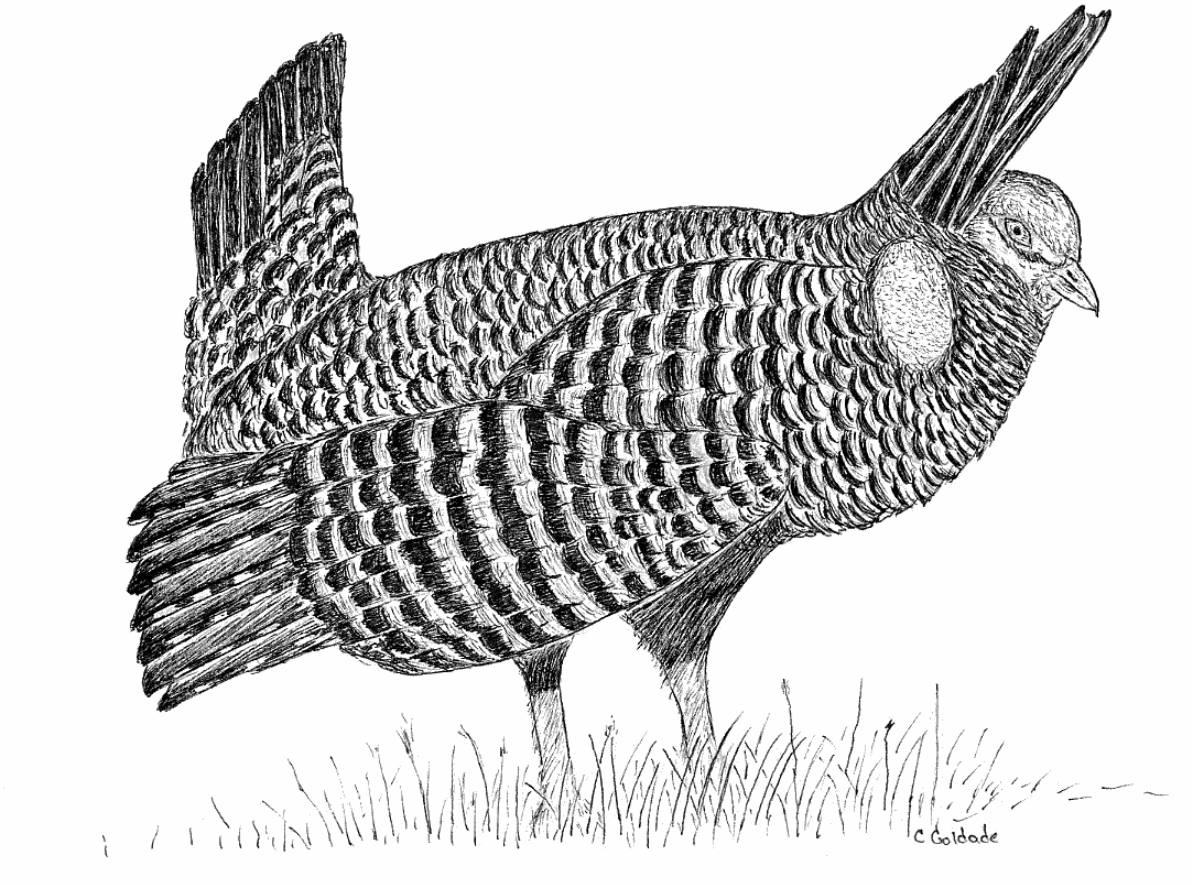
EFFECTS OF MANAGEMENT PRACTICES ON GRASSLAND BIRDS:

LESSER PRAIRIE-CHICKEN



Grasslands Ecosystem Initiative
Northern Prairie Wildlife Research Center
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Jamestown, North Dakota 58401

This report is one in a series of literature syntheses on North American grassland birds. The need for these reports was identified by the Prairie Pothole Joint Venture (PPJV), a part of the North American Waterfowl Management Plan. The PPJV recently adopted a new goal, to stabilize or increase populations of declining grassland- and wetland-associated wildlife species in the Prairie Pothole Region. To further that objective, it is essential to understand the habitat needs of birds other than waterfowl, and how management practices affect their habitats. The focus of these reports is on management of breeding habitat, particularly in the northern Great Plains.

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Species for which syntheses are available or are in preparation:

American Bittern
Mountain Plover
Marbled Godwit
Long-billed Curlew
Willet
Wilson's Phalarope
Upland Sandpiper
Greater Prairie-Chicken
Lesser Prairie-Chicken
Northern Harrier
Swainson's Hawk
Ferruginous Hawk
Short-eared Owl
Burrowing Owl
Horned Lark
Sedge Wren
Loggerhead Shrike
Sprague's Pipit
Grasshopper Sparrow
Baird's Sparrow
Henslow's Sparrow
Le Conte's Sparrow
Nelson's Sharp-tailed Sparrow
Vesper Sparrow
Savannah Sparrow
Lark Sparrow
Field Sparrow
Clay-colored Sparrow
Chestnut-collared Longspur
McCown's Longspur
Dickcissel
Lark Bunting
Bobolink
Eastern Meadowlark
Western Meadowlark
Brown-headed Cowbird

EFFECTS OF MANAGEMENT PRACTICES ON GRASSLAND BIRDS:

LESSER PRAIRIE-CHICKEN

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ORGANIZATION AND FEATURES OF THIS SPECIES ACCOUNT

Information on the habitat requirements and effects of habitat management on grassland birds were summarized from information in more than 4,000 published and unpublished papers. A ***range map*** is provided to indicate the breeding distribution of Lesser Prairie-Chicken in the United States and southern Canada. Although birds frequently are observed outside the breeding range indicated, the maps are intended to show areas where managers might concentrate their attention. It may be ineffectual to manage habitat at a site for a species that rarely occurs in an area. The species account begins with a brief ***capsule statement***, which provides the fundamental components or keys to management for the species. A section on ***breeding range*** outlines the current breeding distribution of the species in North America. The ***suitable habitat*** section describes the breeding habitat and occasionally microhabitat characteristics of the species, especially those habitats that occur in the Great Plains. Details on habitat and microhabitat requirements often provide clues to how a species will respond to a particular management practice. A ***table*** near the end of the account complements the section on suitable habitat, and lists the specific habitat characteristics for the species by individual studies. A special section on ***prey habitat*** is included for those predatory species that have more specific prey requirements. The ***area requirements*** section provides details on territory and home range sizes, minimum area requirements, and the effects of patch size, edges, and other landscape and habitat features on abundance and productivity. It may be futile to manage a small block of suitable habitat for a species that has minimum area requirements that are larger than the area being managed. The Brown-headed Cowbird (*Molothrus ater*) is an obligate brood parasite of many grassland birds. The section on ***cowbird brood parasitism*** summarizes rates of cowbird parasitism, host responses to parasitism, and factors that influence parasitism, such as nest concealment and host density. The impact of management depends, in part, upon a species' nesting phenology and biology. The section on ***breeding-season phenology and site fidelity*** includes details on spring arrival and fall departure for migratory populations in the Great Plains, peak breeding periods, the tendency to renest after nest failure or success, and the propensity to return to a previous breeding site. The duration and timing of breeding varies among regions and years. ***Species' response to management*** summarizes the current knowledge and major findings in the literature on the effects of different management practices on the species. The section on ***management recommendations*** complements the previous section and summarizes specific recommendations for habitat management provided in the literature. If management recommendations differ in different portions of the species' breeding range, recommendations are given separately by region. The ***literature cited*** contains references to published and unpublished literature on the management effects and habitat requirements of the species. This section is not meant to be a complete bibliography; a searchable, annotated bibliography of published and unpublished papers dealing with habitat needs of grassland birds and their responses to habitat management is posted at the Web site mentioned below.

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Lesser Prairie-Chicken
(*Tympanuchus pallidicinctus*)

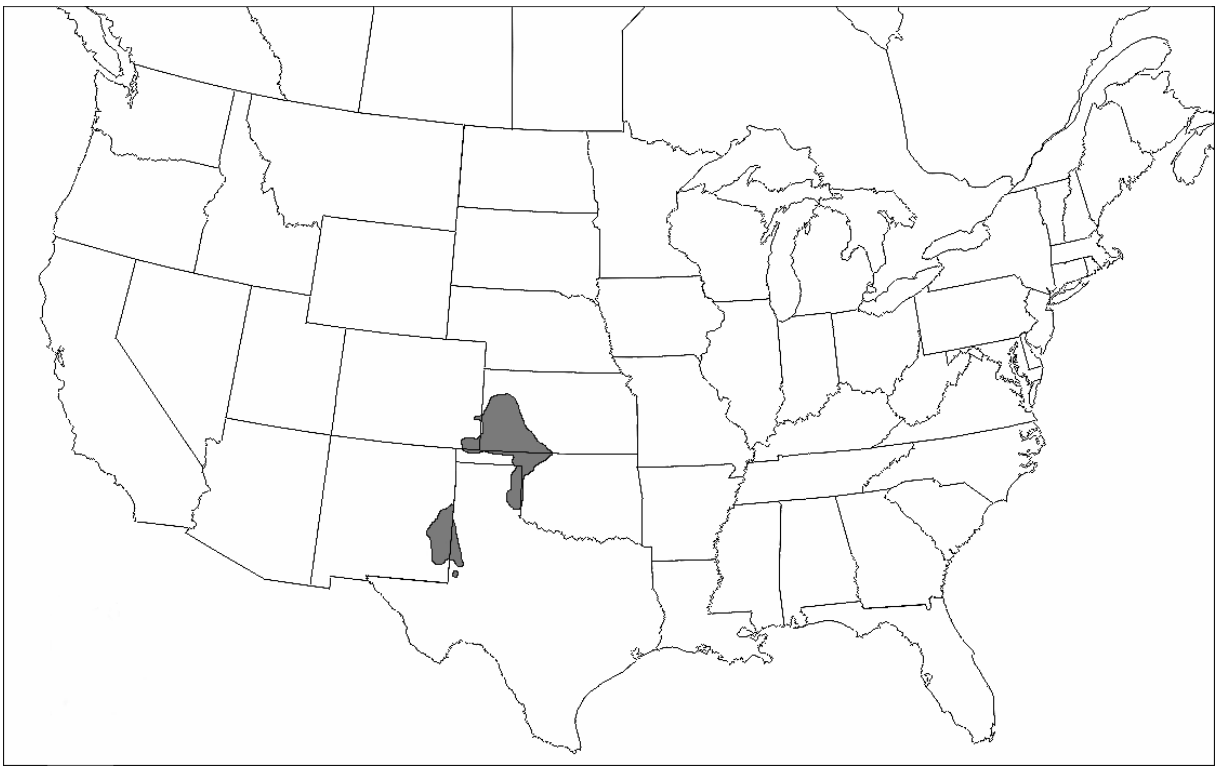

Figure. Shaded area represents the distribution of Lesser Prairie-Chicken. Information courtesy of K. M. Giesen, Colorado Division of Wildlife, Ft. Collins, Colorado.

Key to management is maintaining expansive shinnery oak (*Quercus havardii*) or sand sagebrush (*Artemisia filifolia*) grasslands. Within these grasslands, provide areas of short herbaceous cover for lek sites, shrubs or tall residual grasses for nesting, and areas with about 25% canopy cover of shrubs, forbs, or grasses 25-30 cm tall for brood rearing. Historically, the Lesser Prairie-Chicken was considered a gamebird and was hunted throughout its range; currently, it is hunted only in Kansas and Texas. The following account does not address harvest management, but instead focuses on habitat management.

Breeding range:

Lesser Prairie-Chickens are year-round residents from southeastern Colorado and southwestern Kansas, south through western Oklahoma, extreme eastern New Mexico, and the Texas panhandle (National Geographic Society 1999). (See figure for the current distribution of Lesser Prairie-Chickens.)

Suitable habitat:

In general, Lesser Prairie-Chickens inhabit shrub-grassland communities dominated by shinnery oak or sand sagebrush with an understory composed of mixed-grass or tallgrass species and a variety of forb species (Lee 1950; Schwilling 1955; Bent 1963; Copelin 1963; Hoffman 1963; Jones 1963*a,b*; Crawford 1974; Cannon and Knopf 1979; Merchant 1982; Riley et al.

1992, 1993; Litton et al. 1994; Cable 1996; Giesen 1998; Wildlife Habitat Management Institute 1999; Jamison 2000). Lesser Prairie-Chickens use varying heights, densities, and species of vegetation in accordance with the bird's seasonal life-history requirements. Lesser Prairie-Chickens use small areas of short, herbaceous cover for lek sites; shrubs or tall residual grasses for nesting; areas with about 25% canopy cover of shrubs, forbs, or grasses 25-30 cm tall for brood rearing; and areas with approximately equal proportions of shrubs, grasses, and bare ground for adult foraging. Harvested grain sorghum and corn fields often are used as winter foraging areas (Lee 1950, Schwilling 1955, Bent 1963, Copelin 1963, Jones 1963*a*, Donaldson 1969, Campbell 1972, Crawford 1974, Ahlborn 1980, Merchant 1982, Wilson 1982, Litton et al. 1994, Cable 1996, Giesen 1998). Sandhill habitats used by Lesser Prairie-Chickens are characterized by sandy or sandy loam soils in the Brownfield, Patricia, Tivoli, Brownfield-Tivoli, Tivoli-Vona, and Amarillo-Clovis associations that form level to undulating topography (Bent 1963, Copelin 1963, Crawford 1974, Sell 1979, Wilson 1982, Doerr and Guthery 1983, Olawsky 1987, Olawsky and Smith 1991, Jamison 2000). In Kansas on a year-round basis, male Lesser Prairie-Chickens selected sand sagebrush grassland over cropland, tallgrass and Conservation Reserve Program (CRP) grassland, and other grassland habitats (e.g., shortgrass, mixed-grass, western wheatgrass [*Agropyron smithii*], and alkali sacaton [*Sporobolus airoides*] prairie) (Jamison 2000). In Texas during autumn and winter, Lesser Prairie-Chickens used shinnery oak/sand sagebrush, cultivated sunflower, and shinnery oak/little bluestem (*Schizachyrium scoparium*) habitats more than expected based upon habitat availability, and all other habitats (i.e., shinnery oak, honey mesquite [*Prosopis glandulosa*]/shinnery oak, honey mesquite/blue grama [*Bouteloua gracilis*], and oldfield) less than expected (Taylor and Guthery 1980*a*).

Lesser Prairie-Chicken populations are monitored by counting the numbers of displaying males present at leks. Three studies have examined the relationship between numbers of displaying males (or trends in these numbers) and characteristics of the surrounding landscape (Crawford 1974, Crawford and Bolen 1976*a*, Cannon and Knopf 1981, Leslie et al. 1999, Woodward et al. 2001). In New Mexico, Oklahoma, and Texas, annual rates of habitat change within 4.8 km of (i.e., a 7,238-ha areas surrounding) four leks with declines in numbers of males averaged 1.14%, and averaged 0.21% at eight leks with stable populations (Leslie et al. 1999). Current landscapes (landscapes whose composition was estimated from the most recently available aerial photographs) and mean landscapes (the mean composition of the landscape over time) in which populations declined contained less mixed-grass prairie with <15% canopy coverage of various shrubs other than shinnery oak (low-density mixed shrubland) than landscapes in which populations were stable or increasing (Woodward et al. 2001). Mean landscapes with stable or increasing Lesser Prairie-Chicken populations were composed of 85.8% short- and mixed-grass prairie with some shinnery oak or other shrubs (upland prairie-shrubland) versus 51.9% upland prairie shrubland in landscapes with declining numbers of birds. All mixed-grass prairie containing shrubs (total shrubland) composed 81.9% of current landscapes around leks that were stable or had increased and 63.4% of the landscape around declining leks. Upland prairie-shrubland composed 85.2% of the current landscape around leks that were stable or increasing versus 50.9% of landscapes surrounding declining leks. Current composition of landscapes in which populations had declined had less total shrubland than landscapes in which populations did not decline. Indices of total landscape change (defined as any change from one habitat to another [e.g., native pasture to cropland]) were greater for landscapes in which Lesser Prairie-Chickens declined than for landscapes in which Lesser

Prairie-Chicken populations were stable. In landscapes with declining populations, 44% of the total area had changed from one cover type to another as compared to 8% of the area in landscapes where Lesser Prairie-Chickens did not decline. Lesser Prairie-Chicken declines also were linearly associated with rates of landscape change. Landscapes in which Lesser Prairie-Chicken populations declined lost total shrubland at a greater rate than landscapes in which populations did not decline. Declining trends in Lesser Prairie-Chicken populations were positively correlated with loss of total shrubland. Extensive grazing and conversion of native rangeland to center-pivot irrigated crop fields contributed to loss of native mixed-grass prairie, including shrub-dominated habitats (Leslie et al. 1999, Woodward et al. 2001).

In Texas, spring and autumn numbers of displaying male Lesser Prairie-Chickens were positively associated with the percent of the landscape that was native pasture, deep sands range site category (a category defined by the Soil Conservation Service [now the Natural Resources Conservation Service] based on soil type and potential production of natural vegetation), and percent of cropland in minimum-tillage agriculture (a practice that leaves grain stubble intact following harvest and employs specialized planting equipment that eliminates traditional plowing) (Crawford 1974, Crawford and Bolen 1976*a*). Maximum Lesser Prairie-Chicken populations occurred in landscapes that were composed of 63-95% native pasture, with the remainder planted to grain sorghum.

In Oklahoma, relationships between densities of Lesser Prairie-Chickens (based on counts of displaying males) and vegetation data were examined (Cannon and Knopf 1981). Counts of displaying males were conducted at eight leks, and vegetation data were collected along 30 transects placed in the central 1,036 ha of each 4,144-ha study area surrounding the lek. In sand sagebrush habitats, densities of displaying males on four areas were positively correlated with percent coverage of shrubs, grass frequency (determined from cover types recorded at 2-m intervals), and brush frequency. Densities were negatively correlated with percent grass coverage. In shinnery oak habitats, densities of displaying males were positively correlated with grass frequency and negatively correlated with percent shrub coverage and brush frequency. In shinnery oak pastures, Lesser Prairie-Chickens preferred areas dominated by mixed-grass and tallgrass species. Densities of birds in shinnery oak habitats also were correlated with proportions of different vegetation cover types as characterized by multispectral satellite data (Cannon et al. 1982). In four shinnery oak study areas, densities of displaying males were positively correlated with percent grassland and negatively correlated with percent brushland. However, no significant correlations were detected between remotely sensed cover classes and male Lesser Prairie-Chicken densities in sand sagebrush habitats.

Specific information on habitats used for courtship activities (lek sites), nesting, brood rearing, and foraging appears in the following sections.

Lek Sites.—For lek sites, Lesser Prairie-Chickens prefer areas with short (<10-cm tall) herbaceous cover and unrestricted visibility that are located on ridges, knolls, or in broad swales in pastures (Davison 1940; Schwilling 1955; Bent 1963; Copelin 1963; Jones 1963*a,b*; Donaldson 1969; Crawford and Bolen 1976*a*; Cannon and Knopf 1979; Taylor 1979; Locke 1992; Applegate and Riley 1998; Giesen 1998). They use abandoned oil-drilling sites (oil pads) with little or no vegetation, unimproved roads with little traffic, areas treated with shrub-specific herbicide, recently burned areas, heavily grazed areas (especially near livestock-watering facilities), and cultivated fields adjacent to grassland.

In New Mexico, Oklahoma, and Texas, Leslie et al. (1999) found 21 leks in landscapes composed of native grassland, cultivated land, and CRP fields. In New Mexico, males

established leks in areas with a greater composition of shinnery oak/bluestem, shinnery oak/three-awn (*Aristida* spp.), and shinnery oak/mixed-grass habitats than was generally available on the 14,500-ha study area (Ahlborn 1980). In Kansas, leks were discovered in openings in sand sagebrush on hilltops; in broad, flat areas; in low spots in choppy sandhills; and in cultivated fields (Schwilling 1955). Most lek sites were vegetated by buffalo grass (*Buchloe dactyloides*) or blue grama, located on small rises in sagebrush pasture, and were nearly devoid of shrubs. In Oklahoma, mean height of vegetation on leks (number of leks not given) was 10 cm, and plant cover averaged 64% (Jones 1963*a*,*b*). Percent composition of perennial plants was 26.2% buffalo grass, 4.2% sand dropseed (*Sporobolus cryptandrus*), 3.8% blue grama, 8.8% sideoats grama, and <3% other species (Jones 1963*a*). In Texas, nine of 13 leks were in pasture (Crawford and Bolen 1976*b*). Following cultivation of the area surrounding the leks, leks that were traditionally occupied were no longer consistently used by displaying males. In another Texas study, two of 14 leks located on a 5200-ha shinnery oak/sand sagebrush study area were in areas of relatively undisturbed natural vegetation, and 12 were on areas disturbed by human activities (Taylor 1979). Eight of the 12 leks were on oil pads, three were on tilled areas, and one was a plot treated with tebuthiuron, a shrub-specific herbicide. The two leks on natural sites were on slightly elevated terrain, where shinnery oak was 10-20 cm tall.

In New Mexico, eight of 21 leks were located on oil pads, seven were in honey mesquite/shortgrass habitats, and six were in shinnery oak/tallgrass habitat (Davis et al. 1979). Oil pads used as lek sites had no vegetation; however, leks in honey mesquite/shortgrass habitat generally had grass cover that was 5-10 cm tall. One lek in shinnery oak/tallgrass habitat was located on a sand dune that was devoid of vegetation. On the same study area, 19 of 21 leks observed by Locke (1992) were located on oil pads. Thirty-one of 34 leks located the following spring were situated on oil pads. The remaining leks were in pasture. About one-half of the available oil pads were used as lek sites. Use of oil pads as lek sites was independent of surrounding habitat type(s) (i.e., oil pads had an equal probability of being used as lek sites regardless of adjacent habitat type). In Texas, Sell (1979) found three leks on oil pads, three near windmills, one in a cultivated field, one in an area in which shrubs had been treated with herbicide, and one in native grassland.

Lek density and corresponding interlek distances may provide an index to habitat quality. Interlek distance was defined by Crawford (1974), Locke (1992), and Giesen (1994) as the distance between a lek and its nearest neighbor. Presumably, this definition holds for Crawford and Bolen (1976*a*), as well. Taylor (1979) and Applegate and Riley (1998) referred to an average distance between leks but did not specify how those means were calculated. In landscapes dominated by grassland, interlek distances were 0.84-3.2 km, and lek densities were 0.18-0.97 leks/km^2 (Crawford 1974, Crawford and Bolen 1976*a*, Taylor 1979, Locke 1992, Giesen 1994). Applegate and Riley (1998) suggested that areas managed for Lesser Prairie-Chickens should comprise $\geq$6 leks, and that $\geq$10 leks would be better. The authors also suggested that interlek distances should be $\leq$1.9 km. However, no data were available to support these suggested values. In Texas, density of leks (estimated from interlek distances) varied with the proportion of the landscape that was cultivated (Crawford 1974, Crawford and Bolen 1976*a*). Landscapes that had small percentages of cultivated fields had higher lek densities than landscapes with no crops or landscapes with large percentages of cultivated land. Mean distance between leks on sites with no cultivated crops was 3.2 km. Lek density was highest in landscapes in which 5-37% of the land was cultivated. In these landscapes, distances between leks averaged 2.4 km (numbers of leks were not given). In landscapes where >37% of the area

was cultivated, average distance between leks was 5 km (Crawford 1974). In another Texas study, mean interlek distance for 14 leks on a 5200-ha study area was 1.25 km (Taylor 1979). In New Mexico, mean interlek distance ranged from 0.84 km for 21 leks located in one year to 1.02 km for 34 leks found the following year (Locke 1992). In Colorado, average lek density was 0.18 leks/km^2, and average distance between leks was 1.13 km (number of leks was not given) (Giesen 1994). In Oklahoma, the number of active leks varied from 18 to 40 over an 8-yr period, but only 13 leks were active during all 7 yr in which counts of displaying males were conducted (Davison 1940).

Nesting Habitat.—Lesser Prairie-Chicken hens nest in tall, residual grasses or under shrubs in native pasture, and avoid shortgrass habitats and cultivated fields (Bent 1963, Copelin 1963, Jones 1963*a*, Davis et al. 1979, Sell 1979, Merchant 1982, Wilson 1982, Riley et al. 1992, Giesen 1994). Preferred vegetation for nesting is dense vegetation, such as that provided by shrubs and residual bunchgrasses >40 cm tall, that provides >75% vertical screening in the first 33 cm above ground and 50% overhead cover (Sell 1979, Haukos and Smith 1989, Giesen 1994). Bent (1963) described three nests in southwestern Kansas from the notes of Walter Colvin. Two nests were located beneath sagebrush plants, and one was under a tumbleweed lodged between two clumps of grass. Of seven nests in Oklahoma found by Copelin (1963), three were in little bluestem, two were in a combination of little bluestem and three-awn, one was in a combination of little bluestem and sand bluestem (*Andropogon hallii*), and one was in sand lovegrass (*Eragrostis trichodes*). Shinnery oak, ranging in height from 31 to 38 cm, was present at five of those seven nest sites. Most of the successful nests were between clumps of residual grasses. Shrubs that sheltered nests did not exceed 38 cm in height.

In New Mexico, Lesser Prairie-Chickens nested only in shinnery oak/tallgrass habitats and avoided honey mesquite/shortgrass habitats (Davis et al. 1979). Nesting success was positively associated with percent composition of sand bluestem, three-awn (*Aristida* sp.), and all species of grass combined, within 3 m of nest sites. Nesting attempts were most successful when nests were placed directly under sand bluestem cover. Nesting hens selected shinnery oak/sand bluestem habitats, followed by three-awn/little bluestem habitats and shinnery oak/three-awn habitats. Hens selected nest sites with north or northeast aspects and abundant sand bluestem, shinnery oak, or dropseed that was taller than the average vegetation height within 3 m of nest sites. As a result, nest sites were characterized by more litter and less bare ground than in the surrounding habitat. Percent litter was greater and percent bare ground was lower within 3 m of nests in shinnery oak/tallgrass habitats than was found along transects. Ten of 36 nests for which fate could be determined were successful (i.e., $\geq$1 egg hatched) (Riley et al. 1992). Nests in sand bluestem had a higher success rate (4 of 6 were successful) than nests found in little bluestem (2 of 9), three-awn (1 of 7), sand sagebrush (1 of 5), shinnery oak (0 of 4), or broomlike ragwort (*Senecio spartioides*) (0 of 2). One nest, which was successful, was found in silver bluestem (*Andropogon saccharoides*), and one of two nests found under yucca was successful. Sand bluestem provided better concealment for nesting hens than other species of grass. Mean height of vegetation above nest sites was significantly greater at successful nests (67 cm) than at unsuccessful nests (35 cm). In all shinnery oak habitats, shrub coverage was similar at successful and unsuccessful nests and ranged from 31.3 to 66.2% (Riley et al. 1992).

In other New Mexico studies, nesting hens selected habitats dominated by shinnery oak, purple three-awn, and bluestem grasses; habitats dominated by shinnery oak and interspersed with little bluestem and sand bluestem; and habitats vegetated by shinnery oak, three-awn, dropseed (*Sporobolus* spp.), and grama (Merchant 1982, Wilson 1982). Nesting hens avoided

weeping lovegrass (*Eragrostis curvula*) and oldfield habitats. Hens did not use fallow, cultivated, or shortgrass habitats. Of 24 nests, nine were in little bluestem, six were under yucca (*Yucca glauca*), six were under shinnery oak, two were in purple three-awn, and one was under sand sagebrush (Wilson 1982). Mean heights of plants directly above nests ranged from 42 to 52 cm, and were taller than plants within 3 m of nest sites. Mean basal cover of all plants within 3 m of nests ranged from 6.7 to 8.8%, bare ground ranged from 39 to 49.1%, and litter cover ranged from 44.2 to 52.3% across habitat types. Canopy coverage of grasses within 3 m of nest sites ranged from 3.1 to 13.2%, shrub canopy coverage ranged from 21.4 to 28.3%, and canopy coverage of all vegetation ranged from 31.4 to 38.4%. Of 15 nests, those in grasses were more successful (4 of 5 successful) than those under shrubs (3 of 10 successful).

In Texas, six of eight nests were in habitats with level topography, few unstable sand dunes, and relatively low shinnery oak abundance (Sell 1979). Two nests were in habitats with large, unstable sand dunes; abundant and relatively tall shinnery oak; and low grass cover. Five of the eight nests were under sand sagebrush, two were in purple three-awn, and one was in shinnery oak. Canopy cover of sand sagebrush and structural density measurements were significantly higher at nest sites than in surrounding habitat (no specific values were given for canopy cover or height/density). In another Texas study, eight of 10 female Lesser Prairie-Chickens that were captured and released in areas that had been treated with tebuthiuron later nested in untreated shinnery oak (Haukos and Smith 1989). More hens nested in untreated areas than expected based on the availability of untreated habitats. Vegetation was sampled at 13 nests, only two of which were in treated shinnery oak. All nests were in residual grasses. Vegetation was dominated by purple three-awn at nine nest sites, little bluestem at three nest sites, and sand bluestem at one nest site. Vegetation density estimates from four profile board readings per nest averaged 61-80% obstruction in the first 33 cm above ground, 6-20% from 34 to 66 cm above ground, and <5% obstruction from 67 to 99 cm above ground. Overhead cover at nest sites averaged 42%, and plant height averaged 45 cm.

In Colorado, 12 of 29 nests were under sand sagebrush, and six were under yucca (Giesen 1994). The 11 remaining nests were in bunchgrasses or under other species of shrubs. The tallest vegetation at nest sites averaged 51 cm. Shrub, forb, and grass heights, and height/density of vegetation, were greater at nest sites than along the remainder of the 10-m transect crossing the nest site. Shrubs averaged 48 cm in height at the 26 nest sites where shrubs were present versus 38 cm along transects. Mean height of forbs at 26 nest sites was 21 cm; forbs along transects averaged 16 cm. Grass was present at all nests and averaged 36 cm in height at nest sites and 27 cm along transects. Height/density of vegetation averaged 32 cm at 29 nest sites, and 20 cm along transects. At 29 nest sites, average sand sagebrush plant density was 3471 plants/ha, sand sagebrush cover was 7.2%, grass cover was 29.4%, forb cover was 1.4%, and bare ground was 69.5%. Further evidence suggesting the importance of residual vegetation was presented by Giesen (2000). On the Comanche National Grassland, the amount of annual precipitation was strongly correlated with numbers of displaying males counted two years later. The relationship was explained by the assumed increase in herbaceous vegetation during years of greater moisture. This vegetation then provided more residual nesting cover the following year and was expressed as an increase in displaying males two years following the year of increased precipitation (Giesen 2000).

Brood-rearing Habitat.—Lesser Prairie-Chicken broods forage for invertebrates in areas with abundant bare ground and approximately 25% canopy cover of shrubs, forbs, or grasses <30 cm in height (Jones 1963*a*, Donaldson 1969, Davis et al. 1979, Ahlborn 1980, Riley and Davis

1993). During hot weather, broods may use areas with taller vegetation (Copelin 1963, Donaldson 1969). In New Mexico, brood-foraging sites generally were on bare ground in low sandhills and in areas dominated by shinnery oak (Riley and Davis 1993). Three-awn and shinnery oak dominated at 12 brood-foraging sites, but species composition of vegetation varied widely. Bare ground averaged 63.1% at foraging sites, and average height of cover at the center of foraging sites was 25 cm. Live plant material and litter completely covered the ground at one-third of the foraging sites, whereas bare ground was prevalent at the remaining two-thirds. Basal composition of vegetation (bare ground excluded) at brood-foraging sites was 42.8% grasses, 42.6% shrubs (primarily shinnery oak), and 14.6% forbs. Grass species at foraging sites included three-awn, Hall's panicgrass (*Panicum hallii*), dropseed, sand bluestem, big bluestem (*Andropogon gerardii*), false buffalo grass (*Monroa squarrosa*), hairy grama (*Bouteloua hirsuta*), and thin paspalum (*Paspalum setaceum*). Shrub species at foraging sites included shinnery oak, yucca, and sand sagebrush. Dominant forbs at brood-foraging sites included annual eriogonum (*Eriogonum annum*), *Euphorbia* spp., western ragweed (*Ambrosia psilostachya*), and crotons (*Croton* spp.).

In Oklahoma, Donaldson (1969) observed eight broods in shinnery oak habitats, two in sand sagebrush habitats, and two on unimproved roads. Six of those 12 broods were in phenoxy herbicide-treated shinnery oak, two were in untreated shinnery oak, and one each was in treated and untreated sand sagebrush. Broods used plants moderate to tall in height for resting cover during the day. For feeding, they used low vegetation (specific vegetation heights were not given) with an open aspect. Broods used taller vegetation, particularly thickets of shinnery oak, when temperatures exceeded 32°C than when temperatures were lower. Copelin (1963) found 27 broods under 2-30 m diameter thickets of 1-6 m tall shinnery oaks and one brood in low-growing oaks. Jones (1963*b*) observed 28 Lesser Prairie-Chicken broods over three breeding seasons. The broods used grasslands interspersed with 0.8-2.0 m tall shrubs. Percent composition of perennial plants in brood ranges was 7.8% sand dropseed, 22.8% sand sagebrush, 17.2% skunkbush sumac, 15.7% western ragweed, and < 3% other perennial plants (Jones 1963a).

In New Mexico, encounters of unmarked broods varied from 0.10 to 0.18 per km of transect across three shinnery oak/tallgrass habitat types (Davis et al. 1979). Habitat preferences of radio-marked hens with broods were similar. No broods were detected in honey mesquite/shortgrass habitats. Percent basal composition was determined from transects at brood-foraging sites and haphazardly located transects scattered throughout each habitat type. Percent basal composition of grasses and shrubs at brood-foraging sites suggested that broods used areas with lower grass abundance and greater shrub abundance than generally was available in the habitat type. Minimum height of vegetation at brood-foraging sites was 24 cm. In shinnery oak/sand bluestem habitats, 13 brood-foraging sites had 62% grass and 38% shrub cover versus 65.3% grass and 34.7% shrub cover along 30 transects in the habitat type. In three-awn/little bluestem habitat, 19 brood-foraging sites were characterized by 52.7% grass and 47.3% shrub cover versus 65.3% grass and 34.7% shrub cover along 60 transects in the habitat type. Results of comparisons between brood-foraging sites and the overall habitat in shinnery oak/three-awn were similar to those for three-awn/little bluestem habitat. In shinnery oak/three-awn habitat, 47 brood-foraging sites were characterized by 43.6% basal composition of grass and 56.4% basal composition of shrubs versus 48% basal composition of grass and 52% basal composition of shrubs along 32 transects in the habitat type. Percent total ground cover composed of plants at 13 brood-foraging sites in shinnery oak/sand bluestem habitat averaged 8.4%, whereas that along

transects in the habitat type averaged 18.8%. In three-awn/little bluestem and shinnery oak/three-awn habitats, plant cover at brood-foraging sites was significantly greater than was available in the habitat type. At 19 foraging sites in three-awn/little bluestem shinnery oak habitat, plant cover averaged 14.6% compared to 11.7% along 60 transects in that habitat. At 47 brood sites in shinnery oak/three-awn habitat, plant cover averaged 14%; that along 32 transects averaged 9.2%. Remaining percentages of ground cover were composed of litter and bare ground (Davis et al. 1979).

In another New Mexico study, encounters of unmarked broods along transects suggested that hens with broods preferred shinnery oak/bluestem and shinnery oak/three-awn habitats over cultivated, fallow, shinnery oak/mixed-grass, shortgrass/snakeweed (*Gutierrezia sarothrae*), weeping lovegrass, or oldfield habitats (Ahlborn 1980). Radio locations of hens with broods also suggested they preferred shinnery oak/mixed-grass and shinnery oak/three-awn habitat, but used other habitats less than expected. Sites used by broods were characterized by about 25% canopy cover of vegetation, canopy height of about 30 cm, 24-39% basal composition of shrubs, 47-60% of grasses, and 13-26% of forbs.

Foraging Habitat.—On a year-round basis in Oklahoma, Lesser Prairie-Chickens foraged mostly in grass, especially mixed-grass species 25-80 cm in height (Jones 1963*a*). Seeds of sixweeks fescue (*Festuca octoflora*) and fragrant sumac (*Rhus aromatica* var. *trilobata*) were important food items. During spring, Lesser Prairie-Chickens primarily foraged among shrubs <80 cm tall. They were found in grasses and forbs 25-80 cm tall during summer, and grasses 25-80 cm tall during autumn. In winter, Lesser Prairie-Chickens primarily were found in grasses >80 cm tall. In Oklahoma, Lesser Prairie-Chickens used wheat, western ragweed, and blue grama for feeding on a year-round basis (Donaldson 1969). Lesser Prairie-Chickens occasionally were seen on bare ground, presumably obtaining grit.

In New Mexico, Lesser Prairie-Chickens foraged nearly exclusively in shinnery oak/tallgrass habitats during autumn and winter (Riley et al. 1993). Vegetation at foraging sites was dominated by grass and shinnery oak, with shinnery oak more prevalent at winter sites than at autumn sites (Davis et al. 1979). Autumn foraging sites contained more grass and fewer shrubs than did winter sites. Grasses composed 63% and shrubs composed 37% of the vegetation at 22 autumn foraging sites. Basal composition at 50 winter foraging sites was 59% grasses and 41% shrubs, primarily shinnery oak. Dominant grasses were sand bluestem, little bluestem, dropseed, three-awn, hairy grama, and Hall's panicgrass. Forbs were scarce at autumn and winter foraging sites and were not sampled (Riley et al. 1993). Percent total ground cover at foraging locations differed between autumn and winter (Davis et al. 1979). Total ground cover was 37.4% litter, 37.4% bare ground, and 25.2% live plants at 23 autumn foraging locations. At 51 winter foraging locations, total ground cover was 46% litter, 44.3% bare ground, and 9.7% live plants. Percent basal composition of vegetation at summer foraging sites was 42-59% grasses and 41-58% shrubs. Percent total ground cover composed of plants at adult foraging sites ranged from 10.5 to 12.7%. Lesser Prairie-Chicken foraging habitats were similar to the overall habitat type (Davis et al. 1979).

Grain sorghum, corn, and other grain fields adjacent to native pasture commonly are used as foraging areas from late autumn through early spring (Bent 1963, Davison 1940, Lee 1950, Schwilling 1955, Copelin 1963, Hoffman 1963, Jackson and DeArment 1963, Jones 1963*a*, Donaldson 1969, Crawford 1974, Ahlborn 1980, Merchant 1982, Litton et al. 1994, Applegate and Riley 1998, Giesen 1998, Jamison 2000). In Oklahoma, use of food plots and cultivated grain fields may have been influenced by the abundance in grasslands of natural foods (i.e.,

shinnery oak mast, grass seed, and forb seed) and by the amount of snow cover that affected food availability (Copelin 1963). During one winter, farmers reported that nine of 16 grain food plots were used by Lesser Prairie-Chickens. During the next winter, only one of these 16 areas was used. Of 12 food plots maintained in Lesser Prairie-Chicken range in the following winter, nine were used by Lesser Prairie-Chickens. During the next winter, all four of the plots that remained were used. In another Oklahoma study, Lesser Prairie-Chickens used grain sorghum fields where they were available (Jones 1963*a*). Of 130 Lesser Prairie-Chickens flushed during winter, 59% were using grain sorghum.

Water Use.—Lesser Prairie-Chickens will drink surface water where it is available, particularly during dry periods (Copelin 1963, Crawford and Bolen 1973, Crawford 1974, Candelaria 1979, Davis et al. 1979, Sell 1979). In New Mexico, Davis et al. (1979) captured birds for study at livestock water facilities during spring. In Texas, Lesser Prairie-Chickens were observed drinking surface water from late April through June and again in August (Sell 1979). Males were observed drinking water near lek sites, and females regularly were observed at stock tanks early in the nesting season. Lesser Prairie-Chickens were observed drinking water at earthen and ground-level metal stock tanks during March and April in another Texas study (Crawford and Bolen 1973, Crawford 1974), and Copelin (1963) noted use of ponds and water tanks at windmills in Oklahoma during September. However, necessary moisture generally is obtained through foods, and surface water is not considered a limiting resource because populations of Lesser Prairie-Chickens persisted in areas without readily available surface water prior to settlement (Giesen 1998). Davis et al. (1979) suggested that increasing the distribution of livestock water sources would result in increased grazing pressure and reduced nesting cover near those facilities. Applegate and Riley (1998) also suggested that well-distributed water sources may decrease the mosaic pattern of different vegetation heights that Lesser Prairie-Chickens prefer. A table near the end of the account lists the specific habitat characteristics for Lesser Prairie-Chickens by study.

Area requirements:

No data are available on the minimum size of grassland habitat fragments that are occupied by Lesser Prairie-Chickens. The Wildlife Habitat Management Institute (1999) suggested that grassland areas as small as 500 ha were adequate to maintain breeding populations. They also suggested that complexes of breeding habitat patches totaling 10,000 ha may provide optimum conditions to maintain populations. Copelin (1963) suggested that Lesser Prairie-Chickens require broad, open expanses of prairie grassland >1024 ha, and Sell (1979) suggested that management areas should encompass $\geq$2000 ha. Based on the proximity of radio locations to leks, Taylor and Guthery (1980*a*) recommended that areas managed for Lesser Prairie-Chickens in Texas should be $\geq$3200 ha, with an optimal size of at least 7200 ha.

Male territory sizes within leks may vary with density and dominance status of males on a given lek. Territories have varied in size from 3.6 m (Copelin 1963) to about 7 m in diameter (Hjorth 1970 in Giesen 1998). Davis et al. (1979) suggested that areas at least 0.1 ha in size were required for leks. In Texas, oil pads used as lek sites were approximately 0.16 ha (Taylor 1979).

Sizes of areas used by male and female Lesser Prairie-Chickens have varied with moisture conditions, time of year, and across studies. Lesser Prairie-Chickens generally traveled greater distances over larger areas during drought conditions than when moisture conditions were nearly average or above average (Copelin 1963, Ahlborn 1980, Merchant 1982). Spring

and summer ranges of females varied in size from 174.4 ha in New Mexico to 596 ha in Colorado (Merchant 1982, Giesen 1998). In New Mexico, mean size of female Lesser Prairie-Chickens ranges varied from 62.7 ha to 231 ha during the prenesting period, from 8.5 ha to 92 ha during the nesting period, and from 66.4 ha to 240 ha during the postnesting period (sample sizes ranged from 7 to 40 individuals across time periods and studies) (Candelaria 1979, Merchant 1982, Riley et al. 1994). In Texas, mean monthly range sizes of females varied from 3 ha to 72 ha from May through October (Sell 1979) and from 35 ha to 495 ha from November through February (Taylor and Guthery 1980*a*). In New Mexico, the average size of areas used by hens with broods ranged from 47 ha to 118.9 ha (sample sizes ranged from 3 to 5 individuals) (Candelaria 1979, Ahlborn 1980, Merchant 1982). Mean size of post-nesting ranges for 19 hens without broods was 73.4 ha (Candelaria 1979).

In Colorado, spring and summer ranges of males encompassed 211 ha (Giesen 1998). In Kansas, median monthly ranges of males varied from 12 ha to 140 ha in April and May, from 77 ha to 144 ha from June through September, and from 229 ha to 409 ha during October through November (numbers of individuals ranged from 2 ha to 25 depending upon year and month) (Jamison 2000). In Texas, mean monthly ranges varied in size from 50 ha to 1945 ha between November and February (Taylor and Guthery 1980*a*).

Brood parasitism:

Interspecific brood parasitism has been reported. Ring-necked Pheasants (*Phasianus colchicus*) parasitized three of 74 Lesser Prairie-Chicken nests in southwestern Kansas (Jamison 2000). No studies have documented brood parasitism by Brown-headed Cowbirds. Lesser Prairie-chickens are not suitable hosts for Brown-headed Cowbirds (*Molothrus ater*) because young grouse are precocial and nidifugous.

Breeding-season phenology and site fidelity:

Male Lesser Prairie-Chickens display from mid-February to mid-June (Schwilling 1955, Copelin 1963, Campbell 1972, Crawford and Bolen 1975, Candelaria 1979, Davis et al. 1979, Cable 1996, Jamison 2000). Displays are most intense at sunrise (Copelin 1963), and more males are present during the morning display period than during evening (Crawford and Bolen 1975). Display activity, hen visitation, and copulations peak from early to mid-April (Davison 1940, Candelaria 1979, Crawford and Bolen 1975, Davis et al. 1979). Males generally exhibit high fidelity to leks between years (Campbell 1972, Giesen 1998), but 21% of 48 males that were marked and recaptured in Kansas had moved 0.42-4.41 km to leks other than the one where they initially were captured (Jamison 2000).

Nests are initiated between mid-April and mid-June, with most clutches hatching in late May or early June (Schwilling 1955, Bent 1963, Ahlborn 1980, Merchant 1982, Cable 1996, Jamison 2000). Some hens initiated second and third nests when earlier clutches were destroyed (Candelaria 1979, Merchant 1982, Giesen 1994, Riley et al. 1994). Lesser Prairie-Chickens are not known to raise >1 brood per year (Giesen 1998). Time constraints on breeding due to the cessation of male displays in early summer, and the time required to raise chicks to independence (about 60 d), probably preclude double-broodedness in Lesser Prairie-Chicken.

Species' response to management:

In shinnery oak grasslands, spring burning may result in an increased number of displaying males and relocation of leks to recently burned areas (Cannon and Knopf 1979). In

Oklahoma, burning was conducted in a shinnery oak/bluestem pasture and a weeping lovegrass pasture during April. The shinnery oak/bluestem pasture had not been grazed for the previous 9 mo and residual vegetation was 60-100 cm tall. Burning removed the residual vegetation. Prior to burning, two active leks in the shinnery oak/bluestem habitat were used by 14 and 12 males. The lek site used by 14 males was included in the burned area. After burning, the number of males at the burned lek increased from 14 to 21, the unburned lek was abandoned, and two new leks were established. One of the new leks was established at a historical lek site in the burned lovegrass pasture and the other was established at an entirely new site in the burned shinnery oak/bluestem pasture. The two new leks were used by 12 and six males, respectively. Following the burns, the number of displaying males on the study area increased from a preburn total of 26 to a postburn total of 39. Litton et al. (1994) and Snyder (1996) caution that burning in areas of loose, sandy soils should be avoided because a lack of adequate precipitation and subsequent lack of revegetation may increase the potential for wind erosion.

A 2-yr study on the effects of fire on vegetation in shinnery oak rangelands of Oklahoma suggested that controlled burning could benefit Lesser Prairie-Chickens by providing foraging areas, but that immediate effects of fire on nesting cover were negative, particularly when burns were conducted in spring (Boyd 1999, Boyd and Bidwell 2001). One year following fire, coverage of grasses used as nesting cover was lower in burned (46-57%) than in control plots (64%) although percent cover was similar for some burning seasons (Boyd and Bidwell 2001). Percent bare ground was higher in burned (49-64%) than in unburned plots (6.4%). Height/density of vegetation at 0.33 m above ground in burned plots during May provided <40% visual obstruction the year following fire versus >95% visual obstruction in controls. Mean canopy coverage of shrubs used for nesting was lower in burned plots (31-61%) than controls (74-75%). Two years following fire, canopy cover of nesting grasses rebounded to 67.2% and height/density increased to >80% in burned plots, while measurements of these variables remained unchanged in control plots (Boyd 1999). Frequency of occurrence of forbs was greater in burned plots (46-52%) than controls (16%) 2 yr following burning, but canopy coverage of forbs was <4%. The fire breaks around burned plots often were revegetated with a continuous coverage of forbs that supported larger insect populations than did undisturbed areas (Boyd 1999, Boyd and Bidwell 2001).

Mowing is uncommon in habitats typically occupied by Lesser Prairie-Chickens; therefore, no data are available on the effects of mowing on the species. Overgrazing probably is responsible for declines in numbers of Lesser Prairie-Chickens as a result of degradation of nesting habitat (Taylor and Guthery 1980*b*, Leslie et al. 1999, Mote et al. 1999, Bailey et al. 2000). However, few data are available on the direct effects of grazing on Lesser Prairie-Chickens. Heavy grazing pressure may result in conversion of the original plant community to a shortgrass-dominated habitat or a shortage of the tall, residual cover that is required for successful nesting (Hoffman 1963, Jackson and DeArment 1963, Litton et al. 1994). For example, in New Mexico, greater percent utilization of sand bluestem, little bluestem, and dropseed by livestock resulted in lower mean plant height (Davis et al. 1979). Differences in vegetation composition and structure among shinnery oak/tallgrass habitat types were attributed to historical differences in grazing pressure. Plowing and overgrazing of grasslands were believed to be the main reasons for declining populations of Lesser Prairie-Chickens on Cimarron National Grassland in southwestern Kansas (Cable 1996). In Oklahoma, Copelin (1963) noted that Lesser Prairie-Chickens used moderately grazed pastures more frequently than heavily grazed pastures. In Colorado, livestock grazing was suspected to have resulted in a

reduction in nest success (Giesen 1994). In New Mexico, Lesser Prairie-Chickens used lightly grazed habitats during drought years, but were able to use more heavily grazed habitats in years of near-average precipitation (Merchant 1982). Haukos and Smith (1989) suggested that heavy grazing, in combination with chemical treatment of shinnery oak, may reduce nesting cover for Lesser Prairie-Chickens. Leslie et al. (1999) suggested that extensive grazing and conversion of rangeland to cropland were responsible for habitat changes associated with declining populations of Lesser Prairie-Chickens in New Mexico, Oklahoma, and Texas.

Conservation Reserve Program grasslands may provide suitable habitat, but no data are available that quantify benefits of CRP to Lesser Prairie-Chickens. In southwestern Kansas, vegetation composition and structure in CRP fields were dissimilar to vegetation composition and structure in non-CRP Lesser Prairie-Chicken habitats south of the Cimarron and Arkansas rivers (Cable 1996). In another Kansas study, male Lesser Prairie-Chickens avoided CRP and tallgrass habitats; however, those habitats occurred in small patches and may also have been avoided because of their small size (Jamison 2000). Lesser Prairie-Chickens recently were found in the northern portion of their historical range (i.e., north of the Arkansas River in Kansas) (Rodgers 2000). Most of the 101 leks located in 1999 and 2000 were in, or within 3.2 km of, CRP fields seeded to native grasses (R. D. Rodgers, Kansas Department of Wildlife and Parks, Hays, Kansas, pers. comm.). Species composition of seeding mixes used in CRP fields in Kansas varied considerably. Lesser Prairie-Chickens appeared to prefer CRP fields dominated by little bluestem interspersed with sideoats grama (*Bouteloua curtipendula*) achieving heights of about 45 cm over CRP stands dominated solely by tallgrass species that were taller and denser. Vegetation in fields dominated by little bluestem achieved heights of about 45 cm. Litton et al. (1994) suggested that CRP fields seeded to warm-season bunch grasses, native legumes, and shrubs would benefit Lesser Prairie-Chickens in Texas; however, no data were available on use of such habitats. In Colorado, about one-third of the former cropland in Baca County has been enrolled in the CRP since 1985. However, no leks had been found in CRP fields, and no increase in numbers of birds had been documented since the program's inception (Giesen 2000). In New Mexico, conversion of cropland to CRP grasslands was suggested to have harmed Lesser Prairie-Chicken populations by decreasing winter food sources, but declines also occurred in areas devoid of cropland and CRP grassland (Bailey and Williams 2000). However, no increases in populations were attributed to the CRP. Establishment of CRP grasslands in the Texas Panhandle apparently have not been detrimental to Lesser Prairie-Chickens, even though the vegetative structure in those fields did not provide optimal habitat for the species (Sullivan et al. 2000). Historically, CRP grasslands in Texas were established as moncultures of weeping lovegrass, King Ranch bluestem (*Andropogon ischaemum*), or klinegrass (*Panicum coloratum*) that provide little brood-rearing or winter cover. Newer CRP guidelines encourage the use of seeding mixtures that include forbs. Incorporating forbs into CRP plantings may benefit Lesser Prairie-Chickens, but due to the recent inception of these guidelines, no research has yet evaluated the potential benefits to Lesser Prairie-Chickens (Sullivan et al. 2000).

Agricultural practices in cropland are suspected to affect Lesser Prairie-Chicken populations. Percent minimum-tillage agriculture was one of three land use or habitat variables considered to be of greatest importance in determining numbers of Lesser Prairie-Chickens in Texas (see Suitable habitat for details; Crawford 1974, Crawford and Bolen 1976*a*). Maximum numbers of Lesser Prairie-Chickens were found in areas in which 5-37% of the landscape was planted to grain sorghum using minimum-tillage techniques (Crawford 1974). In another Texas

study, numbers of Lesser Prairie-Chickens declined over a 10-yr period, then stabilized at about one-third the level of initial counts (Jackson and DeArment 1963). Declines were attributed to the use of combines instead of in-field shocking to harvest grain sorghum, treatment of extensive areas with shrub-specific herbicide, drought, and harsh winter conditions.

The effects of shrub-specific herbicides on Lesser Prairie-Chickens are not clear and probably are affected by interactions with grazing pressure and resulting herbaceous cover. Herbicide treatment kills shrubs and allows an increase in grass cover provided that grass cover is not reduced by heavy grazing (Donaldson 1969, Doerr and Guthery 1983, Olawsky 1987, Olawsky and Smith 1991). Herbicides can be used to create an interspersion of different vegetation types, but grazing must be closely monitored to ensure that grass cover is not reduced. In Oklahoma, Donaldson (1969) observed more Lesser Prairie-Chickens in herbicide-treated areas than in untreated areas. Shinnery oak and sand sagebrush habitats were treated between mid-May and mid-July with two aerial applications of phenoxy herbicides (2,4,5-T and 2,4-D, respectively) at the rate of 0.56 kg/ha. More Lesser Prairie-Chickens were flushed in 1280 ha of shinnery oak habitat (255 adults and 78 juveniles) than in 1024 ha of sand sagebrush habitat (113 adults and 31 juveniles) during the 2-yr study. Numbers of males per lek were higher in herbicide-treated than untreated shinnery oak habitats, and no leks were found in untreated sand sagebrush areas. A mean of 19.9 males/lek and 17 males/lek were observed at 14 leks in treated areas in two consecutive years, respectively. In contrast 3.8 and 2.6 males/lek were seen at six leks in untreated areas during those same years. Donaldson (1966) suggested that the habitat components used by Lesser Prairie-Chickens during summer were present in both treated and untreated habitats. However, the time since herbicide application was not specified in Donaldson's (1969) study, and the negative effects of herbicide treatment may not become evident until three or more years following herbicide applications as the treated shrubs fall down and decay (K. M. Giesen, Colorado Division of Wildlife, Fort Collins, Colorado, pers. comm.). In west Texas and eastern New Mexico, Olawsky (1987) noted that a greater proportion of the total number of flocks of Lesser Prairie-Chickens encountered (actual number of flocks detected was not presented) were composed of broods in tebuthiuron-treated plots (15% of the flocks) than in untreated shinnery oak (10% of the flocks). Lesser Prairie-Chickens densities during summer were estimated at 0.25 and 0.2 birds/ha on treated and untreated areas, respectively. During winter, Lesser Prairie-Chicken densities were estimated at 0.53 birds/ha in treated areas and 0.34 birds/ha in untreated areas. However, no statistically significant differences were detected in Lesser Prairie-Chicken flock sizes or densities between tebuthiuron-treated and untreated shinnery oak pastures (Olawsky 1987, Olawsky and Smith 1991). In Texas, 10 female Lesser Prairie-Chickens were captured in treated areas, and eight of those 10 nested in untreated shinnery oak (Haukos and Smith 1989). More hens nested in untreated areas than expected based on the availability of untreated habitat.

Although abandoned oil-drilling sites frequently are used as lek sites, exploration and development for gas and oil production eliminated use of two leks and disrupted activity on a third lek in New Mexico over a 3-yr period (Candelaria 1979, Davis et al. 1979). In Texas, displaying males abandoned one lek after an elevated road was built across it (Crawford and Bolen 1976*b*).

Translocations have been conducted to reintroduce or supplement prairie grouse (*Tympanuchus* spp.) populations in areas where they had been extirpated or where populations were low (Snyder et al.1999). These efforts have met with limited success. Two states have conducted translocations of Lesser Prairie-Chickens. Colorado released 155 birds during a 6-yr

reintroduction attempt. Birds were released during spring into a landscape of native grassland and cropland, but the reintroduction was not successful. Texas biologists translocated 46 Lesser Prairie-Chickens during two years to supplement an existing population in native habitat, but they also were unsuccessful. Results of logistic regression that used data on prairie grouse translocations throughout the country suggested that soft releases (a release technique that allows birds to walk out of a holding pen) of large numbers of birds (>100) over several years would maximize the probability of successful prairie grouse translocation attempts.

Management Recommendations:

Protect, maintain, and restore large (≥1024 ha) tracts of native shinnery oak/tallgrass or sand sagebrush grassland (Copelin 1963, Jones 1963*a*, Crawford 1974, Crawford and Bolen 1976*a*, Davis et al. 1979, Ahlborn 1980, Wilson 1982, Applegate and Riley 1998, Leslie et al. 1999, Wildlife Habitat Management Institute 1999, Horton 2000, Jamison 2000, Jensen et al. 2000). These areas must be large enough to support viable Lesser Prairie-Chicken populations during drought periods (Merchant 1982). Maintain ≥63% native grassland in landscapes managed for Lesser Prairie-Chickens (Crawford and Bolen 1976*a*). Maintain stability of land use, and conserve shrub-dominated habitats within 4.8 km of lek sites (Leslie et al. 1999, Woodward et al. 2001).

Promote use of government programs such as the Conservation Reserve Program (CRP), Environmental Quality Incentives Program (EQIP), Partners for Fish and Wildlife (PFW), the Texas Landowner Incentive Program (LIP), Candidate Conservation Agreements with Assurances (CCAA), and the Wildlife Habitat Incentives Program (WHIP), and Safe Harbor agreements that provide incentives for development or restoration of habitat on private lands (Wildlife Habitat Management Institute 1999, Horton 2000, Bailey and Williams 2000, Sullivan et al. 2000).

In areas where suitable lek sites are limited, eradicate shrubs in 0.1-0.5 ha patches or construct compacted caliche (a cemented soil layer formed when soluable salts are precipitated from evaporating water) pads to provide suitable display sites (Davis et al. 1979, Sell 1979, Taylor 1979).

Provide dense shrubs and residual bunchgrasses >40 cm tall that provide >75% vertical screening in the first 33 cm above ground and 50% overhead cover for quality nesting habitat (Sell 1979, Haukos and Smith 1989, Giesen 1994). In shinnery oak habitats, sand bluestem ≥50 cm in height provides suitable nesting cover (Davis et al. 1979, Riley et al. 1992). Consider fencing some areas to prevent grazing (Jones 1963*a*), and evaluate the feasibility of predator removal efforts to enhance nesting success of imperiled populations in small areas of habitat (Schroeder and Baydack 2001).

Provide brood habitat with approximately 25% canopy of shrubs, forbs, or grasses that are 24-30 cm in height (Davis et al. 1979, Ahlborn 1980, Riley and Davis 1993). In shinnery oak habitats, provide vegetation dominated by three-awn and shinnery oak with about 60% bare ground.

Provide vegetation composed of about 43-60% grasses, 24-43% shrubs (primarily shinnery oak), and 13-26% forbs.

Increase grass cover in shinnery oak habitats (Davis et al. 1979, Cannon and Knopf 1981, Cannon et al. 1982, Merchant 1982). Maintain or increase shrub cover in sand sagebrush habitats (particularly in areas where taller species of grass have been reduced by overgrazing) (Cannon and Knopf 1981, Cannon et al. 1982, Giesen 1994).

Burning should be conducted with great caution in Lesser Prairie-Chicken habitats. Some nesting habitats may require up to 3 yr to provide concealment cover following a fire (Boyd and Bidwell 2001). Conduct spring burns on recently abandoned shinnery oak/bluestem pasture adjacent to areas still inhabited by Lesser Prairie-Chickens (Cannon and Knopf 1979). Applegate and Riley (1998) suggested burning 20-30% of pasture area in late winter or early spring (no data were available to support these values). To prevent wind erosion, avoid burning in areas of loose, sandy soils or during periods of low soil moisture (Litton et al. 1994, Snyder 1996). Conserve shinnery oak motts and protect oak bud, mast, and catkin production in relatively mesic shinnery oak habitats by discing fire breaks around motts, and avoid annual burning of large areas to conserve residual nesting cover (Boyd and Bidwell 2001). Use burning in relatively mesic shinnery oak habitats to increase forb and invertebrate densities for adult and brood-foraging habitat.

Prevent heavy grazing because it results in reduced nesting cover or conversion of the plant community to shortgrass habitat (Hoffman 1963, Jackson and DeArment 1963, Jones 1963*a*, Crawford 1974, Merchant 1982, Wilson 1982, Haukos and Smith 1989, Litton et al. 1994, Giesen 2000). Encourage light or moderate grazing (Copelin 1963, Hoffman 1963, Donaldson 1969). Light or moderate grazing will ensure that some residual nesting cover will be available following dry years (Merchant 1982, Giesen 2000). No data are available on the effects of deferred grazing systems (systems that postpone grazing until grassland plants have matured) or rest-rotation grazing systems (systems that involve multiple pastures through which livestock are rotated) on Lesser Prairie-Chicken populations, but appropriate use of these systems probably would create suitable interspersion of different vegetation heights (Applegate and Riley 1998). Increase sand bluestem and little bluestem composition in shinnery oak/tallgrass habitats by reducing grazing pressure (Davis et al. 1979, Ahlborn 1980, Wilson 1982, Litton et al. 1994).

Discourage development and widespread distribution of livestock-watering facilities. Although Lesser Prairie-Chickens often use surface water at stock-watering facilities (Crawford and Bolen 1973, Crawford 1974), it is not considered a necessary habitat component for Lesser Prairie-Chickens (Schwilling 1955, Giesen 1998). Davis et al. (1979) warned that increasing the distribution of livestock water sources may result in increased grazing pressure near those facilities, and Applegate and Riley (1998) suggested that well-distributed water sources would decrease the interspersion of different vegetation heights preferred by Lesser Prairie-Chickens.

CRP fields currently are not known to be a preferred habitat, but little information is available on use of habitats in areas where CRP fields are available (Litton et al. 1994, Cable 1996, Leslie et al. 1999, Giesen 2000, Jamison 2000, Rodgers 2000). CRP fields planted to native tallgrass and mixed-grass species may benefit Lesser Prairie-Chickens (Litton et al. 1994, Applegate and

Riley 1998). Seeding mixes that result in CRP stands dominated by little bluestem appear to provide suitable habitat for Lesser Prairie-Chickens in Kansas (R. D. Rodgers, Kansas Department of Wildlife and Parks, Hays, Kansas, pers. comm.). Sullivan et al. (2000) suggested implementing CRP in a manner that mimics the structure of native rangeland.

Encourage or employ minimum-tillage practices in cultivated fields that border native grasslands to provide maximum availability of waste grains for winter forage (Crawford 1974, Crawford and Bolen 1976*a*, Ahlborn 1980, Applegate and Riley 1998). Although planting food plots may provide winter food for Lesser Prairie-Chickens (Copelin 1963, Donaldson 1969, Crawford 1974, Applegate and Riley 1998), most populations probably have access to cultivated fields and are limited more by the amount of available nesting cover than by winter food supplies. Prevent cultivation of grassland surrounding leks and disturbance of lek sites, because those activities may result in lek abandonment (Crawford 1974, Crawford and Bolen 1976*b*, Davis et al. 1979).

Although minimizing the use of herbicides has been suggested (Applegate and Riley 1998), application of tebuthiuron or phenoxy herbicide reduces cover of shinnery oak in dense, continuous stands, and may allow an increase in coverage of grasses used for nesting (so long as heavy grazing does not remove this cover) (Copelin 1963, Donaldson 1969, Ahlborn 1980, Haukos and Smith 1989). Provide a mosaic of treated and untreated areas to provide an interspersion of habitats dominated by grasses for nesting cover, and areas dominated by shrubs for brood-rearing, foraging, and adult autumn and winter cover (Donaldson 1969, Ahlborn 1980, Doerr and Guthery 1983, Olawsky 1987, Olawsky and Smith 1991, Riley et al. 1993, Litton et al. 1994). To create a mosaic of habitats, apply tebuthiuron in strips or blocks at rates of 0.2-0.6 kg/ha (Doerr and Guthery 1983, Olawsky 1987).

Preserve small thickets of tall shinnery oak (oak motts) that produce mast crops by excluding these areas from herbicide applications (Litton et al. 1994). Treat shrubs in contour strips on a 6-8 yr rotation to provide suitable interspersion of nesting and brood-rearing habitats while reducing wind erosion of sandy soils. Avoid annual chemical brush treatment of large areas because this may reduce Lesser Prairie-Chicken populations (Jackson and DeArment 1963, Litton et al. 1994).

Discourage petroleum exploration (Davis et al. 1979, Locke 1992). Petroleum exploration may create areas that are suitable for lek sites, but lek sites generally are not limiting and the disturbance associated with production of petroleum may result in destruction of nesting habitat lek abandonment.

Table. Lesser Prairie-Chicken habitat characteristics.

Author(s)	**Location(s)**	**Habitat(s) Studied***	**Species-specific Habitat Characteristics**
Ahlborn 1980	New Mexico	Cropland, idle, shinnery oak (*Quercus havardii*) pasture, shortgrass pasture, tame pasture	Hens with broods preferred shinnery oak pasture over cropland, fallow cropland, shortgrass, and tame pastures; broods used sites characterized by 25% canopy cover of vegetation, canopy height of about 30 cm, 24-39% basal composition of shrubs, 47-60% grasses, and 13-26% basal composition of forbs; adults used grain sorghum fields during autumn and winter
Bent 1963	Kansas	Cropland, sand sagebrush (*Artemisia filifolia*) pasture	Nested in sand sagebrush pasture and foraged in cropland during winter
Cannon and Knopf 1979	Oklahoma	Burned shinnery oak pasture, burned tame pasture, shinnery oak pasture	Continued to display at a lek in burned pasture; males relocated from an unburned lek to a historical site in a burned weeping lovegrass (*Eragrostis curvula*) pasture and initiated display at a new site in burned shinnery oak/bluestem (*Andropogon*) pasture
Cannon and Knopf 1981, Cannon et al. 1982	Oklahoma	Sand sagebrush pasture, shinnery oak pasture	Densities of birds in shinnery oak pasture were positively correlated with grass cover and grass frequency along transects, and with percent of grassland cover types identified from satellite imagery; in sand sagebrush pasture, numbers of birds were positively correlated with percent cover of shrubs and grass frequency along transects, but were not associated with percentages of cover types identified from satellite imagery
Copelin 1963	Oklahoma	Cropland, mixed-grass pasture, sand sagebrush pasture,	Nested in residual grasses and shinnery oak; raised broods in shinnery oak thickets; foraged in cropland (food plots) during winter

		shinnery oak pasture	
Crawford and Bolen 1973;1976 *a*,*b*; Crawford 1974	Texas	Cropland, shinnery oak pasture, stock-watering facilities	Drank water at stock ponds; densities peaked in areas with >63% native pasture; abandoned leks where cultivation destroyed surrounding grassland habitat and where roads were constructed through leks
Davis et al. 1979	New Mexico	Honey mesquite (*Prosopis glandulosa*)/shortgrass pasture, shinnery oak pasture	Preferred pastures dominated by shinnery oak and sand bluestem (*Andropogon hallii*); avoided honey mesquite/shortgrass areas; nested more successfully in residual sand bluestem than in other vegetation types; selected nest sites with north or northeast aspects, more litter and less bare ground than elsewhere in the habitat, and taller vegetation than the average vegetation height within 3 m; broods preferred shinnery oak/sand bluestem pasture and avoided mesquite/shortgrass habitat; broods foraged at sites with a minimum vegetation height of 24 cm and lower grass abundance and greater shrub abundance than generally was available
Davison 1940	Oklahoma	Cropland, native pasture	Displayed on sparsely vegetated, flat-topped ridges overlooking expansive areas of native pasture and on slightly raised knolls that provided unobstructed views of broad valleys
Donaldson 1969	Oklahoma	Sand sagebrush pasture, shinnery oak pasture	More individuals were encountered in phenoxy herbicide-treated shinnery oak and phenoxy herbicide-treated sand sagebrush pastures than in untreated habitats of the same types
Giesen 1994	Colorado	Sand sagebrush pasture	Nested among taller grasses (36 vs. 27 cm), forbs (21 vs. 16 cm), and shrubs (48 vs. 38 cm), and denser vegetation (32 vs. 20 cm) compared to areas within 5 m; nested mostly under sand sagebrush and yucca (*Yucca glauca*); at 29 nest sites, tallest vegetation averaged 51 cm, sand sagebrush

			plant density was 3471 plants/ha, sand sagebrush cover was 7.2%, grass cover was 29.4%, forb cover was 1.4%, and bare ground was 69.5%
Haukos and Smith 1989	Texas	Shinnery oak/sand sagebrush pasture	Selected untreated shinnery oak pastures for nesting over tebuthiuron-treated pastures of the same type; eight of 10 females that were captured in tebuthiuron-treated areas later nested in untreated shinnery oak; 13 nests were in residual grasses with 42% overhead cover, average plant height of 45 cm, and average visual obstruction of 61-80% in the first 33 cm above ground; vegetation was dominated by purple three-awn (*Aristida purpurea*) at nine nest sites, little bluestem (*Schizachyrium scoparium*) at three nests, and sand bluestem at one nest
Hoffman 1963	Colorado	Cropland, mixed-grass pasture, sand sagebrush pasture	Males displayed at lek sites on slightly elevated terrain or on level flats; foraged in cropland during winter
Jackson and DeArment 1963	Texas	Cropland, sand sagebrush pasture, shinnery oak pasture	Used pastures vegetated by sand sagebrush, chickasaw plum (*Prunus angustifolia*), fragrant sumac (*Rhus aromatica* var. *trilobata*), shinnery oak, sand bluestem, little bluestem, sand lovegrass (*Eragrostis trichodes*), sand dropseed (*Sporobolus cryptandrus*), thin paspalum (*Paspalum setaceum*), switchgrass (*Panicum virgatum*), Indiangrass (*Sorghastrum nutans*), and various forbs; foraged in cropland during winter
Jamison 2000	Kansas	Cropland, sand sagebrush pasture	Males preferred habitats vegetated by sand sagebrush, blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), paspalum (*Paspalum* sp.), bluestem, western ragweed (*Ambrosia psilostachya*), sunflowers (*Helianthus* spp.), Russian-thistle (*Salsola iberica*), prickly pear (*Opuntia* sp.), and yucca and used cultivated fields,

			tallgrass and CRP, and other grassland habitats less than expected; median sizes of areas used by males were 12-140 ha in April and May, 77-144 ha from June through September, and 229-409 ha in October and November
Jones 1963*a,b*	Oklahoma	Sand sagebrush/mixed-grass pasture	Displayed in areas dominated by buffalograss; raised broods in areas with 22.8% sand sagebrush and 15.7% western ragweed; foraged in mixed-grass, rested among shrubs, and nested in residual grasses; broods also used shrubs; on a year-round basis, foraged mostly in grass, especially mixed-grass 25-80 cm in height; tallgrass, shortgrass, and shrub vegetation were used equally; sixweeks fescue (*Festuca octoflora*) and fragrant sumac were important food items; during spring, used shrubs <80 cm tall; used grasses and forbs 25-80 cm in height during summer, and grasses 25-80 cm tall during autumn; in winter, used tallgrass (specific heights of tallgrass species were not given)
Lee 1950	New Mexico	Cropland, shinnery oak/sand sagebrush pasture	Used pastures vegetated by shinnery oak, bluestem grasses, sand sagebrush, sunflower, honey mesquite, plum, yucca, dropseed, black grama (*Bouteloua eriopoda*), blue grama, and sideoats grama; foraged in grain sorghum and corn fields from fall through spring
Leslie et al. 1999	New Mexico, Oklahoma, Texas	Cropland, shinnery oak pasture, shinnery oak/little bluestem pasture	Annual rates of habitat change were greater around leks with declining populations than at leks with stable populations (1.14% vs. 0.21% annually)
Locke 1992	New Mexico	Shinnery oak pasture, shortgrass pasture	Displayed on oil pads and in native pasture
Merchant 1982	New Mexico	Cropland, oldfield, shinnery oak pasture,	Nested in shinnery oak habitats with little bluestem, sand bluestem, and purple three-awn; avoided weeping

		shortgrass pasture, tame pasture	lovegrass, cultivated, oldfield, and shortgrass habitats
Olawsky 1987, Olawsky and Smith 1991	New Mexico, Texas	Shinnery oak/sand sagebrush pasture	Occurred in similar densities in tebuthiuron-treated and untreated shinnery oak pastures
Riley et al. 1992, 1993, 1994; Riley and Davis 1993	New Mexico	Shinnery oak pasture, shortgrass pasture	Nested in shinnery oak habitats dominated by sand bluestem; vegetation was taller at 10 successful than 26 unsuccessful nests (67 vs. 35 cm); percent composition of shrubs was similar at successful and unsuccessful nests (basal composition 31-66%); 22 autumn foraging sites were 63% grasses and 37% shrubs, 50 winter sites were 59% grasses and 41% shrubs (forbs were rare); broods foraged in 25-cm tall shinnery oak and three-awn (*Aristida* sp.), bare ground at 12 sites averaged 63%, basal composition of vegetation was 43% grass, 42% shrubs, and 15% forbs; daily movements of 40 prenesting females were 390 m/day within 231-ha ranges; 12 nesting hens moved 250 m/day, and ranges averaged 92 ha; three hens with broods moved an average of 280 m/day within 119-ha ranges; movements of 19 females without broods was 220 m/day within 73-ha ranges
Sell 1979	New Mexico	Shinnery oak/sand sagebrush pasture	Hens generally used habitats with large unstable sand dunes, abundant shinnery oak, low grass cover, and low structural density; nested in sand sagebrush, residual grasses, and shinnery oak; five of eight nests were under sand sagebrush, two nests were in purple three-awn, and one nest was in shinnery oak; visual obstruction and canopy cover of sand sagebrush were significantly higher at nest sites than in surrounding habitat (specific values for visual obstruction, canopy cover, and canopy height were not given)

Taylor 1979, Taylor and Guthery 1980*a*	Texas	Cropland, shinnery oak pasture, shinnery oak/sand sagebrush pasture	Displayed on areas disturbed by human activities including oil pads, cultivated areas, and areas treated with shrub-specific herbicide; preferred shinnery oak/sand sagebrush, cultivated sunflower, and shinnery oak/little bluestem habitats during autumn and winter; autumn-winter ranges were 50-1945 ha for males and 35-495 ha for females
Wilson 1982	New Mexico	Cropland, oldfield, shinnery oak pasture, shortgrass pasture, tame pasture	Prenesting and nesting hens preferred shinnery oak habitat characterized by rolling dunes and dominated primarily by shinnery oak, habitat dominated by little bluestem and sand bluestem, or habitat dominated by three-awn and shinnery oak; canopy coverage of grasses within 3 m of nest sites was 3.1-13.2%, shrub canopy was 21.4-28.3%, and canopy coverage of all vegetation was 31.4-38.4%; nests in grasses were more successful (4 of 5 successful) than those under shrubs (3 of 10 successful)
Woodward et al. 2001	New Mexico, Oklahoma, Texas	Cropland, shinnery oak pasture, shinnery oak/little bluestem pasture	Populations stabilized or increased in landscapes (7238-ha areas) in which low-density shrubland composed 79.% of the total area and declined in landscapes with 43.2% low-density shrubland; total shrubland composed 81.9% around leks that did not decline and 63.4% of the landscape around declining leks; declined in areas where landscapes were unstable (e.g., experienced frequent changes from one landcover to another); population trends were positively correlated with loss of total shrubland

* In an effort to standardize terminology among studies, various descriptors were used to denote the management or type of habitat. "Idle" used as a modifier (e.g., idle tallgrass) denotes undisturbed or unmanaged (e.g., not burned, mowed, or grazed) areas. "Idle" by itself denotes unmanaged areas in which the plant species were not mentioned. Examples of "idle" habitats include weedy or fallow areas (e.g., oldfields), fencerows, grassed waterways, terraces, ditches, and road rights-of-way. "Tame" denotes introduced plant species (e.g., smooth brome [*Bromus inermis*]) that are not native to North American prairies. "Hayland" refers to any habitat that was mowed, regardless of whether the resulting cut vegetation was removed. "Burned" includes habitats that were burned intentionally or accidentally or those burned by natural forces (e.g., lightning). In situations where there are two or more descriptors (e.g., idle tame hayland), the first descriptor modifies the following descriptors. For example, idle tame hayland is habitat that is usually mowed annually but happened to be undisturbed during the year of the study.

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