important potential threat.

(Factor D) The Inadequacy of Existing Regulatory Mechanisms

The ESA's listing Factor D requires the Service to assess whether "existing regulatory mechanisms"—*i.e.*, presently binding and enforceable protections—are adequate to protect a species. 16 U.S.C. § 1533(a)(1)(D). In order to be considered under this factor, such mechanisms must be currently existing – future promises of action will not suffice – and they must also be enforceable.

Numerous courts have found that speculative and unenforceable conservation efforts cannot be considered "adequate" regulatory mechanisms under Factor D. *Defenders of Wildlife v. Jewell*, No. 12-1833, 2014 U.S. Dist. LEXIS 133271, at *41 (D.D.C. Sept. 23, 2014) (the Service's reliance on an unenforceable state plan addendum to achieve a necessary species protection was unreasonable in light of Factor D); *In re Polar Bear Endangered Species Act and Section 4(d) Rule Litigation,* 794 F. Supp. 2d 65, 113 n.56 (D.D.C. 2011) ("the ESA does not permit [the Service] to consider speculative future conservation actions when making a listing determination"); *Biodiversity Legal Found. v. Babbitt,* 943 F. Supp. 23, 26 (D.D.C. 1996) ("The Secretary … cannot use promises of future actions as an excuse for not making a determination based on the existing record"); *Or. Natural Res. Council v. Daley*, 6 F. Supp. 2d at 1155 (holding that because of Factor D, the National Marine Fisheries Service could not rely on voluntary conservation efforts because, in the absence of a method of enforcing compliance, the results of the effort would be "speculative"); *Cf. Save Our Springs v. Babbitt*, 27 F. Supp. 2d at 744 (rejecting conservation agreement as "speculative" where "[t]here are no assurances that the measures will be carried out").

Voluntary conservation plans, such as the Western Association of Fish and Wildlife Agency's Range-Wide Plan (discussed *infra*), are not generally considered adequate regulatory mechanisms. Such plans may, however, be taken into account pursuant to Section 4(b)(1)(A) of the ESA, 16 U.S.C. 1533(b)(1)(A); 50 C.F.R. 424.11(b), and the Service's "Policy for Evaluation of Conservation Efforts When Making Listing Decisions" ("PECE"). Issued in 2003, the PECE policy sets criteria to be used "in determining whether formalized conservation efforts that have yet to be implemented or to show effectiveness contribute to making listing a species as threatened or endangered unnecessary." 68 Fed. Reg. 15100. The two key factors in this evaluation are: "(1) for those efforts yet to be implemented, the certainty that the conservation effort will be implemented and (2) for those efforts that have not yet demonstrated effectiveness, the certainty that the conservation effort will be effective." *Id*. at 15114. In evaluating discretionary conservation efforts, the Service must determine the degree to which such measures have eliminated the threats to the species. Similarly, in the context of the Final Rule listing the Gunnison sage grouse as a "threatened species," the Service determined that Candidate Conservation Agreements ("CCAs") and Candidate Conservation Agreements with Assurances ("CCAAs") do not constitute regulatory mechanisms and as such cannot be considered under Factor D. 79 Fed. Reg. 69223. Voluntary conservation plans, CCAs, and CCAAs thus are more properly assessed under Factor A, to the extent they can demonstrate effectiveness at alleviating threats to the species.

Although the 1995 petition to list the lesser prairie chicken under the ESA sparked a variety of active conservation efforts in the affected states, ranging from limitations on harvest, to translocation efforts, to habitat restoration attempts, the Service found in the 2014 rule, that "existing regulatory mechanisms have not been effective at removing all of the impacts to lesser prairie chickens and their habitat." 79 Fed. Reg. 20064. Nothing has changed since then that would alter the Service's prior determination under this factor. Furthermore, since the inadequacies of the Service's analysis of regulatory mechanisms under PECE was the reason the original listing was vacated by the courts, the voluntary and optional nature of the Range-Wide Plan requires greater scrutiny, particulary as regards its lack of certainty of implementation.

State Classification. In 1973, the lesser prairie chicken was listed as a threatened species in Colorado under the state's Nongame and Endangered or Threatened Species Conservation Act, and it remains state listed today (CPW 2013). This designation prohibits the unauthorized take, possession, and transport of lesser prairie chickens, but provides no protections for destruction or alteration of lesser prairie chicken habitat. This bird would be downlisted to a Species of Special Concern when the Colorado population remains stable at or above 2,500 birds for a period of five years while fluctuating no more than 10% (Davies 1993). The Recovery Plan adopted by the State of Colorado included a variety of voluntary and incentive-based habitat conservation and acquisition projects, as well as a commitment to population monitoring, transplants of lesser prairie chickens, and encouraging scientific research (Davies 1993). This Recovery Plan apparently has not resulted in increased or even stable populations, as population estimates at the time of its adoption were 1,200 to 1,800 (or more) birds (Davies 1993), while current populations stand at an estimated 200-400 birds (CPW 2013).

In 1940, the State of New Mexico began purchasing land in lesser prairie chicken concentration areas in an attempt to improve habitat and restore the population, and ultimately these lands were reclassified from refuges to public hunting areas when the populations proved self-sustaining (Snyder 1967: 126). This has resulted in the extensive state holdings in northeastern New Mexico. In 1999, the New Mexico Department of Game and Fish Director recommended that the lesser prairie chicken be listed as a state threatened species, but the New Mexico Game Commission rejected this recommendation as a result of pressure from the New Mexico Cattle Growers Association (Johnsgard 2002: 38). The state listing of the lesser prairie chicken does not extend the authority of the New Mexico Game and Fish Department to restrict farming or ranching operations on any private or federal land (Massey 2001: 26).

All other states in the range of the lesser prairie chicken continue to classify it as a game bird, although, as outlined further below, all currently prohibit hunting of the species. Texas law also prohibits the destruction of nests or eggs of game birds such as the lesser prairie chicken. Tex. Parks and Wildlife Code Sec. 64.003. Prohibitions on direct mortality, such as from hunting and egg collection, however, do not address the primary threats to the species, namely habitat destruction and alteration. All five range states consider the lesser prairie chicken a species of conservation concern and management priority in their respective State Wildlife Action Plans, but as the Service similarly found in 2014, "this designation provides no protection from direct take or habitat destruction or alteration." 79 Fed. Reg. 20061.

Harvest Regulations. Lesser prairie chickens are not covered by the protections of the Migratory Bird Treaty Act, 16 U.S.C. § 703 *et seq*., because they are considered to be resident game birds. Nontheless, hunting is not considered a significant current threat to the lesser prairie chicken because of all of the range states currently prohibit the practice (Haukos et al. 2016a). Colorado prohibited hunting of lesser prairie-chickens in 1917. Following submission of the 1995 listing petition, New Mexico banned hunting of lesser prairie-chickens in 1996 and Oklahoma followed suit in 1997, although the lesser prairie-chicken is still considered a game bird in both states. Texas allowed limited hunting opportunities until 2009 (Rodgers 2016: 28). Kansas allows hunting of greater prairie chickens and continued to allow hunting of lesser prairie chickens until the bird was federally-listed as threatened in 2014.[6] Now that the ESA listing decision has been withdrawn, Kansas is free to resume hunting seasons, if it so chooses.

Federal Lands. Only about 4 percent of the species' overall range occurs on Federal lands, but as Fish and Wildlife Service previously found, no laws or regulations currently protect lesser prairie chicken habitat on private land, aside from the State harvest restrictions discussed above. 79 Fed. Reg. 20064. Because of this, areas under federal control are especially important to the future conservation and persistence of the species. Unfortunately, these areas are fragmented and increasingly degraded due to energy development.

The Federal land management programs may provide benefits for lesser prairie chickens and their habitats, but these programs only qualify as "existing regulatory mechanisms" for the purposes of this ESA listing factor to the extent they provide current, enforceable conservation for the species. A brief summary of federal programs demonstrates that existing regulatory mechanisms are inadequate to ensure the recovery of the species.

National Grasslands are managed by the U.S. Forest Service. Six National Grasslands are found within the historic range of the lesser prairie chicken, but only two – the Comanche National Grassland in Colorado and the Cimarron National Grassland in Kansas, occur within the species' estimated occupied range. The Black Kettle and Kiowa/Rita Blanca National Grasslands no longer support active lesser prairie chicken populations (Elmore and Dahlgren 2016: 188-189). The lesser prairie chicken is listed as a Region 2 Sensitive Species by the Forest Service, a designation that confers an administrative responsibility on the agency to maintain viable populations of this species on national grassland units, and it is a Management Indicator Species on the Comanche and Cimarron National Grasslands (Robb and Schroeder 2005). Additional information about these grassland units and their current management can be found in the 2014 final listing rule. 79 Fed. Reg. 20062. At the time, the Fish and Wildlife Service found that "habitat loss, fragmentation and degradation are still significant risk factors on both USFS and surrounding private lands." *Id*. at 20063.

Three National Wildlife Refuges also occur within the range of the lesser prairie chicken, the Optima (4,300 acres), the Washita (8,200 acres), and the Muleshoe (5,800 acres), and lesser prairie chickens are rare in all three (Johnsgard 2002: 127). These areas are managed by the U.S. Fish and Wildlife Service, but even National Wildlife Refuges cannot be completely counted upon to provide unimpaired habitat, as Refuges often allow commercial uses such as livestock grazing that degrade habitat suitability, particularly for ground-nesting birds (Braun et al. 1994).

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[6] *See* Kansas Department of Wildlife Parks and Tourism, *available at* http://ksoutdoors.com/KDWPT-Info/News/News-Archive/2014-Weekly-News/11-13-14/PRAIRIE-CHICKEN-SEASON-OPENS-NOV.-15.

The Bureau of Land Management controls the remainder of federal land on which lesser prairie chickens depend. In New Mexico, approximately 41 percent of the lesser prairie chicken's known historical range and the bulk of the estimated occupied range occurs on BLM land. In total, BLM manages 847,291 surface acres and an additional 297,832 acres of subsurface mineral rights on private land within the lesser prairie chicken's range in eastern New Mexico. 79 Fed. Reg. 20063.

In 2008, the Pecos District of the BLM established a Special Status Species Resource Management Plan Amendment (RMPA) to provide increased protections for the lesser prairie chicken and the dunes sagebrush lizard (*Sceloporus arenicolus*), a former candidate species that the Fish and Wildlife Service recently declined to list under the ESA (Rodgers 2016: 31). Pursuant to the BLM's RMPA, this area's provisions include closure to future oil and gas leasing and other mineral sales, but restrictions on development of existing oil and gas leases are minimal. The New Mexico State Land Office withdrawn lands within 1.5 miles from active leks from future leasing until January 2007 (Davis 2005: 22).

The plan also establishes a 57,522 acre Lesser Prairie-Chicken Area of Critical Environmental Concern northwest of Caprock, New Mexico. This ACEC includes 51,751 acres of public land surface areas, in addition to state trust land and private land. It also includes 46,902 acres of federal mineral estate. 79 Fed. Reg. 20063; Rodgers (2016: 31).

More information on the RMPA's protections for the lesser prairie chicken can be found in the 2014 final listing rule. 79 Fed. Reg. 20063-64. In that rule, the Fish and Wildlife Service concluded that "the effectiveness of the amended RMPA is hampered by a lack of explicit measures designed to improve the status of the lesser prairie-chicken, limited certainty that resources will be available to carry out the management plan, limited regulatory or procedural mechanisms in place to carry out the efforts, lack of monitoring efforts, and provision for exceptions to the best management practices under certain conditions, which could negate the benefit of the conservation measures." *Id*. at 20063.

Other Federal Programs. Federal programs to restore grassland habitats include the Conservation Reserve Program, the Environmental Quality Incentives Program (EQIP), and USFWS grasslands grants programs (which have protected or restored more than 300,000 acres of grassland (Riley 2004). In addition, between 1999 and 2005, some 132,900 acres of private land was enrolled in various wildlife habitat incentive programs (Davis 2005), some of which (like grazing deferral) are highly likely to improve habitat conditions for lesser prairie chickens, while others (such as guzzle installation or vegetation treatments) could have neutral or even harmful effects. Federal programs such as EQIP and WHIP include components for grassland improvement, but not all are thought to result in habitat improvements for lesser prairie chickens, and although there were somewhat more EQIP and WHIP lands associated with high-density lesser prairie chicken leks, the results were not definitive (Bartuszevige and Daniels 2013: 6).

The Conservation Reserve Program ("CRP") was originally established in 1956 under the Soil Bank Act. The CRP is a now a voluntary program administered by the U.S.D.A.'s

Farm Services Agency. It was established primarily to reduce the production of surplus agricultural crops and to prevent soil erosion by converting certain cropland to vegetative cover, such as perennial grassland. The program was re-authorized under the Food Security Act of 1985.

This program is credited with increasing the population levels of greater prairie chicken between 1968 and 1997 (Svedarsky et al. 2000). In western Kansas, grasslands increased by 11.9% since 1985 and grassland patch size increased by 18.2%, largely thanks to conversion of cropland to CRP (Spencer 2014: Abstract). Generally, CRP lands cannot be hayed or grazed except in extreme drought conditions (*see* Farm Service Agency 2012). In those circumstances (at least in Kansas), 50% of each field must be left undisturbed or at least 10 inches stubble height (Dahlgren et al. 2016: 266).

CRP fields are under contract for 10-15 years, and their temporary nature does not ensure that the conversion from cropland to grassland will last beyond the term of the contract (Spencer 2014: 3, *and see* Coppedge et al. 2001: 57). Declarations of drought can open CRP lands to emergency haying and livestock grazing, to the detriment of lesser prairie chickens (Elmore and Dahlgren 2016). Heimlich and Kula (1990) projected that only 20% of CRP lands would remain in grassland condition after the termination of initial contracts. Indeed, high crop prices serve as a disincentive to enroll lands in the CRP, and a 1993 survey in Kansas indicated that about a third of the initial participants intended to put CRP lands back into crop production when the contract expired (Diebel et al. 1993). Federal subsidies for ethanol have reached as high as 60 cents per gallon, spurring increases in commodity prices for corn, sorghum, and wheat, which encourages the conversion of CRP lands back into crop production and reduces farmer interest in the Conservation Reserve Program (Rodgers 2016: 28). The whims of Congress and policy conflicts within the federal government undermine the Conservation Reserve Program as a long-term policy solution guaranteeing the maintenance of grassland habitats (Laycock 1987: 7).

More than 2.8 million acres of farmland was enrolled in the CRP during the first nine sign-ups (1986-1990) in Kansas alone (Diebel et al. 1993). Spencer (2014: 52) calculated that CRP lands within the range of the lesser prairie chicken declined from 974,868 acres in 2007 to 712,442 acres in 2014, a decrease of 26.9%. In Oklahoma, Haufler et al. (2012: 16) chronicled 665,637 acres enrolled in the CRP at that time, with 191,000 acres set to expire in 2012 and an additional 220,231 acres set to expire by 2017. Garton et al. (2016: 73) noted that more than 80% of CRP lands expected to be converted to croplands as their contracts expired between 2008 and 2012 were instead retained through re-enrollment in the program or maintained as grasslands for other uses. Nonetheless, acreage of CRP has trended downward in every state where the lesser prairie chicken is found since 2007, and as of 2013, acreage of land enrolled in CRP continued to trend downward in all states (Elmore and Dahlgren 2016: 191, Figure 10.1).

Lautenbach (2015: 21) found that up to 33% of nest sites in Kansas and Colorado were located on CRP lands. However, according to Fuhlendorf et al. (2002: 625), "Conversion of cropland to pasture could have contributed to declines in prairie chickens because in many cases cropland was replaced with introduced grass monocultures that could serve as sink habitats but this relationship is inconclusive." In Kansas, CRP lands are typified by a diversity of native grasses (Fields et al. 2009: 932). This has enabled in a significant range expansion for lesser prairie chickens in northwestern Kansas (Rodgers and Hoffman 2005: 122). Doxon and Carroll (2007: 256) found that Kansas CRP lands planted with native grasses harbored rich insect faunas favorable for brood-rearing habitat. Oyler-McCance et al. (2016: unnumbered 14) determined through genetic analysis that lesser prairie chickens are moving northward and expanding their range in sparsely-population portions of the Shortgrass/CRP Mosaic ecoregion, demonstrating the effectiveness of the CRP program. However, some CRP fields show heavy infestations of weeds such as cheatgrass (Ripper and VerCauteren 2007: 5).

In the northeast panhandle of Texas, by contrast, most CRP lands have been planted with non-native grasses (Kukal 2010: 13); dense stands of weeping lovegrass predominate (Toole 2005: 28-29, Ripper and VerCauteren 2007: 9, Bartuszevige and Daniels 2013: 3). Toole (2005: 29) found that native grasslands in Texas had more than 32 times the dry mass of invertebrates, an important food source, than were collected on CRP lands with non-native vegetation. Boal and Pirius (2012: Discussion 7) found that lesser prairie chickens avoided CRP lands in north Texas that is dominated by weeping lovegrass, and Patten et al. (2006: 10) found similar results in New Mexico. Efforts to replace these non-native monocultures on CRP lands with native grass mixes via tillage or herbicides have been unsuccessful due to their highly competitive nature (Haufler et al. 2012: 17).

Most CRP lands in New Mexico have been planted with monocultures of non-native weeping lovegrass; southeastern Colorado CRP lands tend to be monocultures of sideoats grama (Rodgers and Hoffman 2005: 122). This latter species is native, but of limited habitat value to lesser prairie chickens. Davis (2005: 13) estimated that 70-80% of New Mexico CRP lands were planted to monocultures of weeping lovegrass or Old World bluestem.

Oklahoma CRP lands are dominated by Old World grasses (Ripper and VerCauteren 2007: 11), and lesser prairie chicken populations have not increased in this area (Rodgers and Hoffman 2005: 122). Wolfe et al. (2003: 8) found that CRP fields in Oklahoma seeded to Old World grass species were used less for nesting than their availability, while CRP fields seeded to a native grass mix were used greater than their availability for nesting. Later, native seed mixes were used for some CRP plantings, and as of 2009 less than 30% of Oklahoma CRP lands were planted to native grasses and forbs (Elmore et al. 2009: 16). Bidwell et al. (2002: 12) asserted that most CRP fields contain little or no forb component.

In Colorado, CRP lands are dominated by low-growing sideoats and blue grama, and sometimes invasive cheatgrass, with a low forb component and cheatgrass a significant component of some fields (Ripper and VerCauteren 2007: 10).

Interseeding CRP fields with strips of non-native forbs (alfalfa and sweet clover) resulted in a significant increase in invertebrates, particularly grasshoppers and other orthopterans

(Fields 2004: iii). Ripper et al. (2008: 205) found that vegetation conditions on CRP lands often were consistent with grass height requirements for lesser prairie chickens, but shrubs were slow to become established, and some CRP fields had no native grasses at all.

CRP lands are important to lesser prairie chickens, particularly in Kansas, and the loss of such lands would be detrimental to the species' conservation but these voluntary contractual agreements do not constitute adequate regulatory mechanisms. In the 2014 final listing rule, the Fish and Wildlife Service concluded that it is difficult to predict the fate of CRP enrollments and their influence on the lesser prairie chicken. 79 Fed. Reg. 20028. The Service expressed concerns "that the potential for significant loss of CRP acreages remains." *Id*. at 20029. The Service also expressed concerns about the future value of these grasslands to the lesser prairie chicken, due to woody vegetation encroachment, wind power development, and construction of transmission lines, all of which have the potential fragment and degrade habitat enrolled in the CRP. Ultimately, the Service was compelled to conclude that "CRP grasslands alone are not adequate to provide for the long-term persistence of the species, particularly when the known threats to the lesser prairie-chicken are considered cumulatively." *Id*. at 20030.

The Western Association of Fish and Wildlife Agencies Range-Wide Plan. In 2010, the Natural Resources Conservation Service began a Lesser Prairie-Chicken Initiative to provide technical assistance for lands coming out of the CRP program and improve habitat quality on grazing lands. The program helped to provide some $19 million in assistance to more than 600 producers, improving habitat quality on 700,000 acres of high-priority focal lands in lesser prairie chicken habitat (Rodgers 2016: 34). Building on this program, and after the lesser prairie chicken was proposed for ESA listing in 2012, the Western Association of Fish and Wildlife Agencies ("WAFWA") and the Ecosystem Management Research Institute developed what is now known as five-state Lesser Prairie Chicken Range-Wide Conservation Plan (Van Pelt et al. 2013, entire).

The plan focuses on preserving key focal habitat areas—and connecting corridors between them—within four ecoregions. These ecoregions are: (1) Mixed-Grass Prairie of south-central Kansas, northwest Oklahoma, and northeast Texas Panhandle; (2) Sand Sagebrush Prairie of southwest Kansas, southeast Colorado, and the Oklahoma Panhandle, (3) Sand Shinnery Oak Prairie of eastern New Mexico and the western South Plains of Texas, and (4) Short-Grass Prairie/CRP Mosaic in west-central Kansas. The plan's benchmark goal is to maintain an average of 67,000 birds across the species' range during the next decade with specific subpopulation goals for each eco-region (Van Pelt et al. 2013: 5, Rodgers 2016: 34).

The Range-Wide Plan establishes voluntary, incentive-based mechanisms to encourage habitat management on private lands and to discourage development in targeted area. To help finance the plan, energy industries whose activities threaten the species pay in-lieu fees, administrated by the states and WAFWA, to finance off-site mitigation if development in focal areas and corridors proves to be unavoidable.

On October 23, 2013, the Service announced its endorsement of the plan as a comprehensive conservation program that reflects a sound conservation design and strategy that, when implemented, will provide a net conservation benefit to lesser prairie chicken. The plan served as a basis for the Section 4(d) rule that accompanied the lesser prairie chicken's threatened listing. 79 Fed. Reg. 20073. That special rule relied heavily on the WAFWA Range-Wide Plan to provide sufficient conservation benefits to offset continued energy development activities in lesser prairie chicken habitat.

The first two years of Range-Wide Plan implementation do not inspire confidence. WAFWA recently issued its 2015 Lesser Prairie-Chicken Range-Wide Conservation Plan Annual Progress Report ("Progress Report")(Van Pelt et al. 2016b, entire). The Progress Report documents WAFWA's failure to effectively address threats to the lesser prairie chicken or achieve meaningful progress on its major conservation objectives over the past two years. To be sure, lesser prairie chicken populations have increased due to favorable weather conditions, but the total population is still less than half of what it was a decade ago when the Service first proposed the species for listing under the ESA. Less than a decade ago the population estimate was 80,000 birds (Garton et al. 2016: 49). The Progress Report estimates the population at 29,162. Progress Report at 1.

Due to expected fluctuations in bird population, a more important measure of the Plan's success is the degree to which it has achieved its habitat conservation goals. As noted, the core of the plan is the protection of large blocks of quality habitat in designated focal areas and strongholds within each of the five ecoregions. As the Service stated: "This focal area strategy is intended to direct conservation efforts into high-priority areas and facilitate creation of large blocks of quality habitat, in contrast to untargeted conservation efforts spread across larger areas that typically result in smaller, less contiguous clocks of appropriately managed habitat." 79 Fed Reg. 20075. According to the plan, focal areas should be at least 50,000 acres in size and less than 20 miles apart to provide genetic connectivity zones and encourage lesser prairie chicken movement between areas (Van Pelt et al. 2016a: 73). Strongholds are subsets of focal areas and should measure 25,000-50,000 acres depending on habitat quality. The RWP provides that these strongholds be protected by "long-term agreements"—permanent or 30-year terms (Van Pelt et al. 2016a: 84).[7]

Habitat corridors need to be established to connect stronghold areas so that populations lesser prairie chickens, which are relatively poor dispersers, are not isolated from each other (USFWS 2012). However, Jamison (2000: 120-121) argued that the poor dispersal ability of this species argues against the potential success of corridors, and instead the

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[7] Aspects of the Range-Wide Plan's conservation program may qualify as adequate regulatory mechanisms depending on the nature and enforceability of the easements in question. As the Service found in another listing decision: "Although the decision of whether to enter into a conservation easement is voluntary on the part of the landowner, conservation easements are legally binding documents once they are recorded. Therefore, we have determined that perpetual conservation easements that are recorded may offer some regulatory protection to the species, depending on the terms of the easement." *See* Endangered Status for Gunnison Sage Grouse, 78 Fed. Reg. 2486, 2528 (Jan. 11, 2013).

main focus of conservation efforts should be the expansion of remaining habitats rather than adding smaller isolated patches between existing occupied habitats in an effort to increase connectivity.

Unfortunately, few large patches of intact habitat remain within the range of the lesser prairie chicken, but WAFWA has so far failed to target conservation efforts at these focal areas. In fact, WAFWA has only developed 11 term contracts, all of which were ten years in duration, and none of which appear to be in priority habitat for the lesser prairie chicken. Progress Report at 43, 46. In fact, five of the term contracts in 2015 were for properties with no observed leks within three miles. *Id*. at 47. The conservation benefits of these properties for lesser prairie chicken is not clear.

Under the Range-Wide Plan, developers are encouraged to enroll lands for industrial or agricultural development, for which offsetting mitigation fees are charged; by March 24, 2014, some 3.65 million acres of lands in the lesser prairie chicken range had been enrolled for potential development but no land had been enrolled for mitigation. Declaration of Michelle Shaughnessy, Case No. 7:14-CV-00050-RAJ, at ¶¶11-14.

In addition to establishing goals for protection of key habitat areas, the Range-Wide Plan established a goal of restoring 953,693 acres of cropland and remediating an additional 27,820 acres of cropland over ten years. *Id*. at 19. According to the Progress Report, that amount of restoration is the "minimum amount of restoration needed to achieve the habitat availability goals established by the RWP." *Id*. at 82. This requires nearly 90,000 acres of remediation per year, but according to the report "WAFWA did not complete any qualifying restoration activities during this reporting period and sufficient data were not acquired from [other agencies] to assess overall progress toward the stated restoration goals." *Id*., Appendices D and E.[8]

The Range-Wide Plan also sets a 25% annual permanent mitigation requirement as of March 30, 2015. Progress Report at 10. WAFWA has not met this deadline and has repeatedly sought to delay implementation of permanent mitigation requirements into the future. To date, WAFWA has failed to acquire a single property that complies with the USFWS's permanent mitigation guidelines for the lesser prairie chicken (Taylor et al. 2016). All this has occurred in an environment in which the Range-Wide Plan's overhead expenses have been triple the amount paid out to private landowners for conservation. Serious questions are arising as to the viability of the plan's financial structure. *Id*.

The future of the Range-Wide Plan is seriously in doubt. Since a federal court struck

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[8] According to the U.S. Fish and Wildlife Service, the majority of offsetting mitigation credits obtained as of 2015 were preservation credits, rather than the restoration credits that actually move degraded habitats toward functioning condition. *Permian Basin Petroleum Ass'n v. Dep't of the Interior*, Declaration of Michelle Shaughnessy, Case No. 7:14-CV-00050-RAJ, at ¶26(c). Only 14,523 acres of land have been placed under contract for the development of restoration credits, and given the long time period required to restore degraded land to functioning grassland habitat, as of 2015 it was deemed unlikely by the U.S. Fish and Wildlife Service that any of these lands had yet become suitable habitat. *Id*. ¶32(c).

down the lesser prairie chicken's threatened listing under the ESA, landowners have little incentive to participate in the plan. *See Permian Basin Petroleum Ass'n v. Dep't of the Interior*, 127 F. Supp. 3d 700 (W.D. Tex. 1015). Moreover, as observers have noted, "Elements within the oil and gas industry and a loosely knit coalition of county governments in Kansas have chosen to actively campaign against even the voluntary conservation mechanisms proposed in the Range-Wide Conservation Plan" (Rodgers 2016: 35).

In legal filings, the USFWS observed that "participation in the Range-Wide Plan is voluntary, and its ultimate effectiveness in restoring the lesser prairie-chicken and its habitat to a healthy and secure condition continues to have uncertainties…." *Permian Basin Petroleum Ass'n v. Dep't of the Interior*, Defendant's Additional Filing in Support of their Opposed Motion to Amend the Judgment, Case No. 7:14-CV-00050-RAJ at 3. At the time of the listing, the Range-Wide Plan and the Candidate Conservation Agreement with Assurances covering the portion of the lesser prairie chicken range in New Mexico did not adequately address the habitat loss and fragmentation caused by oil and gas development and wind energy development. *Permian Basin Petroleum Ass'n v. Dep't of the Interior*, Declaration of Michelle Shaughnessy, Case No. 7:14-CV-00050-RAJ, at ¶7. In addition, in the context of the Final Rule listing the Gunnison sage grouse as a "threatened species," the Service determined that Candidate Conservation Agreements ("CCAs") and Candidate Conservation Agreements with Assurances ("CCAAs") do not constitute regulatory mechanisms and as such cannot be considered under Factor D. 79 Fed. Reg. 69223.

In light of these failures, the Service must rethink the advisability of issuing a Section 4(d) rule that relies on the Range-Wide Plan to provide the bulk of conservation benefits to the lesser prairie chicken. As the Service made clear in its filings in the Permian Basin case, "Even with the known and anticipated future conservation benefits of the Range-Wide Plan and other conservation efforts, based on current information … the Service does not believe that the threats to the lesser prairie-chicken have been sufficiently reduced or eliminated such that there is no longer a serious possibility that the Service will relist the species…." *Permian Basin Petroleum Ass'n v. Dep't of the Interior*, Defendant's Additional Filing in Support of their Opposed Motion to Amend the Judgment, Case No. 7:14-CV-00050-RAJ at 3.

These statements by USFWS staff demonstrate that the Range-Wide Plan does not provide adequate levels of conservation such that listing under the ESA would not be warranted. Moreover, these statement assume that the Range-Wide Plan is functioning as intended. But the record shows that the plan is failing to meet its objectives by a wide margin. The USFWS thus should not rely on the Range-Wide Plan in determining whether to relist the lesser-prairie chicken, nor should it provide significant credit to the plan in fashioning any Section 4(d) rule for the species (should the bird be relisted as threatened instead of endangered). The Range-Wide Plan has, to date, failed to achieve meaningful conservation for the lesser prairie chicken, and thus the species requires regulatory protection to ensure its long-term survival and recovery.

The Lesser Prairie-Chicken Initiative. The USDA's Natural Resources Conservation Service launched the Lesser Prairie-Chicken Initiative (LPCI) in 2010 to "help ranchers and farmers voluntarily enhance lesser prairie-chicken habitat while improving the long-term sustainability of their agricultural operations." LPCI FY16-18 Conservation Strategy ("FY16-18 Strategy").[9] To date, the NRCS claims the program has helped to protect more than 1 million acres of lesser prairie-chicken habitat. The FY16-18 Strategy sets forth a goal of 1.5 million acres by 2016. *Id*.

The program utilizes Farm Bill conservation programs, including the Environmental Quality Incentives Program (EQIP), Agricultural Conservation Easement Program (ACEP) and the Conservation Stewardship Program (CSP). NRCS has so far invested nearly $24 million in the LPCI while participating landowners have invested an additional $10 million. The current three-year strategy is designed to complement conservation efforts underway through the WAFWA Lesser Prairie-Chicken Range-Wide Conservation Plan. *Id*.

While these efforts are laudable, they rely on temporary voluntary activities. These include prescribed grazing to maintain essential habitat, removal of invasive trees and conifers, removal of invasive mesquite, and short-term conservation easements. *Id*. As a voluntary program that relies on promises of future action, the LPCI does not qualify as an existing regulatory mechanism. Moreover, as a relatively new program, the effectiveness of the LPCI for protecting essential habitat and alleviating threats to the species is unclear.

Non-regulatory rankings. The International Union for the Conservation of Nature (IUCN) lists the lesser prairie chicken as a Vulnerable species on the IUCN Red List as of 2012, citing threats to its habitat from farming, livestock grazing, utility lines, hunting, pollution, and droughts.

NatureServe rates the lesser prairie chicken G3 (globally vulnerable) and N3 (nationally vulnerable). It is furthermore ranked as S1 (state critically imperiled) in Oklahoma, S2 (state imperiled) in New Mexico, Texas, and Colorado; S3 (state vulnerable) in Kansas; and SX (state extinct) in Nebraska. The NatureServe entry for the lesser prairie chicken was last reviewed in 2011 and the national status was last reviewed in 1997. Reasons for the rating include its small, fragmented range; declining distribution and abundance; habitat loss and degradation due to agricultural cultivation, conversion of Conservation Reserve Program lands to cropland, inappropriate livestock grazing, wind energy development, oil and gas development, woody plant invasion, inappropriate herbicide applications, and habitat fragmentation resulting from structural and transportation developments.

The Service regards NatureServe as an authoritative source for conservation ranks for species in the United States. NatureServe presents information developed by biologists in state and provincial natural heritage programs and conservation data centers and by staff

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[9] USDA NRCS Lesser Prairie-Chicken Initiative FY16-18 Conservation Strategy, at http://www.nrcs.usda.gov/wps/PA_NRCSConsumption/download?cid=nrcseprd967006&ext=pdf.

of The Nature Conservancy and NatureServe. These programs rely on collaboration with, and contributions of data from, scientists at universities, conservation organizations, natural history museums, botanical gardens, and state and federal agencies (NatureServe 2007). We hereby incorporate all analysis, references, and documentation provided by NatureServe in its on-line database at http://www.natureserve.org/explorer into this Petition by reference, including all data and analysis underlying its conservation status classification scheme.

NatureServe rankings do not provide any regulatory or policy mechanisms to protect *T. pallidicinctus*. However, NatureServe's "imperiled" and "vulnerable" rankings for this species supports our conclusion that it needs greater protections. The Service should consider all of the information presented in this petition alongside NatureServe, IUCN, and other non-profit rankings.

Summary of Existing Regulatory Mechanisms. In the 2014 final listing rule, the Fish and Wildlife Service concluded its analysis of ESA Factor D by saying:

> In summary, most occupied lesser prairie-chicken habitat occurs on private land, where State conservation agencies currently have little authority to protect lesser prairie-chicken or facilitate and monitor management of lesser prairie-chicken habitat beyond regulating recreational harvest. Because most lesser prairie-chicken habitat destruction and modification on private land occurs through otherwise lawful activities such as agricultural conversion, livestock grazing, energy development, and fire exclusion, few (if any) regulatory mechanisms are in place to substantially alter human land uses at a sufficient scale to protect lesser prairie-chicken populations and their habitat. While almost no regulatory protections in place for the species, regulatory incentives, in the form of county state, and national legislative actions, have been created to facilitate the expansion of activities that result in fragmentation of occupied lesser prairie-chicken habitat, such as that resulting from oil, gas, and wind energy development. For the remaining 4 percent of occupied habitat currently under Federal management, habitat quality depends primarily on factors related to multiple use mandates, such as livestock grazing and oil, gas, and wind power development activities. Because prior leasing commitments [10 years for oil and gas, potentially longer for wind farms] and management decisions on the majority of unoccupied parcels of Federal land offer little flexibility for reversal, any new regulatory protection for uncommitted land unites are important and will take time to achieve substantial benefits for the species in the long term.
>
> We note that the existing regulatory mechanisms at the Federal and State level *have not been sufficient to halt the decline of the species*. Further, the best available information does not show any existing regulatory mechanisms at the local level that address the identified threats to the

> species. In spite of the existing regulatory mechanisms, the current and projected threat from the loss and fragmentation of lesser prairie-chicken habitat and range is still ongoing. *The existing regulatory mechanisms have not been effective at removing all of the impacts to lesser prairie-chickens and their habitat.*

79 Fed. Reg. 20064 (emphasis added). Petitioners are aware of no new information that would cause the Service to alter its 2014 conclusions with respect to this factor, and in fact the failure to meet mitigation targets underscores the severity of Factor D problems. Therefore, the Service must again conclude that existing regulatory mechanisms are inadequate to conserve the lesser prairie chicken.

(Factor E) Other Natural or Man-made Factors Affecting its Continued Existence

Drought. Drought is defined as a prolonged and abnormal moisture deficiency, and the Palmer Drought Index incorporates precipitation, temperature, evapotranspiration, and duration to provide an objective measure of drought severity (Palmer 1965). For grasslands generally, high moisture conditions can result in disproportionately high increases (greater than 70%) in vegetation productivity (Knapp and Smith 2001: 483). Precipitation in the current growing season is positively correlated with plant species diversity and richness in both grazed and ungrazed plots (Collins et al. 1987: 94, 96). In drought years, ungrazed grasslands showed an abundance of forbs, while grazed grasslands did not (Fields 2004: 40). Tilman and El Haddi (1992: 257) found that the 1988 drought in Minnesota (a 50-year drought) reduced aboveground vegetation biomass by 47%, and resulted in a 37% decrease in plant species richness driven by the local extinction of rare species. Changing patterns of temperatures are likely to result in changing patterns of rainfall, potentially making droughts more frequent and prolonged in arid areas (Weltzin et al. 2003: 942). Drought and climate change are therefore interlinked.

Drought can interact with other threats to lesser prairie chicken survival to depress populations in a synergistic way. Vegetation productivity of the grasslands inhabited by lesser prairie chickens is tightly tied to precipitation (Sala et al. 1988: 40). Drought could lead to malnutrition that prevents females from becoming reproductively active, or to increased predation through dehydration or malnutrition (Peterson 2016: 175). Several threat factors may work together to depress lesser prairie chicken populations; for example, severe weather events could reduce adult and juvenile bird numbers, while drought could compound the problem by reducing chick survival and recruitment, leading to an overall population decline (*id*.).

Dusang (2011: 30) found that minimum winter temperature and annual precipitation were the most significant constraints on the distribution of lesser prairie chickens, with maximum summer temperature also having predictive value. This researcher hypothesized that shifting temperatures are responsible for the northward shift of lesser prairie chicken range. Conversely, drought can suppress grass growth and delay catkin and leaf emergence for sand shinnery oak, and can also lead to early leaf drop in sand shinnery oak (Merchant 1982: 25). The loss of grasses needed as cover as well as forage plants that support chick growth and survival provide the primary mechanisms for drought to affect prairie chicken populations.

Moisture levels influence the population levels and distribution of many grassland birds (O'Connor et al. 1999: 56, Niemuth et al. 2008: 218, 219), and the Palmer Drought Severity Index provides a useful index for tracking these changes in moisture due to its monthly reporting (Niemuth et al. 2008: 213). For plains sharp-tailed grouse, Flanners-Wanner et al. (2004: 28) found that temperature and precipitation levels were correlated with metrics of population change, and found that weather-based population trend models predicted actual population trends fairly closely. Woodhouse and Overpeck (1998: 2707) hypothesized that prolonged drought on the Great Plains is caused by a ridge of high pressure that blocks the flow of moisture from the Gulf of Mexico from reaching the Plains. Ross et al. (2016: 7-8) demonstrated conclusively that lesser prairie chicken populations showed a strong positive response to wet conditions during the spring of the previous year, and strong negative effects from hot and dry summer weather during the previous year.

Ocean surface temperature is a critical and perhaps determining factor in dictating the patterns of drought on the Great Plains (Woodhouse and Overpeck 1998: 2709, Schubert et al. 2004: 501). Woodhouse and Overpeck (1998: 2709) postulate that low variability in El Niño-Southern Oscillation events play a major role in setting the stage for drought on the Great Plains. Schubert et al. (2004: 491) point out the distinct lack of El Niño-Southern Oscillation events during the 1930s drought, and postulated that El Niño-Southern Oscillation events caused only weaker droughts that are limited to the Southern Plains. Hoerling and Kumar (2003: 691) postulated that the La Niña oscillation, with cold sea surface temperatures in the eastern Pacific Ocean, was linked to Northern Hemisphere drought between 1998 and 2002. Ross et al. (2016: 8) found that lesser prairie chicken population fluctuations had no significant relationship with El Niño-Southern Oscillation events or the longer-term Pacific Decadal Oscillation, but instead responded to short-term weather variability.

Drought can delay nest initiation, increase nest abandonment, and reduce nest success for lesser prairie chickens (Grisham et al. 2014: 863, Lautenbach 2015: 27). However, severe drought apparently did not prevent sufficient nest success and reproduction to support a population increase in the Mixed Grass Prairie and Shortgrass/CRP Mosaic populations during the following year; substantial population declines were recorded in 2014, however, for the Shinnery Oak Prairie and Sand Sage Prairie populations (McDonald et al. 2014a, Table 7). So in certain circumstances, prairie chicken populations may increase even in the face of drought. The 2013 drought comes in the context of a longer-term drought that began in 2011 and finally ended in 2015. *See* Appendix A.

In western Kansas, severe droughts peaked in 1894 and again in 1913 (Palmer 1965: 34). In the Texas panhandle, extended droughts in the 1930s, 1950s, and early 1990s have been correlated with substantial population declines of lesser prairie chickens (Sullivan et

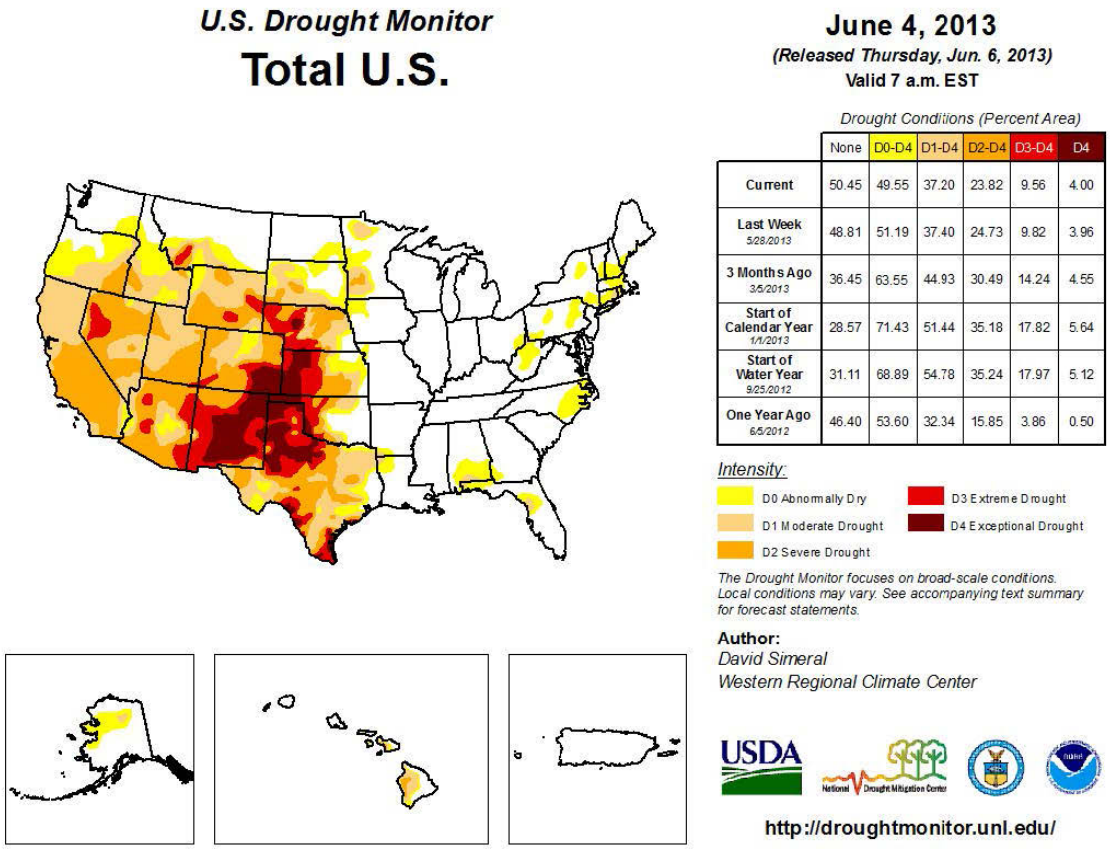

Figure 13. Map produced by U.S. Drought Monitor (Figure 7 reproduced from McDonald et al. 2014a: 21).

al. 2000: 178). A severe drought during the spring and summer of 2006 in Kansas (Rodgers 2007a: 1) led to a 38% statewide population decrease in 2007 (Rodgers 2007b: unnumbered 1). Conversely, New Mexico experienced drought in 1979 and 1980 (Merchant 1982: 19), and a series of wet years in the mid-1990s that fostered a lesser prairie chicken population boomlet (Bailey and Williams 2000: 164). The WAFWA lesser prairie chicken population surveys (McDonald et al. 2013, 2014a, and 2015) each publish a map labeled "June 4 2013," in which virtually all of the lesser prairie chicken range was in a Class D4 drought ("exceptional drought") according to the U.S. Drought Monitor. *See* Figure 13. This drought was the most intense drought event in this region based on the Palmer Drought Severity Index in the observational record extending back to 1895 (Kunkel et al. 2013a: 14).

Multiyear droughts have occurred on the Great Plains about twice a century over the last 300 to 400 years (Woodhouse and Overpeck 1998: 2710). The Dust Bowl droughts dealt a major blow to the lesser prairie chicken population rangewide during the 1930s (Crawford 1980: 2). Between the 1952 and 1953 seasons, a severe drought in Texas and Oklahoma dropped the Texas population count by 52%, even though no hunting was allowed in that state at the time (Copelin 1963: 49). Crawford (1980: 5) concluded that the recurrence of a drought on the magnitude of the 1930s drought could result in the rangewide extinction of the lesser prairie chicken. Notably, the multidecadal droughts that occurred based on paleoclimactic records during the 13th and 16th centuries were substantially longer and more severe than 20th century droughts (Woodhouse and Overpeck 1998: 2709). Cook et al. (2015: 3) used drought reconstruction modeling to determine that the Southern Plains experienced megadroughts during the Medieval period that were more severe and prolonged than any in recent history, and projected that decadal and multidecadal drought severity in the latter half of the 21st century would eclipse even these Medieval drought periods.

Climate change. Climate change is likely to result in increased summer temperatures and increased drought in the southern Great Plains, both of which pose major threats to lesser prairie chicken persistence. In addition, extreme weather events, including tornadoes, hailstorms, floods, and heat and cold waves are likely to become more frequent under changing climate regimes (Grisham et al. 2016a: 235). There is a near-unanimous scientific consensus that the current global increase in temperatures and extreme weather events is caused by human-induced climate change (Solomon et al. 2007: 23; IPCC 2014: 4). Huber and Knutti (2012: 32) used energy balance models that incorporate the rise of ocean temperatures, which are much slower to change but show broad trends more clearly, to demonstrate a major increase in global temperatures since 1950 that is definitively correlated with the human-caused increase in atmospheric carbon. Meehl et al. (2007: 749) projected that if greenhouse gas emissions remain constant or increase, then climate change would likely be larger in the 21st century than that experienced in the 20th. According to Prinn et al. (2011: 515) greenhouse gas emissions are expected to increase in the future under all possible scenarios ranging from strong international action to combat climate change to no action.

Global average temperatures are projected to increase over year 2000 levels under varying scenarios by 3.2-12.6°F by the year 2100 (Prinn et al. 2011: 527). On the Great Plains, temperatures have already risen 1.5°F from the baseline temperatures of the 1960s and 1970s, and are projected to reach 2.5-6°F above that baseline by 2050 and 5-13.5°F above that baseline by 2090 depending on future emissions of greenhouse gases (Karl 2009: 125). McLachlan et al. (2010: 17) projected a 2.8-3.5°F temperature increase within the range of lesser prairie chickens by 2060, along with a 10% overall decrease in precipitation and a decrease in overall plant productivity (perhaps of lower stature and/or lesser density) as a result of climate change. Kunkel et al. (2013a: 39, b: 37) projected an annual median temperature increase of 4.5- 8.3°F for the Great Plains and Southwest regions by 2099.

Recent increases in overall temperature and heat waves resulting from climate change have been even greater than the worst-case scenarios predicted in climate models (Ganguly et al. 2007: 15558). The heat wave of 2011 yielded 40 consecutive days above 100°F in the Dallas-Fort Worth area, second only to a 42-day streak of similar temperatures in 1980 (Kunkel et al. 2013a: 19). Moss et al. (2001: 47) implicated climate change as "a major cause" of the decline of the capercaillie population in Scotland. Knapp and Smith (2001: 484) posited that the grasslands of the central United States are a particularly important bellwether for detecting climate change impacts due to their high variability in moisture regime from year to year.

Climate change is a major threat to biodiversity, as species are constrained to move poleward or upward in elevation as temperatures rise, and ecological communities disaggregate (Heller and Zavaleta 2009: 15). Climate change causes changes in the geographical distribution of plants (Parmesan 2006: 637), potentially leaving obligate bird species without all the habitat elements they need to survive. In fragmented landscapes, rapid climate change has the potential to overwhelm the capacity for adaptation and dramatically reduce genetic diversity, resulting in extinctions (Jump and Peñuelas 2005: 1017). According to EPA (2009: viii), "Species that are most vulnerable tend to be: restricted in their distributions, small in population size, undergoing population reductions, habitat specialists, and found in habitats that are likely to be most adversely affected by future climate change." While the lesser prairie chicken has a five-state distribution, its populations are shrinking and its habitats are known to be vulnerable to future climate change.

Peterson (2003: 653) found a greater impact of climate change on Great Plains bird assemblages than on Rocky Mountain birds, in terms of both projected population declines and habitat shifts. Impacts of climate change include population extinctions, which are already beginning to occur (McLaughlin et al. 2002, Parmesan 2006: 645). The largest current populations of lesser prairie chicken are located in areas outside and to the north of the known historical distribution of the species (Dahlgren et al. 2016: 276), indicating that this species is already moving northward in response to climactic shifts.

Data from 2011, which ranks as the worst drought and warmest La Niña event in the region in recorded history, indicates that temperatures on the ground in lesser prairie chicken range exceeded 130°F and humidity was consistently below 10% in 2011, levels which are well outside the threshold for egg viability and nest survival (Grisham et al. 2013: 8). These findings are consistent with the studies of Guthery et al. (2001: 115) and Reyna and Burggren (2012: 44, Figure 3) on bobwhite quail, which found that periodic hot spells were sufficient to kill bobwhite eggs, chicks, and adults and cause both males and females to go out of reproductive condition, leading to inhibited quail reproduction across expansive areas. Merchant (1982: 51) argued that high temperatures and a lack of water can weaken females to the point of increased vulnerability to predators, and heat stress and related dehydration can increase chick mortality, particularly during drought when vegetation is sparser. Bell (2005: 21) documented that hens with broods selected cooler, shaded microhabitats when ambient temperatures exceeded 26.4°C (79.5°F). With climate change, increasing temperatures will make widespread nest and brood failures as a result of excessive temperatures an increasingly more frequent occurrence, threatening the persistence of lesser prairie chicken populations across affected areas.

Grisham et al. (2013: 7) postulated that warmer winter temperatures associated with La Niña events which are correlated with drought conditions the following summer that negatively affect lesser prairie chicken populations. Dusang (2011: 30) found that the four most important factors predicting habitat suitability for lesser prairie chickens in western Oklahoma were minimum temperature of the coldest month, annual precipitation, elevation, and maximum temperature of the warmest month. These factors will be affected by climate change. Lesser prairie chickens select habitats for optimal temperature, seeking shade in hotter weather, and warmer microsites in cooler weather (Dusang 2011: 37, Larsson et al. 2013). Fields et al. (2009: 935) found that hotter, drier weather was correlated with lower daily brood survival. Dusang (2011: 38) hypothesized that cooler and moister microclimates associated with taller shrub vegetation may cease to exist as a result of climate change, rendering habitats in western Oklahoma untenable. Weltzin et al. (2003: 943, Figure 1) predicted significantly drier summer climate regimes across the range of the lesser prairie chicken based on climate modeling.

Climate change is expected to result in more severe and more prolonged drought, as dry areas get drier (Trenberth 2011: 123). Because severe drought on the Great Plains is driven by anomalies in Pacific sea surface temperature (Schubert et al. 2004: 491), and because these anomalies can be exacerbated by rising sea surface temperatures associated with increasing greenhouse gases in the atmosphere (Hoerling and Kumar 2003: 691), it is reasonable to predict that drought conditions of increasing length and severity are likely to occur on the Southern Plains as a result of climate change. A similar pattern is expected in the southwestern United States (Seager et al. 2007: 1183). Amid rising global temperatures, the effects of drought on vegetation is likely to be amplified due to increased thermal and water stress at high temperatures (Breshears et al. 2005: 15147). According to Grisham et al. (2016a: 221), "localized extirpations [of lesser prairie chicken populations] are likely due to recurring drought conditions."

McLachlan et al. (2010: 29) predicted a decline in lesser prairie chicken population over the next 60 years as a result of climate-induced vegetation change, but were unable to quantify that projected decline. According to Cushman et al. (2010: 38), "The interaction of climate change and expansion of the human footprint are likely to result in synergistic increases in impacts greater than the sum of either alone." Grisham et al. (2016a: 231) asserted, "The long-term effects of drought conditions exacerbated by climate change on plant community composition and structure will be the main factor driving the population viability of Lesser Prairie-Chickens at local and range-wide scales. Channell (2010: 29) constructed a maximum entropy model to predict the future distribution of lesser prairie chickens; with a minimum expected climate change by 2050, the occupied range might expand to the north, with areas of range loss in southwestern Kansas and the Texas and Oklahoma panhandle due to drier conditions. Under the maximum climate change model, lesser prairie chicken range shifts to the east, and western and northern portions of the historical distribution become too hot and dry to support the species (*id*.). Glick et al. (2011: 100) predicted a 100% loss of Plains grasslands in New Mexico by 2030, corresponding to an expansion of Chihuahuan desert scrub. This would cause the extinction of the lesser prairie chicken on these lands. Grisham et al. (2013: 7) modeled clutch size, predicted incubation start date, and nest survival rates in Texas and New Mexico based on projected climactic changes for the region (an estimated rise in winter temperatures of 2°C by 2050 and 2.9-3°C by 2080), and found nest survival levels would drop below levels considered viable for population persistence by 2050 and 2080, respectively.

Climate change interacts with habitat loss and fragmentation to drive species toward extinction. Travis (2003: 470) modeled the probability of patch occupancy, which is known to rapidly spiral downward toward extinction with increasing habitat loss and fragmentation, and found that climate change could accelerate the loss of patch occupancy at levels of habitat fragmentation that otherwise should support a stable population. In addition, climate change could bring the lesser prairie chicken into contact with novel parasites, or expand their exposure to diseases such as West Nile virus (WNV) which now occurs only rarely in the region (Peterson 2016: 176). The effects of climate change will potentially interact with WNV in several concerning ways: first, warmer temperature speeds the development and activity of the mosquitoes that carry WNV (Mottram et al. 1986) and enhances survivorship of overwintering adults (Bailey et al. 1982). Additionally, warmer temperatures hasten the development of the virus inside the mosquito, decreasing the time to infectivity and raising potential transmission rates (Dohm et al. 2002). Furthermore, increased drought conditions actually favor the mosquitoes, because the water remains stagnant and organic matter concentrates, providing a food source, and drought also concentrates birds at the same water sources, where they are more likely to be bitten (Epstein & Mills 2005).

Some have recommended assisted migration to facilitate shifting ranges as a result of climate change (McLachlan et al. 2007), but this presupposes areas of suitable habitat in the landscape to which the species is shifting (dubious in the case of the lesser prairie chicken due to heavy crop cultivation to the north and woodland expansion to the east), and would be frustrated by the poor track record of lesser prairie chicken translocation projects, as detailed elsewhere in this petition.

Based on spring lek surveys, the lesser prairie chicken has already expanded its range north and west by 2004 (Fields 2004: 27), and further northward in 2008, 2011, and 2012 (Dusang 2011: 34, Dahlgren et al. 2016: 259). While some researchers (*e.g.,* Fields 2004: 28) attribute this range expansion to CRP conversion of croplands to grasslands, it is also possible that the dwindling of lesser prairie chicken populations in the south and west coupled with the range expansion in the north is a spatial response to climate change.

Heller and Zavaleta (2009: 29) recommend developing adaptation plans for entire landscapes and regions, incorporating tools like reserve selection, ecosystem management, and land-use zoning; top-ranked solutions include increasing connectivity integrating climate change into planning (such as reserves, grazing limits, or pest outbreaks), and mitigating other threats such as invasive species and fragmentation. While these recommendations have direct application to lesser prairie chicken conservation, none have been attempted thus far in the context of lesser prairie chicken action plans. Thus, climate change remains one of the key threats that is likely contribute to the extinction of the lesser prairie chicken in the foreseeable future if major conservation improvements are not undertaken.

Small, isolated populations. Small and isolated populations are more vulnerable to extirpation as a result of stochastic events such as extreme weather or disease, or as a result of inbreeding. The effective population size (N_e) is generally calculated as the number of breeding adults corrected to account for any skew in the sex ratios; traditionally, an N_e below 50 places a population at immediate risk of extinction as a result of inbreeding and an N_e less than 500 places the population at a long-term risk of extinction as a result of genetic drift (Harmon and Braude 2010: 130). Importantly, populations with smaller N_e levels increasingly lose the adaptive advantages of natural selection, which are increasingly replaced by the stochastic changes of genetic drift (Ellegren 2009: 301). Garton et al. (2016: 60) used the following counts of breeding males as stand-ins for effective population sizes: 85 strutting males for N_e=50, and 852 strutting males for N_e=500.

From a strictly genetic standpoint, Franklin and Frankham (1998: 69) argued that a minimum viable population ranges from an effective size (N_e) between 500 and 1,000; Lynch and Lande (1998: 72) took issue with the Franklin and Frankham model, and contended that the genetic minimum viable population should be revised upward to N_e between 1,000 and 5,000. Traill et al. (2010: 30) examined a number of population viability studies and concluded that "[t]he bottom line is that both the evolutionary and demographic constraints on populations require sizes to be at least 5,000 adult individuals." Aldridge and Brigham (2003: 30) examined the scientific literature on greater sage grouse, and concluded that 5,000 birds may be required to maintain a minimum viable population. Several of the lesser prairie chicken ecoregional populations (specifically Shinnery Oak Prairie and Sand Sage Prairie) are currently below this threshold today.

For prairie grouse, Toepfer and Davis (2007) recommended a minimum population of 2,500 total birds to secure a genetically healthy population, with a minimum population of 10,000 birds to withstand two years of reproductive failure assuming 50% adult mortality. Regardless of which genetic minimum viable population one subscribes to, a population must not only weather the stresses of inbreeding and mutations, but also must be large enough to survive stochastic events that may cause populations to drop quickly. Thus, ecological factors must be considered in population viability analysis in addition to genetic factors.

The small population size, low survival rates, and fragmentation of remaining habitat have likely reduced the reproductive success and possibly the genetic diversity of lesser prairie chickens, making them more vulnerable to stochastic events such as drought and severe weather (USFWS 2012). For greater prairie chickens, Westemeier et al. (1998a: 1697) pointed out that as population numbers decline and genetic diversity decreases with increasing habitat loss and fragmentation, genetic and demographic factors reinforce each other to send the population into an "extinction vortex."

According to DeYoung and Williford (2016: 91), "Insufficient habitat remains to support the long-term viability of most populations, and habitat restoration efforts will be critical to the long-term persistence of prairie grouse." McLachlan et al. (2010: 26) estimated the current rangewide carrying capacity for lesser prairie chickens at 49,592 birds, and expected that carrying capacity to decline with climate change. This figure is significantly below the ten-year average of 67,000 birds rangewide that states adopting the Rangewide Conservation Plan have set for their initial population goal (Van Pelt et al. 2013: 5). This disparity indicates that significant habitat increase and/or rehabilitation will need to occur such that the available habitat would be able to support this minimum rangewide population.

Genetic drift and inbreeding. The lesser prairie chicken qualifies as a species once continuous in distribution that now occupies a fragmented range, and is therefore vulnerable to genetic drift and inbreeding. Hanski and Gilpin (1991: 13) observed that in the absence of movements of individuals between populations that are separated by fragmented habitats may be critical to exacerbating isolation that leads to inbreeding and other genetic problems. Inbreeding depression significantly affects birth weight, survival, reproduction, resistance to disease, predation vulnerability, and environmental stress in wild populations, with sufficiently substantial effects to impact individual and population performance (Keller and Waller 2002: 230). Thus, loss of genetic diversity represents a threat to the persistence of lesser prairie chicken populations.

For greater prairie chickens (*Tympanuchus cupido pinnatus*), Johnson et al. (2003: 3339) found that smaller, more isolated populations of greater prairie chickens living in more fragmented habitats possessed lower genetic variation for both mitochondrial DNA and nuclear DNA. An isolated greater prairie chicken population in Illinois which has decreased from 2,000 birds to 50 birds between 1962 and 1994 showed progressively lower fertility (as measured by egg hatching rates) and lower genetic diversity (Westemeier et al. 1998a: 1695). A similar response would be expected for lesser prairie chickens.

Van den Bussche et al. (2003: 681) determined that there were significant genetic differences between the lesser prairie chicken populations of New Mexico and Oklahoma, supporting an isolation-by-distance hypothesis with low historic levels of gene flow between the two populations. Hagen (2003: 183-184) analyzed genetic diversity of lesser prairie chickens, and found that the genetics of the New Mexico population are significantly different from all other populations, while the Kansas county populations of Gove, Finney, and Beaver counties are significantly different from most other populations. Hagen et al. (2010: 33) found significant genetic differences in mitochondrial DNA between the New Mexico population of lesser prairie chicken and all other populations, which were relatively homogeneous based on mtDNA analysis. Similarly, Pruett et al. (2011: 1212) found that the New Mexico and Oklahoma populations are genetically differentiated. In the most recent scientific analysis, Oyler-McCance et al. (2016: unnumbered 11) found that both the Shinnery Oak Prairie (eastern New Mexico and western Texas panhandle) and Sand Sagebrush Prairie (eastern Colorado, western Kansas, and the Oklahoma panhandle) populations were genetically distinct, while all other populations showed signs of admixture, based on DNA from cell nuclei. This demonstrates that fragmentation and isolation of populations are already having significant effects on the genetics of lesser prairie chickens.

Genetic population viability depends on the effective population size, which is based on the proportion of the population that is actively breeding and adjusted to reflect a 1:1 sex ratio (Lande and Barrowclough 1987). Stiver et al. (2008: 473) found for Gunnison sage grouse that the variability in reproductive success was almost as high for females as for males, due to the high (73%) rate of nest failure; this study found a ratio of effective population size (N_e) to total population of 0.19 for Gunnison sage grouse (*id*.). Based on genetics testing of lesser prairie chickens, Pruett et al. (2011: 1209) found a ratio between N_e and total population of 0.341 (or 34%) in Oklahoma, and 0.377 (or 38%) for the New Mexico population. Thus, with a total population estimate of 1,000-3,000 in Oklahoma and 2,500-6,300 in New Mexico at the time, the N_e was calculated using two different genetic methods at 57.6 (95% confidence interval range 32.9-152.3) and 54.9 (range 39.6-123.9) in New Mexico and at 69.4 (range 43.8-145.6) and 114.7 (range 81.7-236.9) in Oklahoma. Pruett at al. (2011: 1212) concluded:

> Current genetic N_e estimates for New Mexico and Oklahoma imply that the lesser prairie-chicken has low population viability and is at risk of inbreeding depression and mutational meltdown… To reach N_e = 500, a census size of 1,500–50,000 birds is required given, respectively, demographic and current genetic estimates of N_e.

These researchers found that if the N_e level remained at levels found in 2011, half of genetic diversity would be lost for these populations within 42 to 98 generations (*id*.).

Oyler-McCance et al. (2016: unnumbered 6, Table 2) calculated N_e for sampled lesser prairie chicken populations based on genetic testing, and found that six of the 22 populations sampled (or 27%) were below N_e=50, the critical threshold below which genetic viability for the population is no longer maintained. These populations are likely already experiencing inbreeding. Pruett et al. (2011: 1206) observed that "lekking species that have undergone population declines would have a higher likelihood of extinction as a result of genetic factors than monogamous species" dues to a lower N_e as a result of sex-skewed participation in breeding. All populations of lesser prairie chicken, and the four combined regional populations as well (Shinnery Oak Prairie, Sand Sage Prairie, Mixed Grass Prairie, and Shortgrass/CRP Mosaic), were found to have N_e<500 (Oyler-McCance et al. 2016: unnumbered 6, table 2).

Genetics testing by Bouzat and Johnson (2004: 503) indicated increased inbreeding is already occurring within individual lek populations in New Mexico, perhaps driven by the lek-breeding system in which very few males do the breeding; the strong site fidelity of individual prairie chicken males to traditional leks; and rangewide population declines. Pruett et al. (2011: 1210) found slightly lower genetic diversity in the New Mexico population than in the Oklahoma population.

Oyler-McCance et al. (2016: unnumbered 9) found little or no gene flow between the four ecoregions inhabited by lesser prairie chickens. For greater prairie chickens, isolation and small population sizes can both contribute to loss of genetic variation for resistance to specific diseases (Bollmer et al. 2011: 4702, Eimes et al. 2011: 1847,

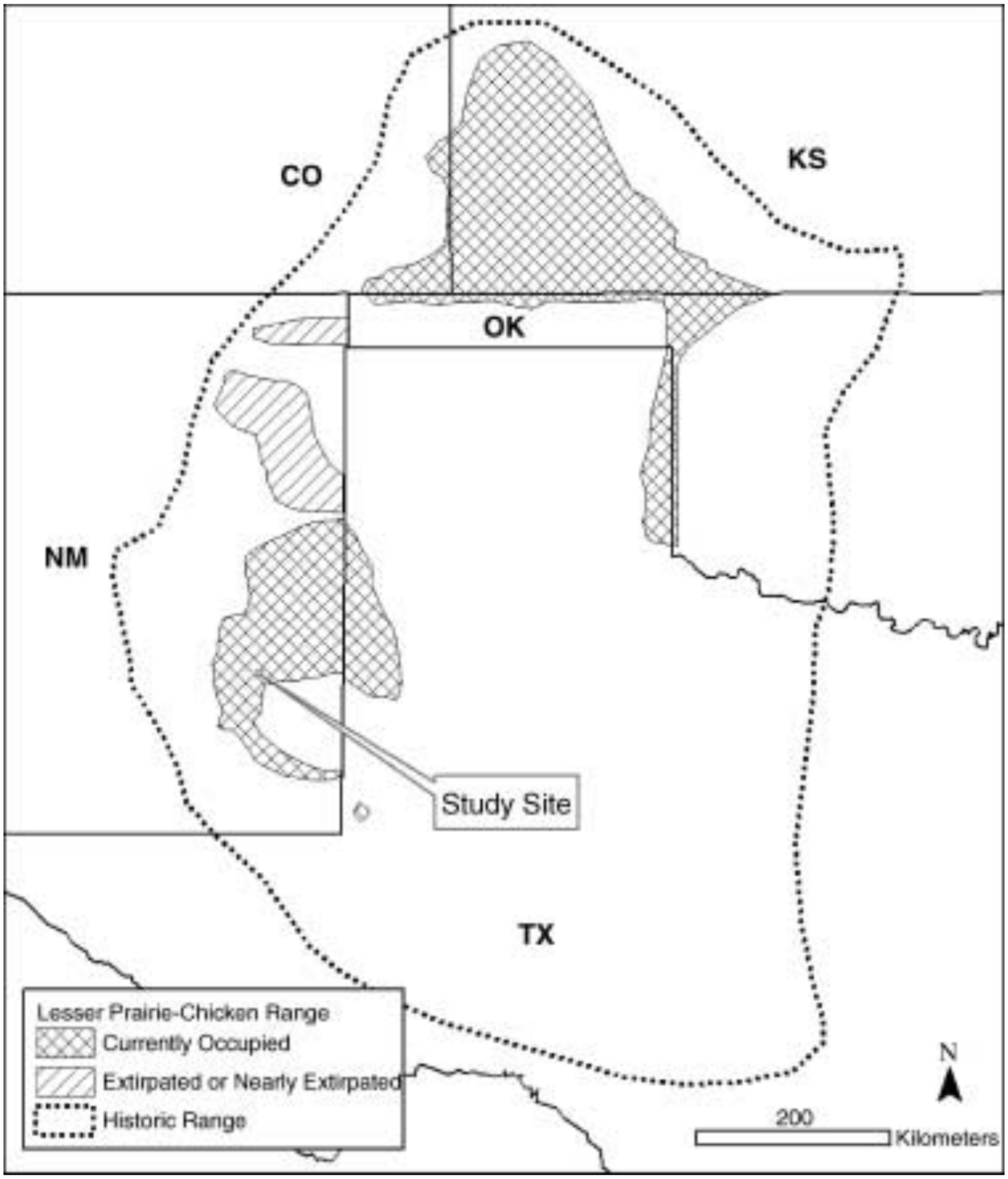

Figure 14. Relative isolation of New Mexico populations of lesser prairie chickens from their nearest conspecifics on the Texas-Oklahoma border. Not the distance greater than 200 km between occupied habitats in New Mexico and Oklahoma. Map reproduced from Bouzat and Johnson 2004.

Bateson et al. 2015, *and see* Figure 14). Cushman et al. (2010: 25) recommended the establishment of connecting corridors between core population areas, stating, "Long-term viability of the lesser prairie-chicken may depend on gene flow and demographic rescue among the metapopulation of core areas."

Hybridization. Greater and lesser prairie chickens are sympatric in northwestern Kansas, in Gove, Ness and Trego Counties (Oyler-McCance et al. 2016: unnumbered 4). This contact zone between greater and lesser prairie chickens developed during the 1990s (Bain and Farley 2002: 685). Several studies have documented natural hybridization between the lesser prairie chicken and the greater prairie chicken where their ranges overlap in northern Kansas. Bain and Farley (2002: 684-685) documented that male hybrid prairie chickens display intermediate feather coloration and patterning, and intermediate size, shape, and color of the inflated throat air sacs. Tailfeather displays by hybrid males are also somewhat intermediate between the display patterns of the greater and the lesser prairie chicken (Bain and Farley 2002: 685). Oyler-McCance et al. (2016: unnumbered 11) documented the hybridization of the two prairie chicken species through genetic analysis, and attributed this hybridization to range expansion of lesser prairie chickens, supported by increasing suitable habitat as a result of Conservation Reserve Program lands. For 2012, McDonald et al. (2013: 16) estimated a total of 453 mixed leks with both greater and lesser prairie chickens in attendance, and estimated a total of 350 hybrid birds. Johnsgard (2002) argued that interbreeding is too rare to jeopardize the gene pool of either species. The current hybridization rate in this zone of contact is 5% (Dahlgren et al. 2016: 259).

In the zone of hybridization, some forms of vocalization intermediate between the two species have been documented (Bain and Farley 2002: 685, Dahlgren et al. 2016: 264). These intermediate vocalizations suggest that hybrids can create viable offspring, but this has not been demonstrated through genetic testing (Dahlgren et al. 2016: 264). Because the Shortgrass Prairie/CRP Mosaic ecoregion holds the majority of the remaining lesser prairie chicken population and also overlaps with the distribution of greater prairie chickens, more than 65% of the lesser prairie chicken population may be exposed to hybridization (McDonald et al. 2014b). The estimated number of hybrid prairie chickens grew from 97 birds in 2014 to 308 hybrids in 2016 (McDonald et al. 2016: 23). This constitutes a threat to the survival of ecoregional populations through the potential for genetic dilution.

Competition and nest parasitism. Association with humans is the trait that most closely correlates with invasiveness in non-native species of animals (Jeschke and Strayer 2008), which can be detrimental to lesser prairie chickens. According to Sharp (1957: 242), "Strife and intolerance are believed to affect the welfare and breeding potential of gallinaceous birds." The ring-necked pheasant (*Phasianus colchicus*) was introduced from China as a gamebird, and thrives in fragmented cropland areas (Allen 1950). This species is a documented nest parasite of lesser prairie chickens, and also could be a source of competition or behavioral interference for lesser prairie chickens. "Some populations of Lesser Prairie-Chickens have been affected by Ring-Necked Pheasants (*Phasianus colchicus*)" according to Wolfe et al. (2016: 302).

Pheasants increased in population in the Texas panhandle during the 1990s, and this species has been documented disrupting courtship activities of lesser prairie chickens (Sullivan et al. 2000: 185). Kimmel (1987) observed that ring-necked pheasants would attempt to take over and defend entire leks, disrupting the breeding behavior of prairie chickens. Holt et al. (2010) documented ring-necked pheasants disturbing lesser prairie chickens on their leks, and noted that male lesser prairie chickens would not display when pheasants were present on the lek. These researchers stated, "Disturbance of leks during the breeding season could prevent breeding activities and have a negative impact on populations.” Pheasants may also compete with prairie chickens for food or habitat (Kimmel 1987).

Ring-necked pheasants are nest parasites, laying their eggs in the nests of other species and thereby committing the parasitized species to raising pheasant chicks along with their own. Hagen et al. (2002) reported that 3 of 75 lesser prairie chicken nests in their southwestern Kansas study area were parasitized by ring-necked pheasants. Pitman et al. (2006a) reported that 4 of 209 lesser prairie chicken nests were parasitized by ring-necked pheasants, one nest was parasitized by northern bobwhite, and one nest was parasitized by both species. Ring-necked pheasants are also known to parasitize the nests of greater prairie chickens where the two species are sympatric (Sevdarsky et al. 2000). Westemeier et al. (1998b) found that greater prairie chicken nests parasitized by pheasants exhibited greater prairie chicken embryo mortality and greater nest abandonment than unparasitized nests, suggesting a possible mechanism for nest parasitism to reduce recruitment of prairie chickens. As a result of nest parasitism, some ring-necked pheasants are raised by lesser prairie chickens, and disturbance of lesser prairie chicken lekking by ring-necked pheasants may be the result of prairie chicken-raised pheasants attempting to behave as their host/maternal species (Holt et al. 2010). Hagen et al. (2002) reported no apparent loss of nest success for lesser prairie chickens hosting pheasant eggs.

Vance and Westemeier (1979) found similar nest parasitism (which increased the rate of nest abandonment) and interference with the courtship displays of the closely-related greater prairie chicken, arguing that breeding could be delayed or completely disrupted on smaller leks, threatening the survival of small and isolated populations. Sharp (1957: 244) characterized the interaction between pheasants and greater prairie chickens as “severe competition,” asserting:

> There is some evidence that, when a pheasant population invades the range of the prairie chicken, the chickens wane and may cease to exist. Prairie chickens showed a drastic decline on their former booming grounds in the Nebraska Sandhills during 1936-43 when the pheasants became common. When a change in habitat conditions occurred, starting in 1943, the pheasant population crashed (Sharp, 1953). Prairie chickens then increased beyond all expectations and, by 1954, they were just about as abundant as in years prior to 1929.

Sharp (1957) found that pheasants thrived during drought conditions, whereas greater prairie chicken numbers dwindled during drought periods. Given the small scale of known impacts but the potentially expanding pheasant populations, ring-necked pheasants currently present a minor but potentially increasing threat to the survival of lesser prairie chickens.

In addition to pheasants, other non-native gamebirds such as scaled quail (*Callipepla squamata*) and bobwhite quail (*Colinus virginianus*) have been introduced into grasslands within the range of the lesser prairie chicken (Hoffman 1963: 732). These species may compete with lesser prairie chickens for food and habitat, but the degree to which prairie chicken numbers or distribution suffer as a result is unknown.

CONCLUSION AND REQUESTED DESIGNATION

WildEarth Guardians et al. hereby petition the U.S. Fish and Wildlife Service under the Department of Interior to list the full species, the lesser prairie chicken (*Tympanuchus pallidicinctus*), as an "endangered" species pursuant to the Endangered Species Act. This listing action is warranted, given the rarity of the species and possible declines in abundance, limited range, fragmented nature of suitable habitats, and multiple range-wide threats to the species and its habitat particularly from oil and gas, and wind energy development. Adequate regulatory mechanisms do not exist to protect this species from further population declines. The lesser prairie chicken is threatened by at least three of the five listing factors under the ESA: the present or threatened destruction, modification, or curtailment of habitat or range (Factor A), the inadequacy of existing regulatory mechanisms (Factor D), and other natural or man-made factors affecting its continued existence (Factor E).

Furthermore, WildEarth Guardians et al. petition the U.S. Fish and Wildlife Service to list three Distinct Population Segments of lesser prairie chicken: the Shinnery Oak Prairie DPS, the Sand Sagebrush Prairie DPS, and the Mixed-Grass Prairie and Shortgrass Prairie/CRP Mosaic DPS. For two of these DPSs —the Shinnery Oak Prairie and Sand Sagebrush Prairie DPSs — we request emergency listing as "endangered" at the soonest possible time pursuant to the Endangered Species Act.

Habitat degradation and loss related to cropland conversion and energy development, as well as climate change, are leading threats to the lesser prairie chicken. As Hagen and Elmore (2016: 351) noted,

> In retrospect, we can only hear the faint echoes of the last remaining Heath Hen (*T. cupido cupido*) on the eastern shores. After nearly 50 years of protection under ESA, we stand witness to the mere phantom of the Attwater's Prairie-Chicken holding onto a tiny parcel of coastal prairie. Many wonder if a similar fate awaits the Lesser Prairie-Chicken.

To prevent this outcome, "endangered species" listing is warranted. This petition also requests that critical habitat be designated for *Typanuchus pallidicinctus* concurrent with ESA listing. Designating critical habitat for the lesser prairie chicken will support its recovery and protect areas crucial to long-term survival of lesser prairie chicken populations.

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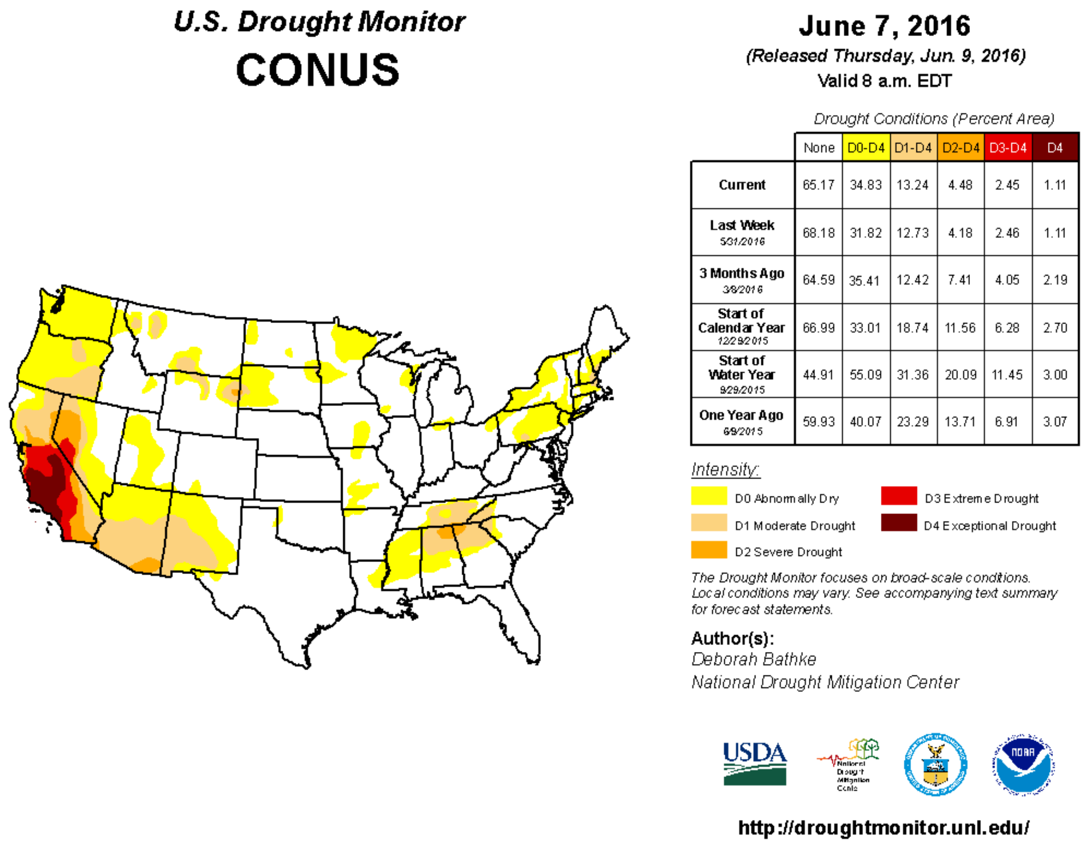
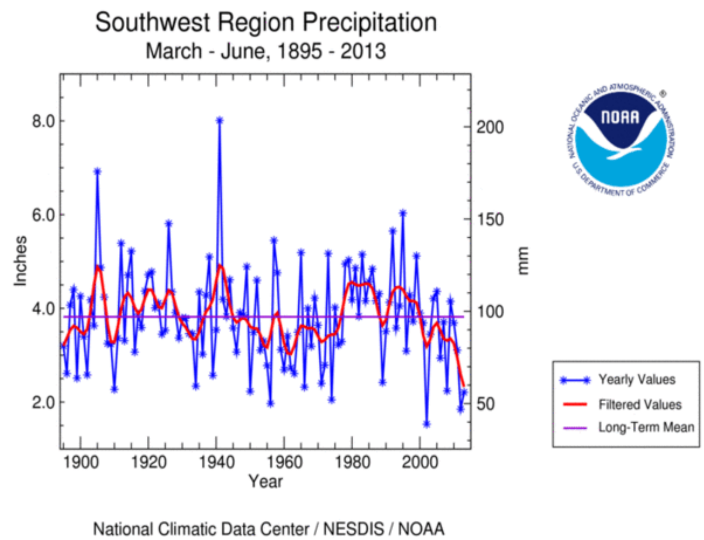
APPENDIX A

Drought maps across the lesser prairie chicken range (reproduced from U.S. Drought Monitor Map Archive; http://droughtmonitor.unl.edu/MapsAndData/MapArchive.aspx) from comparable dates over the past six years, site last visited August 30, 2016.





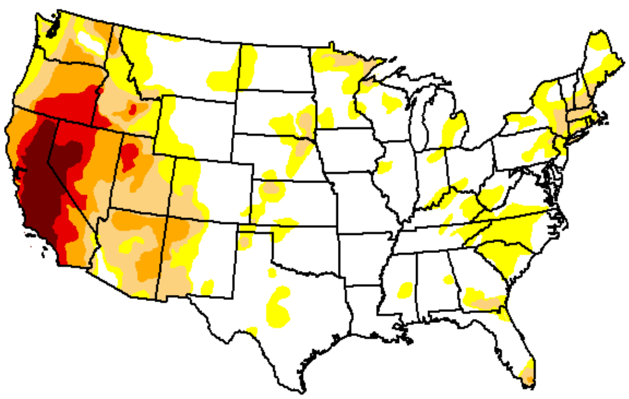
U.S. Drought Monitor

CONUS

June 2, 2015

(Released Thursday, Jun. 4, 2015)

Valid 7 a.m. EST



Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	56.75	43.25	24.57	14.19	7.09	3.13
Last Week 5/26/2015	49.27	50.73	26.35	14.20	6.94	3.13
3 Months Ago 3/3/2015	47.49	52.51	31.88	15.66	8.43	3.21
Start of Calendar Year 12/30/2014	53.20	46.80	28.68	16.93	8.96	2.54
Start of Water Year 9/30/2014	52.22	47.78	30.57	18.66	9.41	3.85
One Year Ago 6/3/2014	52.14	47.86	37.32	27.28	13.24	3.02

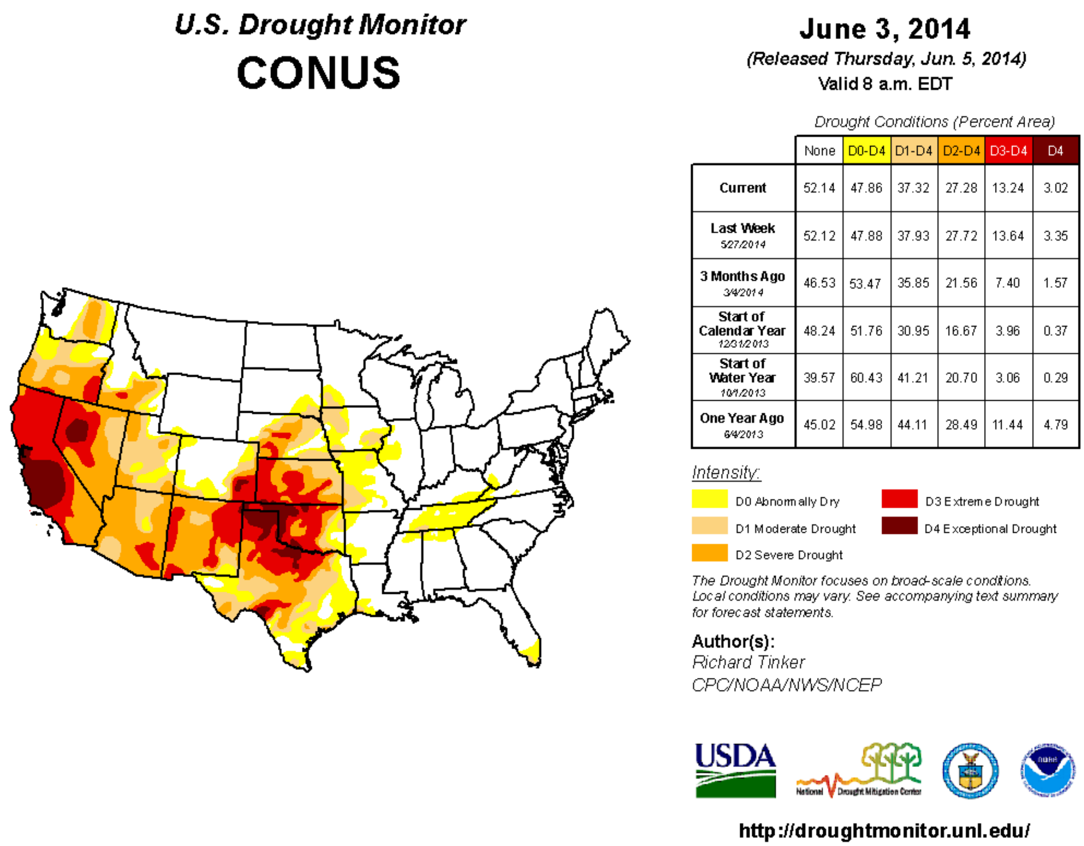
Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

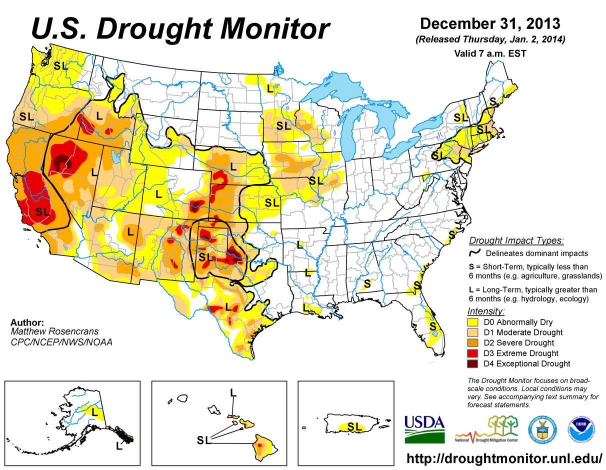
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

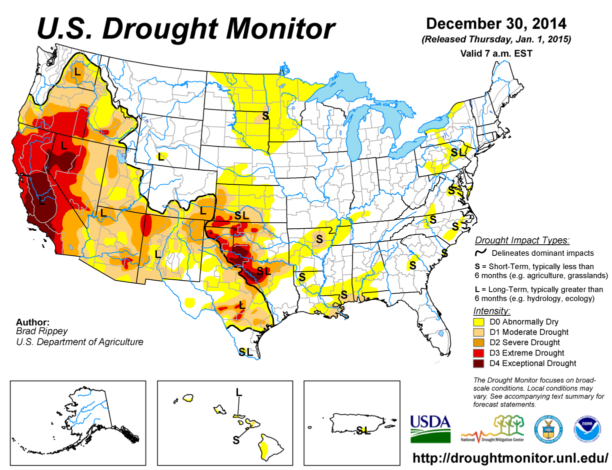
Author(s):
David Miskus
NOAA/NWS/NCEP/CPC

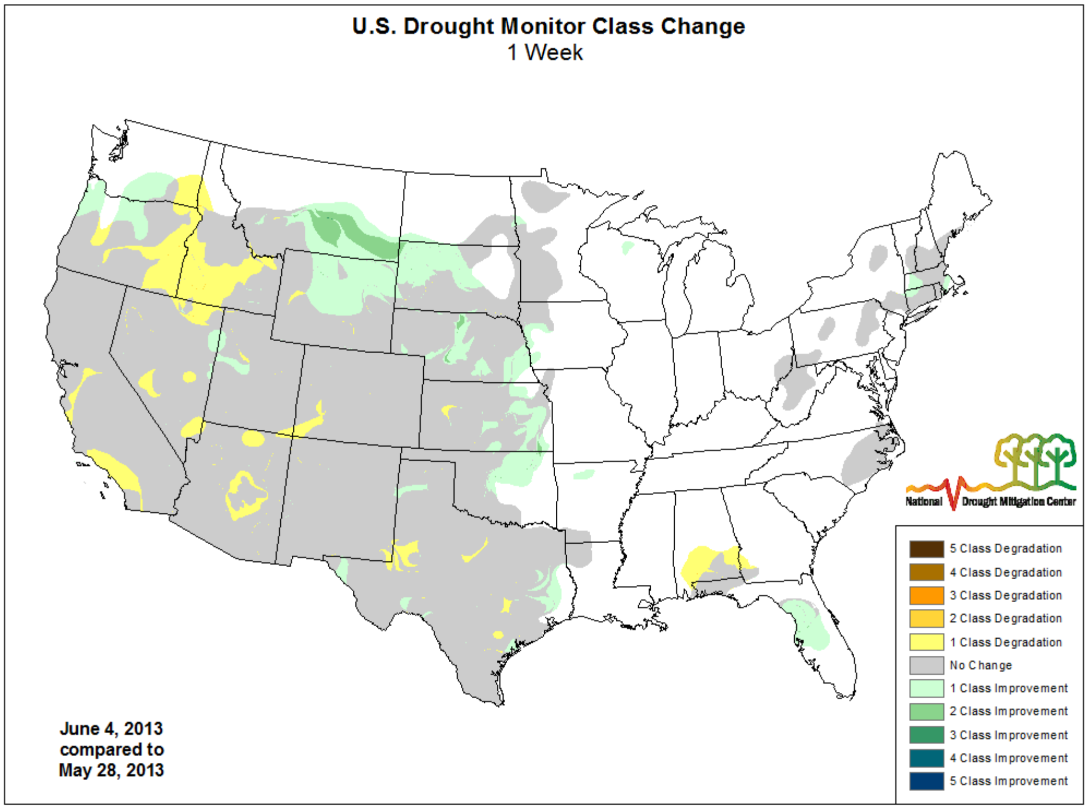
http://droughtmonitor.unl.edu/



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	52.14	47.86	37.32	27.28	13.24	3.02
Last Week 5/27/2014	52.12	47.88	37.93	27.72	13.64	3.35
3 Months Ago 3/4/2014	46.53	53.47	35.85	21.56	7.40	1.57
Start of Calendar Year 12/31/2013	48.24	51.76	30.95	16.67	3.96	0.37
Start of Water Year 10/1/2013	39.57	60.43	41.21	20.70	3.06	0.29
One Year Ago 6/4/2013	45.02	54.98	44.11	28.49	11.44	4.79







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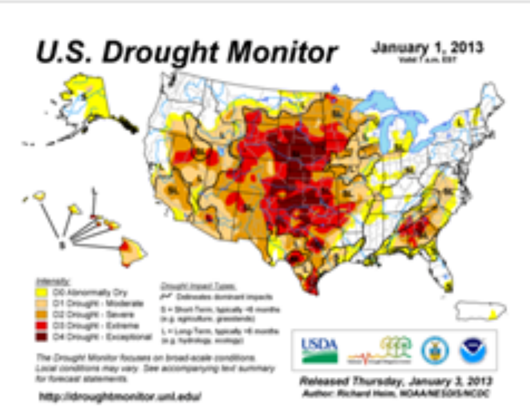
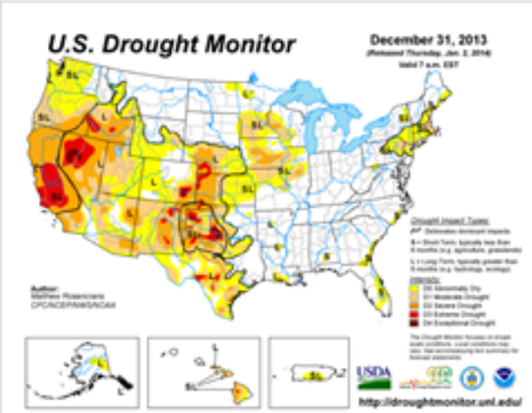
Regional Drought Overview



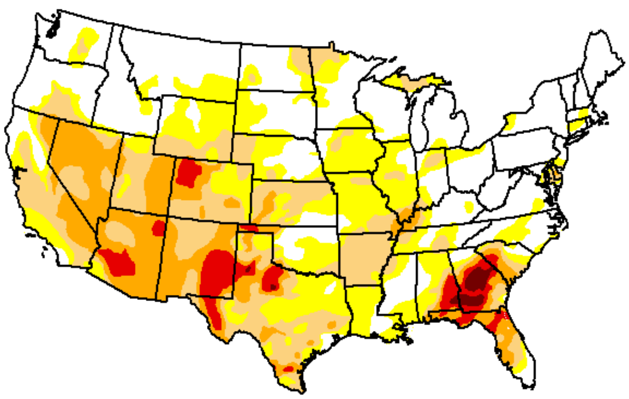
USDM map depicting drought at the beginning of 2013



USDM map depicting drought at the end of 2013

U.S. Drought Monitor

CONUS



June 5, 2012

(Released Thursday, Jun. 7, 2012)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	36.01	63.99	38.60	18.92	4.60	0.60
Last Week *5/29/2012*	35.98	64.02	37.37	18.94	5.22	0.66
3 Months Ago *3/6/2012*	42.81	57.19	39.02	19.30	7.24	2.44
Start of Calendar Year *1/3/2012*	50.41	49.59	31.90	18.83	10.18	3.32
Start of Water Year *9/27/2011*	56.45	43.55	29.13	23.44	17.80	11.37
One Year Ago *6/7/2011*	67.68	32.32	26.77	21.32	15.74	7.80

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author(s):
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U.S. Drought Monitor

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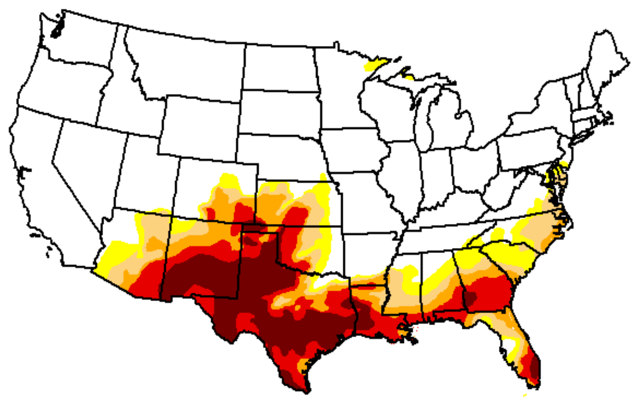

June 7, 2011

(Released Thursday, Jun. 9, 2011)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	67.68	32.32	26.77	21.32	15.74	7.80
Last Week *5/31/2011*	68.95	31.05	25.56	20.69	14.68	6.25
3 Months Ago *3/8/2011*	59.25	40.75	27.48	12.56	2.68	0.00
Start of Calendar Year *1/4/2011*	60.50	39.50	21.74	8.50	2.60	0.00
Start of Water Year *9/28/2010*	60.05	39.95	13.16	3.09	0.30	0.00
One Year Ago *6/8/2010*	78.36	21.64	9.04	2.96	0.48	0.00

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

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