

FADING FOOTPRINTS IN THE SAND

The Lesser Prairie-Chicken and the Sand Shinnery Grasslands

Texas is a state already well known as a place for making final, futile last stands. So it was at San Antonio for the defenders of the Alamo. So it is now on the coastal plain for the Attwater's prairie-chicken. So it may likely to be in north Texas for the lesser prairie-chicken.

Far beyond the east Texas coastal plain, to the west of the Edwards Plateau of central Texas, and among the upper, often dry, tributaries of the Brazos and Red rivers, lies a little-visited and even less valued part of north Texas. This remote panhandle region is largely marked by sandy plains, alkaline and often temporary lakes, arid and sun-baked flats, and vegetation that is more easily described by its absence than by its profusion or diversity. Here and there are scattered, often slowly vanishing towns and villages with names like "Cactus" and "Shallowater." This portion of Texas and adjacent New Mexico encompasses the so-called Staked Plains, a desolate and arid region so flat and featureless that early Spanish explorers were reputed to have placed tall stakes at intervals along their route so as not to become lost for lack of obvious landmarks. But it was ideal habitat for lesser prairie-chickens.

This region was once largely covered by drought-tolerant perennial grasses, such as several grama grasses (*Bouteloua* spp.) and bluestems, especially little bluestem (*Schizachyrium scoparium*). Sand dropseed (*Sporobolus cryptandrus*), sand lovegrass (*Eragrostis trichoides*), three-awn grass (*Aristida* spp.), and needle-and-thread (*Stipa comata*) were also common, the first two on sandier sites. Shrubs, including soapweed yucca (*Yucca glauca*), also occurred widely, and wild plum (*Prunus* spp.) and aromatic sumac (*Rhus aromatica*) were present on

somewhat moister or less sandy sites. Throughout the entire region, sandsage (*Artemisia filifolia*) was the most prevalent shrub on highly sandy soils.

Sandsage is a woody, long-lived, and aromatic shrub that grows to a height of about three feet and is usually much smaller than the more familiar big sagebrush, which is also locally common on firmer ground. Sandsage grows best on well-drained, sandy soil and is perhaps more tolerant of a stabilized dune substrate than are any of the dozens of other species of sage occurring throughout the arid American West, a region that is traditionally regarded as almost synonymous with sagebrush. Sandsage extends north to westernmost South Dakota, south to northern Mexico (see Map 5), and west to the Great Basin region of Utah and Arizona. It has long, narrow, aromatic leaves and a bitter taste, and it is rich in oils that tend to repel leaf-eating insects. It represents a potential livestock food described by range management experts as "poor to worthless" for cattle and "poor to fair" for sheep and horses. Nevertheless, deer and especially antelope can thrive on it. Although sage leaves and flower heads are consumed by lesser prairie-chickens, the plant is not known to be a significant food source. The leaves may, however, provide a substitute for free water in a generally arid habitat. On hot days the birds often rest in its shade; they may also roost among sage and sometimes nest under clumps of sage. Some leaves may persist into the winter, potentially providing emergency foods. The small but numerous seeds of sandsage are known to be a minor food source for the sharp-tailed grouse and may be so for the lesser prairie-chicken.

From western Oklahoma southward, clumps of scrubby oaks, especially shinnery oak (*Quercus havardii*), become increasingly frequent on very sandy soils, where they often share dominance with sandsage and perennial native grasses such as sand dropseed and little bluestem. Shinnery oak is part of that great genus of magnificent American trees with which our country was, quite literally, constructed. Yet shinnery oak not only barely qualifies as a tree, it sometimes doesn't even seem to enter the contest. It is usually nothing more than an inconspicuous shrub, growing up to no more than three feet tall, sometimes barely reaching beyond one's shins. ("Shinnery," however, comes from the Louisiana French *chenière*, meaning an oak woodland.) In spite of a life span of only 11 to 15 years for single aboveground shoots, the underground stems persist through repeated cloning and stem rejuvenation, thus individual plants may reach hundreds if not thousands of years of age. The underground stems may spread to cover an acre or more and form dense mottes that provide escape cover and reliable food sources for many animal species. The tree's usual height is shrublike in sandy, well-drained areas, but in somewhat moister soils, and with the greatest good fortune and freedom from range fires, it may at times attain the stature of a small tree.

Shinnery oak produces a considerable number of small (dime-size) acorns,

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which are a primary food source during fall and winter for prairie-chickens and are also eaten by them during spring and summer. Its nutritious leaves are easily accessible to smaller mammals and birds, as are its catkins and insect (cynipid wasp) galls, and all these are seasonally consumed by prairie-chickens. The catkins and buds are unusually high in protein content (19-22 percent) and may provide important spring foods. The birds also use shinnery oak as a source of summer shade, overhead nest cover, and perhaps as escape cover or for nocturnal roosting when higher trees are unavailable. Where sand sage communities without oaks occur in the vicinity of those with oaks, prairie-chicken densities are considerably greater in the latter, indicating the ecological importance of this species to the birds.

The oak's 5- to 7-million-acre range (see Map 5), extending from the western half of Oklahoma and the panhandle of Texas plus adjacent parts of eastern New Mexico, almost perfectly circumscribes the primary range of the lesser prairie-chicken. In a curious way, shinnery oak seems to be the lesser prairie-chicken's single closest ecological partner, in the same way that the bear oak was once the ecological counterpart to the heath hen. In recent years, elimination of shinnery oak by defoliating herbicides (especially tebuthiuron) has been a serious problem. This is especially true on federally owned Bureau of Land Management (BLM) lands. That agency abrogated a 1960s understanding with the New Mexico Department of Game and Fish and treated some 100,000 acres of grazing lands with herbicides. Most follow-up work indicated negative effects on lesser prairie-chicken populations and harmful effects on mule deer and lagomorphs, but higher subsequent populations of rodents. In later years, as the BLM began to realize the wildlife benefits of maintaining shinnery oak communities, the agency has restricted cattle grazing and other harmful influences on native wildlife.

The largest publicly owned shinnery oak habitat occurs on BLM lands in New Mexico, where the agency controls 500,000 to 1 million acres. There are also about 500,000 acres of state trust land in New Mexico. In Texas and Oklahoma nearly all the shinnery oak is on privately owned lands. Most of these native scrubby grasslands were long since converted to rangeland for cattle-raising and then to irrigated farmlands, exploiting the underground but easily accessible Ogallala aquifer. The shrubby oaks and sandsage, traditionally favorite lesser prairie-chicken habitats, have largely been eliminated by burning or by defoliation treatments to make room for plants that cattle consider more palatable and humans find more profitable. The aquifer itself has progressively shrunk, now providing less than half the volume of water it offered only 50 years ago, forcing farmers to give up on irrigation-based crops and return to dry-land wheat and sorghum crops.

There is no fossil evidence that provides us with a clue as to the origin of the

lesser prairie-chicken. As recently as the mid-20th century it had a range so close to the northern race of greater prairie-chicken of the more mesic grasslands that one wonders if the two might have been in extensive geographic contact during historical times. The lesser prairie-chicken is also only poorly separated geographically from the Attwater's race of prairie-chicken. Some apparent wintering lessers once strayed east almost to the coastal plain of Texas, and early records also suggest there was perhaps a general movement southward in winter, followed by a northward shift in spring. In the early 1920s a few lessers were even collected as far north as southwestern Nebraska, not far from where the interior greater prairie-chickens are still occasionally to be found (Map 4).

Perhaps the ancestral lessers ranged farther south during late Pleistocene times, possibly becoming isolated in the arid Mexican highlands. They then probably remained there long enough to develop the paler plumage, smaller size, and some male display and call differences that now help distinguish them from greater prairie-chickens. Some of these behavioral differences, such as speed of movements and tone frequencies of vocalizations, are the obvious result of body downsizing, but others are less predictable and more distinctive than might have been anticipated as a result of chance evolutionary divergence. Most taxonomists, after looking at these several distinctive features, have concluded that the lesser prairie-chicken should be recognized as a species distinct from all three of the larger prairie-chickens, the now-extinct heath hen and the Attwater's and northern races of the greater prairie-chicken. A few others have disagreed, claiming that all four should simply be called "pinnated grouse," thereby distinguishing them, at least at the species level, from the sharp-tailed grouse and all other grassland grouse of the world.

Although lesser and interior greater prairie-chickens are not now in significant geographic contact and thus have few or no opportunities to interbreed, captive-produced hybrids are fully fertile and appear to be as sexually active as their parental types. These same traits of hybrid fertility and sexual activity are also true of interior greater prairie-chickens and sharp-tailed grouse hybrids (see Figure 16, p. 96). These two grouse sometimes naturally interbreed in the few areas where they are in geographic contact, but the hybridization frequency is evidently now too low to jeopardize their respective gene pools.

There are no good estimates of the original numbers of lesser prairie-chickens in the Southwest and only a few educated guesses. Its maximum historical range, from west-central Texas to west-central Kansas, may have approximated 100,000–150,000 square miles, of which about two-thirds were in Texas. The rest of the range was about equally divided between Oklahoma and Kansas, with New Mexico and Colorado getting the leftovers and Nebraska a few remaining crumbs. One early (1945) estimate by the Texas Game, Fish, and Oys-



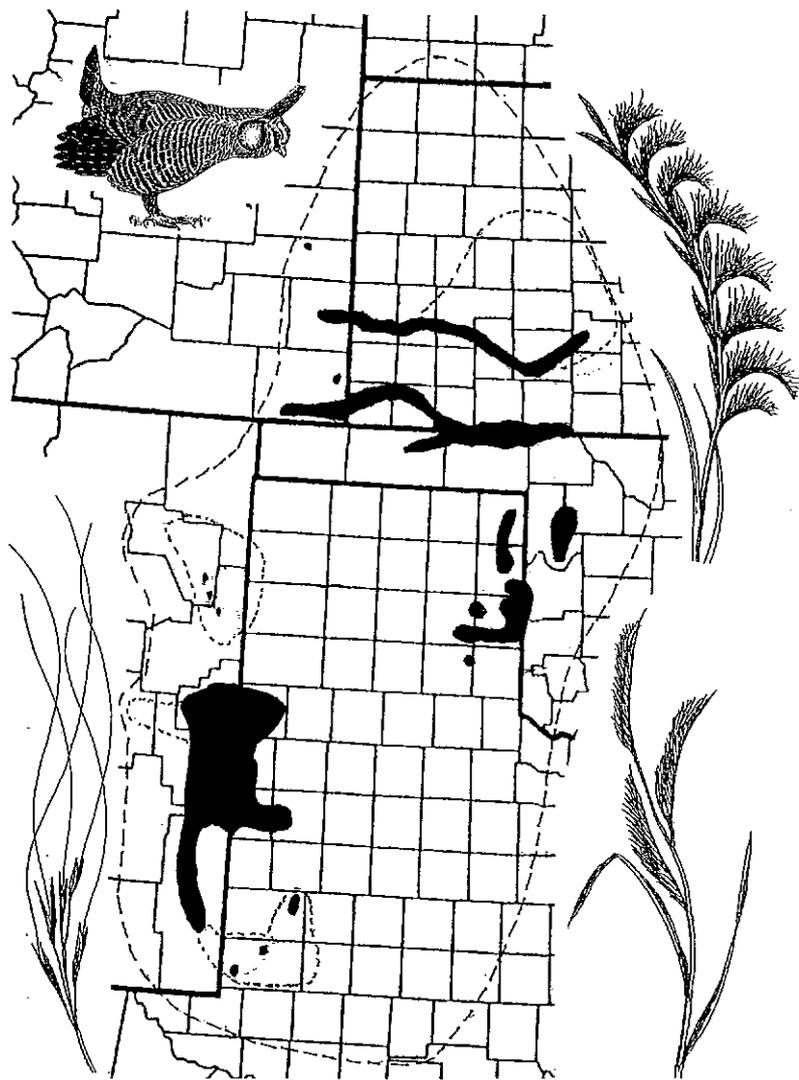
Map 4. Historical range of the lesser prairie-chicken. Shorter range sketches illustrate the range in the grasslands (below).

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Map 4. Historical (dashed line) and current (inked) distributions of the lesser prairie-chicken. Short dashes enclose a few extirpated or nearly extirpated populations. Inset sketches illustrate needle-and-thread (left), little bluestem (above right), and hairy grama (below right), important native cover grasses of the south-central plains.

ter Commission suggested that as many as 2 million lesser-prairie-chickens may have been present in Texas before 1900, a density representing about 20 birds per square mile. If that is the case, then the overall population of the species might have once approached 3 million. There are no estimates for the original populations of Kansas, Oklahoma, New Mexico, or Colorado. By the mid-1900s the species' total population probably comprised no more than 40,000 birds, or about 1 percent of the suggested 3 million.

As with the Attwater's and interior greater prairie-chickens, no thought was given in Texas to possible conservation of these birds before 1900. Indeed, hunting contests were held in the panhandle as well as along the Gulf Coast, each with up to 50 hunters participating and with the birds often being left to rot where they had been killed. Market hunting was unrestricted and, most important perhaps, the land was rapidly being converted to grazing and agricultural purposes. Probably by 1900 the lesser prairie-chicken populations of Texas had already entered a steep decline, and the tapping of the Ogallala aquifer in north Texas opened a large and previously undeveloped region to cotton growing and small-grain agriculture. Moreover, periodic droughts, especially those of the 1930s, were sometimes devastating both to human and prairie-chicken populations in north Texas. By 1937 the lesser's Texas population was judged to be only about 12,000 birds, or less than 1 percent of its presumed historical status. The Texas state legislature then established its first closed season on prairie-chickens, which in the case of the lesser was to remain in effect until 1967, when a two-day season was initiated. Since that time, two-day seasons have generally been allowed in both the northeastern and southwestern parts of the panhandle. In 1940 the northeastern part of the Texas panhandle had an estimated 1,715 square miles of suitable prairie-chicken habitat and the southwestern region 3,560 square miles, or a total of 5,275 square miles. In 1967 the state's population was estimated at only 10,000 birds, or about 2 birds per square mile. By 1989 these range estimates had been reduced more than 60 percent, to 1,182 and 1,078 square miles, respectively. At a modest 2 birds per square mile, the total Texas population might then have numbered about 4,000 individuals.

Robert Sullivan and coauthors have estimated that the Texas range of lesser prairie-chickens was reduced 78 percent between 1963 and 1980, the losses being particularly great in the southwestern and east-central panhandle, whereas those in the northeastern panhandle remained fairly stable. Mean lek numbers declined precipitously in the southwestern panhandle during this period; during the 1990s they were about 55 percent below the 1969-1989 average. During the same period in the northeastern panhandle they were only about 7 percent below the 1942-1989 average. In the late 1990s small range expansions occurred in Bailey, Cochran, Gray, Hemphill, Lipscomb, Terry, and Wheeler counties as

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chickens, no thought was given to their recovery in 1900. Indeed, hunting was common along the Gulf Coast, each county often being left to rot and neglected, most impacted by grazing and agriculture. Lesser prairie-chicken populations of the Ogallala region in the undeveloped region to the west of periodic droughts, especially those due to human and agricultural activity. Lesser prairie-chicken's Texas population is estimated to be 1 percent of its pre-1900 population. It was first established in 1911. Since that time, two-thirds of the Texas prairie-chicken habitat has been lost, or about 5,275 square miles. This represents a reduction of more than 60 percent from a modest 2 birds per square mile to 1 in 1990, or 4,000

chickens in the Texas range of lesser prairie-chickens in 1980, the losses were about 50 percent in the panhandle, whereas in the south. Mean lek numbers during this period; during 1989 average. During 1989 only about 7 percent of the expansions occurred in the Wheeler counties as

a result of special conservation efforts. An estimate in 2001 by the Texas Game and Parks Department of the panhandle's population of lesser prairie-chickens was 3,000 birds, with most of them in Hemphill, Wheeler, and Lipscomb counties, in the northeastern corner of the panhandle.

In Hemphill County there are some 100,000 acres of sandsage grassland left and in adjoining Wheeler County about 6,720 acres of shinnery oak grassland. However, according to Kenneth Seyffert the density of birds in Hemphill County went from 2,747 acres (1,112 ha) per lek during the period 1967-1987 to 3,317 acres (1,343 ha) per lek between 1986 and 1999, suggesting a population decline of about 20 percent in a few decades. The decline in Wheeler County was even greater during that period, from 425 acres (172 ha) per lek to 5,689 acres (2,303 ha), suggesting a density reduction of about 75 percent. Besides these birds in the northeastern panhandle, there are also some surviving in Bailey, Cochran, and Yoakum counties, along the New Mexico border, and perhaps in nearby Lamb and Andrews counties. Some have also been reported in Hockley, Oldham, and Deaf Smith counties, and seemingly suitable sandsage habitat still exists in Hartley County. Some birds might also still occur in Donley and Collingsworth counties in the northeast, but they seem to be gone from their historical ranges in Armstrong, Carson, Moore, Ochiltree, Parmer, Potter, and Roberts counties. Unpublished data from the Texas Breeding Bird Atlas Web site (<http://tbba.cbi.tamucc.edu/>) indicate that there were four possible, five probable, and two confirmed Texas breedings between the spring of 1987 and early 1992. Five of the records were from the southwestern panhandle; seven were from the northeastern panhandle.

More than 3 million acres of Texas land have been converted to noncropland cover as part of the Conservation Reserve Program, but much of this acreage is planted to near-monocultures of nonnative grass species apparently unattractive to prairie-chickens. Such vegetation may actually favor potentially significant predator species such as coyotes more than prairie-chickens by providing an increase in suitable cover for the predators. Many of the relict prairies now exist as remnant patches of less than 250 acres, an area far too small to support prairie-chickens. In the last 10 years of the 20th century the population of seven of the counties where lesser prairie-chickens still occur dropped an average of about 1 percent per year, reflecting the long-term human population drain in the region. Additionally, the level of the Ogallala aquifer, the lifeblood for agriculture in the panhandle, dropped more than one foot per year between 1991 and 1996, and during the entire decade of the 1990s the rate of decline averaged slightly under a foot per year. The annual use in Texas represents about 1 percent of the likely total Texas water reserves. The Texas high plains region uses nearly 90 percent of all the water pumped out of the Ogallala aquifer in the state, which is used mostly for center pivot irrigation. 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.

The exact status of New Mexico's lesser prairie-chicken population has long been something of a mystery. The state's Department of Game and Fish has undertaken few rangewide studies of its distribution and only in the late 1990s began to conduct extensive display-ground counts for estimating population trends. At the start of the twentieth century the lesser probably still ranged rather widely over at least eight eastern counties, from Union and Harding in the north to Lea and Eddy in the south. Locally it extended west to the Pecos River Valley, and its total range may have included about 15,000 square miles. In 1968 James Sands reported that the largest remaining New Mexico populations were in Roosevelt and northern Lea counties, with a few also in eastern Chaves and parts of De Baca, Quay, and Curry counties. During the early 1970s the state's population was thought by Sands to be about 8,000 to 10,000 birds, down substantially from the 40,000 to 50,000 of the 1950s. Survey data for the period 1971 to 1997 analyzed by the New Mexico Heritage Institute indicated that a clear population decline occurred after 1988. In the post-World War II years the lesser prairie-chicken remained legal game in New Mexico, at least until 1996. The average annual harvest during the 1960s was about 1,000 birds, but by 1979 was reduced to only about 130. Maximum hunter harvests of about 4,000 birds occurred in 1987 and 1988, but these numbers subsequently declined rapidly and the season was finally closed in 1996.

James Bailey and Sartor Williams have estimated that the species' New Mexico population was once about 125,000 birds, occupying some 38,000 square kilometers (14,672 sq mi) a mean density of about 3.3 birds per square kilometer (8.5 birds per sq mi). By 1961 the population was estimated at 40,000 to 50,000 birds, and in 1968 at 8,000 to 10,000 birds. In 1979 the estimate was still 10,000. By the late 1990s the lesser prairie-chicken's historical range had been reduced by more than half, with most of the remaining birds occurring in about 20 percent of the original range, mainly on privately owned lands in southern Roosevelt, extreme northern Lea, and eastern Chaves counties. The area shown on Map 5 as fully occupied in northern Roosevelt and Curry counties now actually consists of only sparse and isolated populations, according to Bailey and Williams. In west-central Lea County, where there were 20 leks in 1987, only a single lek was found in 2000. The birds now appear to be entirely gone from their historical range within Union, Harding, and Quay counties in northeastern New Mexico, and nearly all those still surviving as late as 1997-1998 in east-central New Mexico occurred within about 25 miles of the Texas border, near Portales. On the Texas side of this border some birds were still present in Bailey, Cochran, and Yoakum counties during the late 1990s.

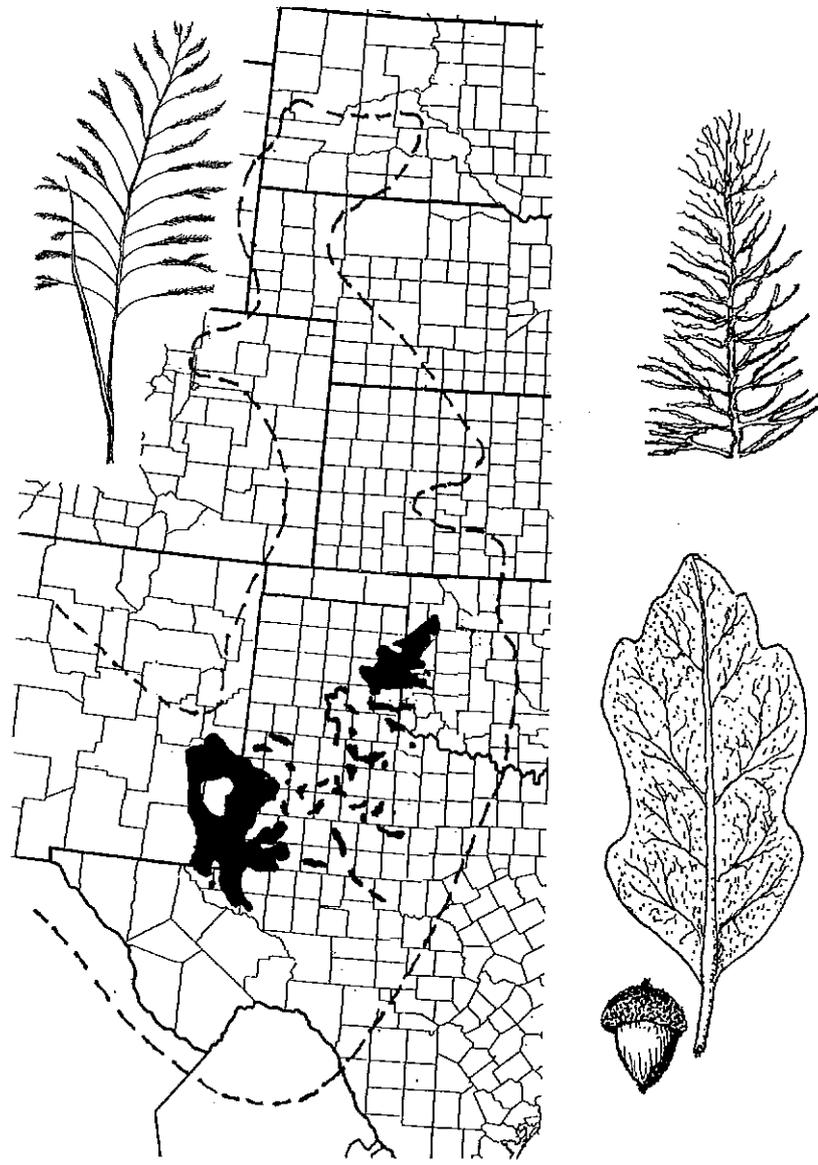


Map 5. Great E and shinnery c food plants for common native community after P

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Map 5. Great Plains distributions of sand sagebrush (dashed line; *upper right sketch*) and shinnery oak community (inked; *lower right sketch*), important native cover and food plants for the lesser prairie-chicken. Also shown (*upper left*) is sand dropseed, a common native grass of sandy soils in the region. Distribution of shinnery oak community after Peterson and Boyd (1998).

Two years of drought, starting in 1989, resulted in an abrupt population decline throughout the New Mexican range, a trend that may have been exacerbated by excessive grazing, development of gas and oil reserves, the control of so-designated undesirable native shrubs, especially sand sagebrush and shinnery oak, and the inherent genetic and ecological problems associated with small, isolated populations. Shrub control on BLM land has contributed to this problem, but uncontrolled herbicide applications on private lands have probably had greater negative effects on native habitats. Roadside lek surveys in the late 1990s revealed up to 53 leks in east-central New Mexico, but counting method variations have not permitted reliable population trends to be established. Only 2 leks were found in southeastern New Mexico in 1999, and none were found that year in northeastern New Mexico. Assuming a mean of about 8 males per lek, the spring 2000 population in New Mexico might well have been under 500 males, or a total of about 1,000 breeders.

In 1997 the lesser prairie-chicken was described as imperiled in the state by the state's Natural Heritage Program. In October of that year the New Mexico Department of Game and Fish announced that it would begin a study to determine whether the species should be officially listed as threatened or endangered under the provisions of the state's Wildlife Conservation Act. However, two years later, the New Mexico Game Commission refused to accept the recommendation of its departmental director to list the species as state-threatened, evidently largely as a result of pressures from New Mexico's Cattle Growers Association. Instead, the commission announced an "interim management approach," a temporary management plan intended to last for at least six years, thus effectively delaying the listing process.

The story in Oklahoma is similarly discouraging. At one time most of the state lying west of the 100th meridian was probably occupied by lesser prairie-chickens, as it essentially comprised arid prairies. As elsewhere, the birds were most abundant on sites with sandy soils and some brushy plants, usually sand sagebrush and shinnery oak. This oak usually grows only a few feet high, but occasionally dense growths of much taller plants form mottes that may be several hundred feet in diameter. The trees rarely reach 20 feet in height, these tall trees actually being hybrids with post oak (*Q. stellata*). On mixed-grass prairies with firmer soils, sand sage is less evident, and the brushy component is made up largely of skunkbrush sumac and wild plum. Such habitats approach those of the interior greater prairie-chicken, and in Oklahoma, as in Texas and Kansas, the breeding ranges of these two species approached one another closely. The lesser certainly ranged east at least to Woods and Woodward counties, and probably to Major, as recently as the 1940s, whereas interior greater prairie-chickens were then present as far west as Kay and Noble counties, only about 50 miles to the east.

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No early estimates of lesser prairie-chicken populations exist for Oklahoma. The birds were legally hunted with few restrictions up until 1915, but thereafter the season was opened only periodically until 1951. Based on a few sample counts by state Wildlife Conservation Department biologists in 1940 from study areas totaling only 20 square miles, a statewide population of 14,914 birds was extrapolated. Such estimations obviously have little value as such but are often the only numbers available. Protection continued throughout the 1940s, but short, one- and three-day hunting seasons were allowed in 1950 and 1951. The species' state range seemingly retracted hardly at all during the 1940s and 1950s, although there were severe droughts between 1952 and 1955. The latter half of the 1950s were more favorable for breeding, and in 1956 average density estimates of 6.5 males per square mile were determined for mixed-grass prairie; 4.0 males, in shinnery oak; and 1.75 males per square mile, in sandsage grasslands.

By 1960 the species' known range in Oklahoma was calculated at about 2,400 square miles, and another 1,400 square miles of potential but unoccupied grasslands range existed. The estimated spring population of males was 15,000, the same total as 1940. However, estimated spring densities were higher than in 1956, as many as 11.25 males estimated per square mile in shinnery oak habitats and as low as 2.3 in sandsage grasslands. In one study area the density of males increased progressively from 1956 to 1962, but more droughts during the late 1960s and early 1970s caused a population crash. In 1979 the spring male population for the entire state was estimated at about 7,500 birds, or about half as many as had been estimated in 1960, and the occupied range had also declined by 55 percent. More than half the remaining range consisted of sand sagebrush; nearly all the rest was shinnery oak habitat.

From 1980 onward display-ground counts have been performed in several counties. The 11-year (1980-1990) average of males per lek then hovered between 6 and 8 (11-year mean 7.4 males), without any clearly apparent trend. However, between 1988 and 1999 the density index declined about 80 percent, probably as a result of the severe droughts of the 1990s. Hunting of both species of prairie-chickens was terminated in Oklahoma after 1997. In the spring of 2000 lek counts indicated a reduction of 31 percent in the number of males attending leks relative to 1999, down to 4.6 males per lek. The average lek density (12.5 square miles per lek) remained the same.

An analysis of Oklahoma's lesser prairie-chickens by Russell Horton suggested that the species' range has diminished by about 64 percent according to historic records and now includes only 8 of the 22 counties where they once occurred. As of the year 2000, fewer than 3,000 birds were present during the breeding season, or 20 percent of the estimated 1940 population. A landscape level analysis of prairie-chicken habitats in Oklahoma, New Mexico, and Texas

revealed that of 13 studied lesser prairie-chicken populations, 5 were judged as declining; 4 of these were in Oklahoma. In all regions, reductions in the total amount of available shrublands, rather than changes in specific cover types, correlated most closely with population losses. In Oklahoma these landscape cover changes were estimated at a rate of 11 percent per decade, as compared with 3 percent in Texas and 1 percent in New Mexico.

Kansas is a prairie state that was once fully occupied by prairie-chickens, the lesser to the west and south, and the northern race of the greater to the east and north. The sandy lands immediately to the south of the Arkansas and Cimarron rivers are the core of the lesser's range in Kansas, but there are winter records well to the north and also to the east of these regions. In the Arkansas River Valley the birds are most numerous from the Colorado line to the general vicinity of the Great Bend region. The apparent eastern limits there (in Edwards County) approach the western limits of the greater prairie-chicken, and the two species evidently have some local contact. Although the prairie-chickens of Quivera National Wildlife Refuge (in Stafford County) are typically greater, two refuge biologists thought they observed lessers there in the spring of 2001. Matthew Bain, a graduate student at Fort Hays State University, informed me that as of spring 2001 he had found mixed leks in 4 counties north of the Arkansas River, namely Ness, Gove, Trego, and Ellis (personal communication). In 2001 he surveyed 57 leks there, of which 13 were mixed, 16 consisted of lessers only, and 28 were of greater only. Hybrid males have been observed on 2 leks. His study of species interactions and hybridization is still under way.

Nobody knows how many lessers once occurred in Kansas, but one remarkable estimate of 15,000–20,000 in a single Seward County grain field (unstated size) in 1904 gives some idea of the immense numbers that must once have existed. The drought years of the 1930s nearly doomed the lesser prairie-chickens in Kansas and elsewhere in the southern plains; by one account they were reduced to surviving in Kansas on only two large ranches, in Seward and Meade counties. By the 1950s they had recovered and were known to be present in at least 14 counties, but by then most of their prime habitats had been converted to weedy, abandoned ranchland or to farmland. The advent of irrigation, especially center-pivot irrigation, has effectively spelled the end for the sandsage grassland habitats of western Kansas. When these finally disappear the lesser prairie-chicken will as well.

The lesser prairie-chicken has never been a significant game bird in Kansas, at least relative to the interior greater. As compared with the well-documented greater, relatively little long-term tracking of their populations has been attempted. Hunter kills for the lessers have been estimated annually in Kansas since at least 1975 and have ranged from a high of 6,200 in 1982 to a low of 100

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Max Thomps birds might exist unknown. By th creases during ea of the Arkansas (CRP) plantings, to a least 165 leks spots in an other umented the po reported that in 20 historic range, bi parent downwar likely the result o

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Fieldwork done

in 1996. Annual average statewide kills were 2,600 for the late 1970s, 2,500 for the 1980s, and 560 for the 1990s through 1998, the last year for which figures are available. Only Texas currently allows the hunting of lesser prairie-chickens, and the Texas kill is relatively small by comparison. Kansas seasons in the 1990s lasted for two months, with a daily limit of a single bird.

Max Thompson and Charles Ely estimated that perhaps 10,000 to 15,000 birds might exist in Kansas in the early 1990s, but the basis for this estimate is unknown. By the spring of 2000, annual lek surveys indicated population increases during each of the previous three years among 10 survey routes south of the Arkansas River. Apparently because of Conservation Reserve Program (CRP) plantings, the population north of the Arkansas River has also increased to a least 165 leks as of the spring of 2001. These trends provide two of the bright spots in an otherwise depressing picture. William Jensen and others have documented the population trends of lesser prairie-chickens in Kansas. They reported that in 2000 the species occupied 31 of the 39 counties representing its historic range, but statewide its population was declining. Although this apparent downward trend may be the result of a statistical artifact, it is more likely the result of habitat loss and deterioration.

Of all the states within the historical range of the lesser prairie-chicken, Colorado has probably always had the fewest birds. Historical records suggest it may once have occurred only in six counties (Baca, Bent, Cheyenne, Kiowa, Lincoln, and Prowers) during presettlement times. It has never been common, and Colorado was the first state to ban its hunting, in the early 1900s. As was the case elsewhere, the dust-bowl days of the 1930s following a period of already marginal farming and ranching on arid lands almost ended the Colorado populations. During that period the species' overall range probably decreased about 92 percent, and its population declined about 97 percent. Display-ground counts by Kenneth Giesen suggested that in the early 1990s Colorado's spring population was at about 1,000 to 2,000 birds. It had increased gradually since the early 1970s, when it was listed as a threatened species in Colorado. Studies by Giesen in the late 1980s and early 1990s indicated that about 35 to 45 display grounds were then known in the state, with an average of 9.6 males present per ground. Colorado's largest remaining population of lesser prairie-chickens is near Campo, Baca County, in extreme southeastern Colorado. Here the Comanche National Grasslands and the Cimarron River provide an extension of the comparable sandsage habitat occurring in the Cimarron National Grassland of adjacent Kansas. There is a smaller population in Prowers County along the Arkansas River, and an even smaller one in Kiowa County along Big Sandy Creek. The species disappeared from Bent County during the early 1940s and has also been extirpated from Lincoln and Cheyenne counties.

Fieldwork done in conjunction with the *Colorado Breeding Bird Atlas* indicated

that most breeding-season sightings occurred in shortgrass prairies, with fewer in altered mixed grasses and still fewer in low sagebrush. However, the absence of sand sagebrush on shortgrass prairies dominated only by grama grasses (*Bouteloua* spp.) and buffalo grass (*Buchloe dactyloides*) is known to have a negative effect on lesser prairie-chickens, and Giesen suggested that management plans enhancing the abundance of sandsage may help increase the state's population. Lek counts in the spring of 2000 resulted in a total count of 27 leks and 316 birds, including some females. This result was a substantial improvement over counts the previous spring, perhaps because of CRP plantings. But drought conditions in southeastern Colorado continued to result in poor reproduction there, and future population declines were expected. Kenneth Giesen estimated in 2000 that the total Colorado population then may have numbered fewer than 1,500 breeding birds. Lek counts in 2001 revealed 298 birds on 30 leks, down slightly from the previous year.

Considering the available information from all five states where lesser prairie-chickens still occur, the only thing that can be said with certainty is that the birds have been declining almost everywhere.

SEXUAL BEHAVIOR AND REPRODUCTIVE BIOLOGY

The immediate impression I had on first seeing and hearing lesser prairie-chickens engaged in territorial and courtship displays was that I was watching a fast-forward version of the greater's displays, with a touch of the Marx Brothers thrown in. As compared with greater's, the birds' movements seemed too rapid, and their vocalizations too high-pitched and frenzied; these impressions collectively produced a kind of comic-opera effect.

Like greater prairie-chickens, lesser prairie-chicken males gather in small groups on shortgrass or shrub-laced display grounds, or leks. Likewise, lek locations tend to be permanent, and once males become established on particular territories, they tend to return to the same lek year after year. Males unable to establish territories may form "satellite" leks nearby. If these new locations manage to attract females, the number of leks in an area gradually increases. Although there is seemingly a great deal more running back and forth to defend territorial boundaries in lessers than in greater's, the individual males are similarly spaced out on relatively small territories, the territories having been established and maintained through daily threats and occasional fighting. Fighting by lessers, however, is generally less violent and less prolonged than is the case with greater's. The position, and perhaps the size, of any given territory nevertheless represents a direct reflection of that male's individual vigor, and thus his relative fitness for reproduction. Like the greater's, male lessers concentrate most of their displays during the hour or two surrounding sunrise,

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A female visits days immediately nize which males individual for mating until the similarities between here, for specific, important comparison.

One of the firstogy of the lesser late 1950s and early 1960s. At the time area ranged from for any area, but during a comparable year period, Cope from 8 to 21 annually, with yearly with as many as 4 year to year. Of the 1930s when the area during the two studies these leks were also males reclaimed territories milled about, probably participating in the springs were ever observed 17 wing-n seasons. Fifteen of other 2 remained other male moved lek he had been using.

Most of the leks grass vegetation; where the ridges within individual territories

over a period of two or three spring months. A moderate amount of display may occur during autumn, and some early evening displays may also occur. All matings, however, are evidently attained during early-morning hours over a period of a few weeks in spring, generally centered in mid-April.

A female visits these leks, probably the nearest available one, for only a few days immediately before the start of egg-laying. Somehow females can recognize which males are most dominant, and each usually selects that particular individual for mating. After being fertilized, females do not return again for mating until the next year unless reneesting becomes necessary. These overall similarities between prairie-chickens and other lek-forming grouse tend to end here, for specific, or species-level, differences within broader similarity are also important components of display if the birds are to avoid potential hybridization.

One of the first people to study the display behavior and reproductive biology of the lesser prairie-chicken was Farrell Copelin. He did this work in the late 1950s and early 1960s on a 16-square-mile study tract in Ellis County, Oklahoma. At the time of his study the spring lesser prairie-chicken density in that area ranged from 15 to 20 males per square mile. This is a rather high density for any area, but represents only half the density that had been observed during a comparable study begun before the droughts of the 1930s. Over a five-year period, Copelin found a total of 28 leks on this 16-square-mile area, with from 8 to 21 active in any given year. From 121 to 291 males were present annually, with yearly averages of 14 to 16 males present per lek. The largest leks, with as many as 43 males, seemed to be the ones most consistently used from year to year. Of the 28 leks, 17 were in exactly the same locations as during the 1930s when the area had been last studied. And at least one was used every year during the two studies, these collectively totaling 11 years. Surprisingly, most of these leks were also active during the fall months when older and experienced males reclaimed their old territories, and the youngest ones sometimes simply milled about, probably learning the lek locations and the accepted rules for participating in the spring. A few females visited the leks during fall, but no matings were ever observed during that season. During his studies, Copelin recognized 17 wing-marked and leg-banded birds over a period of two or more seasons. Fifteen of these males occupied the same territory each season. The other 2 remained on the same lek, but altered their territorial positions. Another male moved from one lek to a nearby one nearly a mile away when the lek he had been using was abandoned.

Most of the leks were established on ridges or other elevated sites in short-grass vegetation; only 1 of 44 was on plowed ground. In sandsage habitats where the ridges were brushy, leks were chosen in shortgrass meadows. Most individual territories were established by mid-April, although some activity on

the leks began in late February. These territories observed by Copelin averaged only 12 to 15 feet in diameter, a small size for prairie grouse. In similar leks studied by Ingemar Hjorth in Kansas, he found that the birds were more likely to choose leks on smooth ground than to select for elevated sites, and all the territories there were at least 7 meters (23 ft) in diameter. On a lek I visited in western Kansas, 18 males were gathered within a 30-yard distance, mostly situated along the upper slopes of a gentle dune that was well vegetated with grasses and sandsage up to three feet tall. The birds performed primarily on the grassy substrate between the shrubs but sometimes flew up to perch in a sage where they would look about, cackle, and sometimes even yodel.

Territorial disputes observed by Copelin reached their peak in March and early April. Females visited the leks from the last half of March through the first week in May, with a peak number present during the third week of April. Copulations were seen between April 24 and May 6, with the maximum number (four) observed on April 26. A variety of other studies performed throughout the lesser prairie-chicken's range agree with this timetable, with the second and third weeks of April usually representing the peak period for female attendance and highest copulation frequency. On the lek I observed in the second week of April, at least four females were present during most of the period of intense male activity, and two copulations occurred, plus several other attempted copulations. Although Copelin did not comment on differential mating success in copulation among individual males, Roger Sharpe observed that on one lek a single dominant male obtained 13 of 27 observed copulations (48 percent), while on another lek a single male obtained 11 of 13 (85 percent). This "master cock" mating trait is typical of all lek-forming species and seems to be strongly correlated with relative individual male dominance. Sharpe noticed that the dominant male on the leks he studied consistently drove intruding males out of his territory, readily attacked any other male that he observed copulating, but was himself never interrupted during mating.

Sharpe observed several features of lesser prairie-chicken display that set it apart from both of the two races of greater. The auditory portion of the male lesser's primary advertisement display lasts only about 0.6 second, rather than 1.96 seconds, and its average pitch is about 500 cycles per second (Hz) higher than in greater, which is around 800 Hz. Interestingly, in a hybrid male studied by John Crawford, the vocalization had a mean duration intermediate (1.22 seconds) between the two parentals. However, it usually had six distinct syllables rather than the three typical of both parentals. A pair of these captive-bred hybrids proved fertile, producing four second-generation chicks out of 26 eggs laid. Wild hybrids have recently been reported in a few areas of limited geographic contact in central Kansas.

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display (usually called

“gobbling” or “yodeling”) is generally preceded by rapid foot-stamping and fol-
lowed by an exaggerated tail-spreading as the first of three rapid gobblelike
notes is uttered. At this time the head is jerked downward and the lateral red-
dish throat sacs are inflated (Figures 5 and 6). During the short second note, the
head is jerked back upward. The third phrase lasts longest, as is also true in
greater, when the throat sacs deflate and a more normal posture is gradually
assumed. The tail is not fanned again during this final stage. The associated call
is similar to a small dog’s excited barking, but generally has richer, more liquid
tones.

Some “low-intensity” gobbling, which lasts only about half as long as the
usual type, may also occur, although at least four (rather than three) syllables
are quickly uttered, according to Roger Sharpe. Another minor call is the
“squeak,” the functional counterpart of whooping in greater prairie-chickens;
like whooping it is uttered when a female is present on the lek. However, it is
much softer than the whoop; acoustically it is more like the “chilk” call of
sharp-tailed grouse. Additionally, a rapid wing-shuffling sometimes occurs be-
tween bouts of booming, perhaps representing a distinct if minor display.

A common distinctive postural and vocal variation on gobbling is one that
Ingemar Hjorth called “bubbling,” but “gurgling” might be a better descriptive

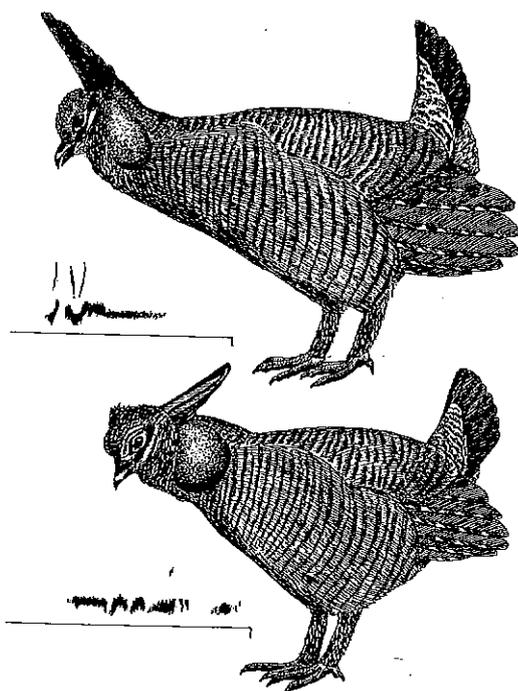


Figure 5. Booming postures of lesser prairie-chicken, with associated vocalizations, including yodeling (above) and bubbling (below; both after photos by the author). Sonograms after Hjorth (1970); duration 1.0 second.

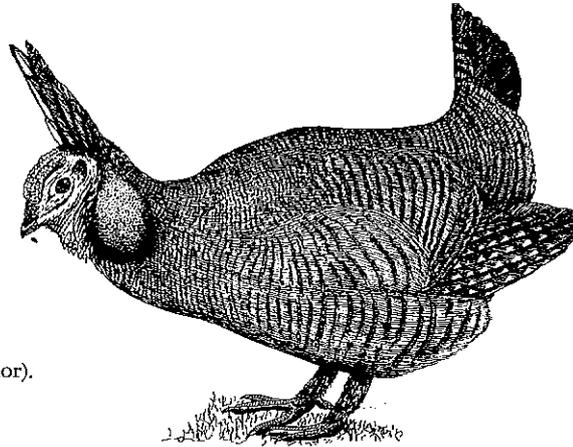


Figure 6. Lesser prairie-chicken, male booming (after photo by the author).

term. In this display five or six rapid melodic notes are produced, sounding something like the sound of air bubbles rapidly coming out of water. The amount of pinnae erection varies; the tail-swishing is less pronounced but more pulsating; and the primaries are rapidly quivered. The brilliant yellow eye-combs are fully enlarged, and the reddish air sacs are even more fully expanded than during yodeling. The display may precede or end a yodeling sequence but seems especially frequent when two males meet near the edges of their respective territories.

Male lessers do not orient their bubbling/tooting postures toward specific females or toward other males; instead they pivot quickly about between sequences or run a few feet before pausing to repeat their performance. This nearly nonstop activity is almost dizzying to a person used to watching the more sedate, almost magisterial performances typical of greater prairie-chickens. Added to this visual confusion is the virtually constant sound of males yodeling or bubbling simultaneously. These pleasant sounds are frequently interspersed with a cacophony of rapid, high-pitched cackling, similar to hysterical human laughter.

Another feature that distinguishes lessers' displays from that of the greater, and indeed from all other socially displaying grouse, is the tendency of male lessers to engage in directly competitive simultaneous displays. These consist of rapidly repeated, sequentially overlapping bubbling contests between nearby males. As many as 10 such bubbling sequences may be performed in rapid succession by both birds, their joint actions producing a prolonged and erratically melodic sequence of sounds somewhat resembling the irregular noises made by the bubbling "mudpots" at Yellowstone Park.

Ingemar Hjorth called this interactive bubbling behavior "duetting," noting

that the participants are much closer together's pecking with a time-lag: several seconds, and sequences usually is a nearly continuous. Roger Sharpe says the birds' spend and daily basis, a degree of actual.

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Figure 7. Lesser prairie-chicken, male cackling after Giese

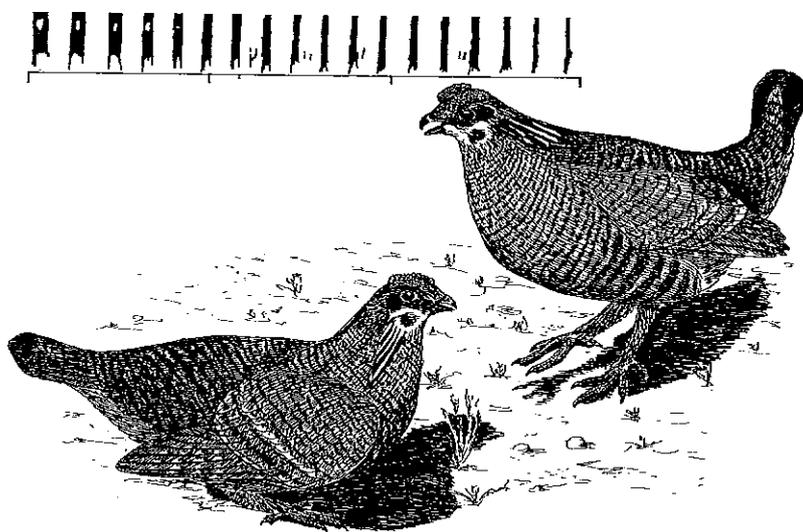


that the participating males may stand up to 20 feet apart. Often, however, they are much closer, sometimes standing only a foot apart, or nearly within each other's pecking range. The first bird's display initiation is joined by the second with a time-leg averaging only 0.3 second. They then display in concert for several seconds, and stop at about the same time. Such interactive bubbling sequences usually last three to four seconds, but may be much longer. The result is a nearly continuous train of sound that can be heard more than a mile away. Roger Sharpe suggested that such acoustic competition may be the result of the birds' spending more time on the lek than do greater, on both a seasonal and daily basis, and that this form of ritualized aggression may help reduce the degree of actual fighting among males.

In addition to competitive booming, males on adjoining territories spend a good deal of time threatening one another along territorial boundaries (Figures 7 and 8). Calls uttered at such times include rapid cackles and less intense whining notes. Quick, vertical movements of the head are also common during these encounters. The wings may be held close to the body or partly outstretched, ready for a quick response to an attack. Sometimes the opposing males perform wing-flapping, preening, or pecking movements toward the ground.

In a study of lek locations and dispersion patterns, Brian Locke found that local populations tend to expand by forming new leks rather than by increas-

Figure 7. Lesser prairie-chicken, males in crouching territorial confrontation (after Oklahoma Department of Wildlife Conservation photo). Sonogram of prolonged cackling after Giesen (1998); duration 3.0 seconds.



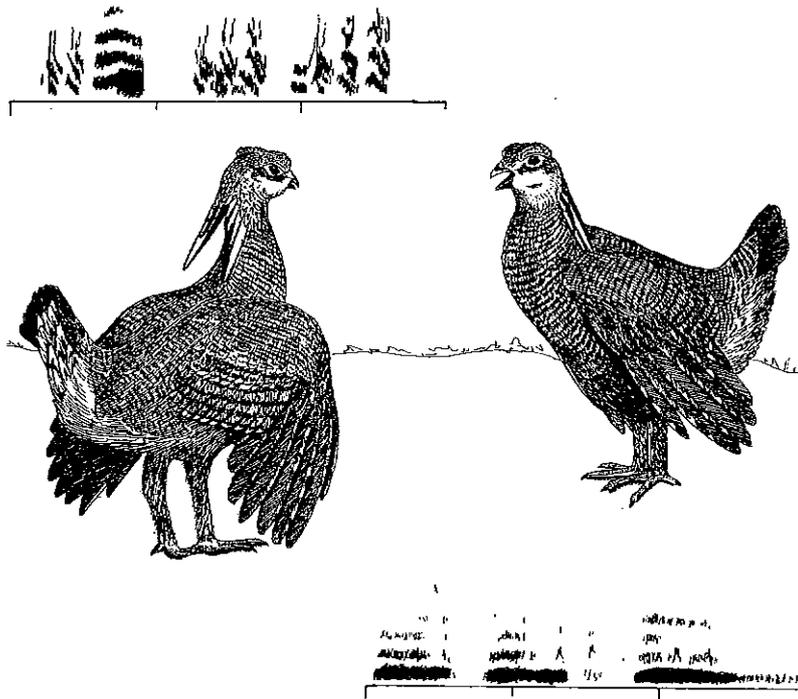


Figure 8. Lesser prairie-chicken, males in standing territorial confrontation (after photo by Roger Sharpe). Sonograms of cackling (*above*) and whining (*below*) after Hjorth (1970); duration 1.0 second.

ing the average number of males per lek. He noted that the leks were more closely spaced than would be predicted by some lek-spacing hypotheses, but also noted that some apparently suitable lek sites such as oil pads were not used. He believed the birds can hear and respond to adjacent leks from as far away as 1,000 yards. Locke also observed that most leks were situated closer together than the average size of a female's spring home range, which is typically less than a square mile. Because of this lek spacing, females generally have more than one lek they might easily visit. By one hypothesis a female simply chooses the one with the largest number of available males. This tendency results in the so-called male buffet model of lek formation and would tend to produce large lek sizes, as the largest leks would attract the most females. However, the larger the lek size, the lower the chance of any participating male's ever getting a mating opportunity. Alternatively, females might be attracted to specific and highly attractive "hotshot" males, around which other males could perhaps benefit by their simple association. In either case, but especially the latter, this male clustering tendency that produces lekking behavior could occur

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Lek sizes have been reported for males present have been reported for males ever reported among 434 Colorado (42) was almost as high as in the active rangeland and the density of males per lek number of males per smaller territories: female-attracting territorial size, influence

As with other species. The only individual but a few seconds display season, but then a single mating eggs. Therefore, it is unlikely that mating.

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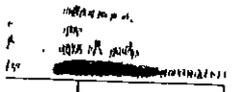
because nondominant males might occasionally steal a few matings while the master cock is otherwise occupied. Or perhaps by simply living long enough and competing strongly enough, a persistent male might gradually work his way up the dominance ranks, ultimately taking over the position of master cock should he live long enough. Few birds live more than five years in the wild, so it is likely that, as with greater prairie chickens, most master cocks are three to four years of age.

Lek sizes have been studied in a variety of areas, and the mean numbers of males present has usually ranged between 10 and 21. The largest number of males ever reported at a single lek was evidently the 43 seen by Copelin. But among 434 Colorado leks, the maximum observed number of attending males (42) was almost as great. More males are typically present at leks located on native rangeland than on human-altered sites, and in areas of high lek density the density of males present on individual leks is also high, regardless of the total number of males present. Dominant males situated at the center of leks have smaller territories than do peripheral males, indicating that a male's relative female-attracting behavior or his relative territorial position, but not his territorial size, influence individual mating choice by females.

As with other lekking birds, no pair-bonding is associated with courtship. The only individualized behavior is that related to mating itself, which takes but a few seconds. Females may visit more than one lek in the course of a spring display season, but there is no evidence for any of the prairie grouse that more than a single mating is needed to fertilize an entire clutch of a dozen or more eggs. Therefore, unless a nest failure requires the initiation of a new clutch, it is unlikely that a female will revisit the lek following her first successful mating.

After such a mating, the female leaves the lek and apparently heads directly to a nest site. The site is often more than a mile from the lek where she was fertilized and may even be closer to other leks. The first egg is probably laid within a few days after copulation, although some have suggested that a longer period between mating and egg-laying may elapse. Females choose sites that have good concealment features, both vertically and horizontally, with sandsage or shinny oak often serving this purpose. These shrubs, plus associated grasses and forbs, tend to be of greater density immediately around nest sites than is true of surrounding rangelands. Nests are often placed on slightly sloping land with a north or northeastern exposure, providing some protection from sunlight and hot southwesterly winds.

As with the greater prairie-chickens, incubation lasts 24 to 26 days, is done entirely by the female, and starts with the completion of the clutch. Most clutches have about 10 eggs, rarely as few as 8 or as many as 14. Late-season clutches, and those associated with reneating, average fewer in number. Among



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a total of 10 different studies whose results were summarized by Kenneth Giesen, an average of only 28 percent of the nests hatched successfully. Predation by various mammals (coyotes and skunks), snakes, and birds (corvids and hawks) is a major cause of egg loss, as is true for most ground-nesting birds. Drought, a late nesting onset, livestock grazing, and reduced nesting cover all negatively influence nesting success, whereas increased height, abundance, and density of native grasses near the nest have favorable influences. The presence of overhead vegetational cover such as shinnery oak may also improve nest success by reducing the nest's visibility to overhead predators or by providing cooling effects in hot weather.

Brood size varies greatly between years and depending on the age of the chicks when counts are made, with broods produced during drought years smaller in number than those in years of better precipitation. By the time fall arrives roughly half the flock should be composed of immature birds, a proportion needed to compensate for the roughly 50 percent annual mortality rate of adults.

CONSERVATION DEVELOPMENTS

In October 1995 the U.S. Fish and Wildlife Service received a formal petition requesting that it list the lesser prairie-chicken as a nationally threatened species. More than a year later (July 1997), the agency finally admitted that enough evidence existed in the petition to warrant a formal status investigation. Since most lesser prairie-chickens occur on privately owned grazing lands or on BLM lands leased for grazing purposes, ranchers were not enamored with the idea of listing the species as legally threatened. In June 1998 the Fish and Wildlife Service neatly skirted the controversy by concluding that such a listing was biologically warranted but was precluded because of higher conservation priorities for other even more seriously threatened species.

After this initial petition for threatened status was submitted, a five-state consortium of conservation agencies formed the Lesser Prairie-Chicken Interstate Working Group to coordinate management activities and evaluate conservation needs. Their 51-page report, an assessment and conservation strategy for the species, was released in February 1999. Partly as a result of their recommendations, about 80,000 acres of private lands in Oklahoma and New Mexico were designated for habitat improvement under "candidate species conservation agreements." Participating ranchers joined the High Plains Partnership for Species at Risk, a consortium of state and federal wildlife agencies, private conservation groups, and private landowners. At best it is an improbable alliance of strange bedfellows, and the results are likely to be unpredictable.

As of the year 2000, the population of prairie-chickens is apparently somewhere between 1,000 and 3,000 each in Texas and Oklahoma, 1,000 in New Mexico, and 1,000 in Kansas, therefore a comfortable number of prairie-chickens provide ample warning that the species is in apparent danger of extinction.

As of the year 2007, the world population of lesser prairie-chickens is apparently somewhere between 10,000 and 20,000 breeding-season birds, with up to 3,000 each in Texas and Oklahoma, about 1,500 in Colorado, fewer than 1,000 in New Mexico, and an undetermined number in Kansas, perhaps 5,000 to 10,000. Kansas, therefore, must represent our last, best chance of saving the species from extinction. A population of 10,000 to 20,000 birds may seem to be a comfortable number, but the history of the Attwater's prairie-chicken should provide ample warning that this may not be the case, as the lesser prairie-chicken is in apparent decline almost everywhere.

CAN THE FABRIC BE MENDED AND THE PIECES PRESERVED?

Our natural habitats of North America once resembled a beautiful tapestry in which the emerald greens of the coastal, northern, and montane forests gradually gave way to the softer summer-green and winter-golden tones of the interior grasslands, and then to the grays and browns of the deserts. Black tears and stains have now disrupted the nation's fabric, where agriculture, forestry, cities, and the other stigmata of modern life have left their marks. Of all these disruptions, none have been more devastating than those affecting the prairies, especially the midgrass and tallgrass prairies; a great gaping hole in the tapestry now exists where the Great Plains grasslands once held sway.

There, in areas once dominated by tall bluestem grasses, a substantial percentage of America's human population can now live their entire lives without ever seeing those bronzy red grasses. They may not even be vaguely aware that the occasional patches of grass that survive in rights-of-way beside the paved highways they traverse once spread as far as the eye could see in all directions and were in large part responsible for creating the rich soils on which they have built their homes, their fortunes, and their lives. Even fewer residents of the region have probably ever seen a prairie grouse.

With these thoughts in mind, the question arises whether some small parts of the prairies and their associated flora and fauna can be saved, at least in sufficient quantities to assure remnant populations for future study, for enjoyment, and to provide a degree of respect for the biodiversity that once surrounded us and still survives in a few locations. Even a relict tallgrass prairie no larger than a few hundred acres, such as the 260-acre Nine-Mile Prairie near Lincoln, Ne-

braska, may support nearly 400 species of native plants, to say nothing of the even larger array of animals and microorganisms living there. Most of these organisms have been studied only to the degree that they have been given scientific names. Some of the invertebrates and soil microflora have not even received that much attention. NASA has spent uncounted millions in collecting and bringing back small samples of moon soil and rocks for exhaustive scientific analysis. Yet their massive buildings near Houston were built on tallgrass prairie soils, and these facilities have completely replaced the now-vanished coastal prairie communities, which had barely been surveyed by biologists before they were completely gone.

STRATEGIES FOR PRESERVING THE PRAIRIE GROUSE

The formula for saving prairie-chickens, sharp-tailed grouse, and sage-grouse from extinction is fairly straightforward, albeit often difficult and expensive: save their habitats in sufficient size and quantity to protect their genetic diversity and overall viability.

The most conspicuous and most numerous of our large prairie mammals, the bison, was almost lost a century ago. Even today few areas of native grassland are large enough to sustain completely unconfined herds, which are now mainly limited to national parks, national monuments, and national grasslands. Only a few entrepreneurs and conservation groups, such as Ted Turner and the Nature Conservancy, have the wherewithal to provide large-scale habitat protection for bison and their associated prairie ecosystem. Grouse don't need areas as large as bison, a point in their favor, but they do require more space than almost any of the other grassland birds. By the time Nine-Mile Prairie in southeastern Nebraska was finally somewhat protected in the 1940s, it was already too small to support greater prairie-chickens, and since then it has only gotten smaller. A similar nearby tallgrass prairie (Audubon's Spring Creek Prairie) of slightly more than 600 acres is also too small, but some surrounding natural grasslands raise the total contiguous grassland area to about 1,500 acres, barely enough to support a tiny prairie-chicken flock.

PRAIRIE PRESERVES, PARKS, AND WILDLIFE REFUGES AS POPULATION REFUGIA

The estimated original regions historically occupied by tallgrass prairies has been independently estimated by Dennis Farney and David Wilcove as 231,000–400,000 square miles, out of a total native North American grassland area of about 1–1.3 million square miles. The combined mixed-grass and shortgrass regions were judged by Wilcove to encompass 625,000 square miles. For conve-

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nience, one might assume these two latter habitat types once occupied roughly comparable areas, for their common boundaries are usually indistinct and shift dynamically back and forth during wetter and drier climatic periods. This treatment would suggest that each of these three native grassland types may have once occupied about 300,000 square miles before European settlement. An alternative estimate can be obtained by basing original areas on a vegetation map prepared by A. W. Kuchler. The estimated original areas of these three megacosystems are then rather smaller, the tallgrass, mixed-grass, and shortgrass components comprising about 221,000, 219,000, and 237,000 square miles, respectively. A compromise estimate for each of the three grassland types might be of about 250,000 square miles.

Many grassland preserves that support prairie grouse already exist in the United States and southern Canada, only a few of which were established primarily for maintaining grouse habitat. In my book *Prairie Birds: Fragile Splendor in the Great Plains*, I tallied all the existing major grassland preserves in the Great Plains, a region that encompasses the ranges of all the surviving forms of grouse described in this book except for the two sage-grouse and some northern populations of the prairie sharp-tailed grouse. The reserves selected for listing generally were those of at least 1,000 acres, an area just barely large enough to support prairie grouse. The tallgrass preserves collectively represented about 820 total square miles in the United States, and 31 square miles in Canada. Of all the midgrass preserves, there were 1,200 square miles in the United States and 1,300 square miles in Canada. Of the shortgrass preserves, generally too dry for farming, there were 75,500 square miles in the United States and almost none in Canada. These total preserved areas sometimes include extensive non-grassland habitats, such as wetlands and variably wooded areas. Nonetheless, the figures provide a fairly accurate estimate of the maximum preserves.

Comparing the previously estimated historical grassland areas (roughly 250,000 square miles each for tallgrass, mixed-grass, and shortgrass prairies) with the collective areas of the preserved grassland sites, one might tentatively conclude that about 0.3 percent of the original tallgrass prairie is now protected from further destruction, as well as about 1.0 percent of the midgrass prairies, and about 30 percent of the shortgrass prairies. It can be no surprise that the tallgrass-adapted greater prairie-chicken has suffered the most in historic times, and the much more broadly distributed sharp-tailed grouse, the least.

As for the sage-grouse, the estimated historical range of its close ecological associate big sagebrush was approximately 150,000 square miles. Several national parks and national monuments or national grasslands are located within the range of big sagebrush, which still occupies perhaps half its original range. However, only a few of these preserves also support populations of greater sage-grouse, and the total range and fate of the closely related Gunnison sage-

grouse is now largely under the control of the Bureau of Land Management (BLM).

Of the federal agencies charged with protecting our natural heritage, the BLM administers the greatest area, some 526,000 square miles in nearly 50 separate administrative districts. These lands are mostly in regions too arid to support agriculture, but they provide wonderful habitat for sage-grouse and related sage-steppe biota. They are also coveted by ranchers, long accustomed to grazing BLM lands at cut-rate prices. Their cattle and sheep effectively trample the soil, compacting it and increasing erosion rates, as well as reducing natural cover and increasing the invasion rates of species such as various undesirable nonnative weeds and conifers. In the last few years the BLM has begun shifting its emphasis away from satisfying livestock and oil-and-gas interests toward active protection and management of wildlife habitat, a move long overdue and greatly to be applauded.

The National Forest Service (NFS) has the next largest national domain. It controls nearly 300,000 square miles of more than 140 national forests, about 20 national grasslands, and numerous scenic trails, some of which are also prime habitat for plains sharp-tailed grouse and sage-grouse. It has long been the favorite friend of the logging industry, with wildlife conservation far down on its list of priorities, although a few of its national grasslands probably offer the last, best hope of preserving lesser prairie-chickens. As with the BLM, an increased awareness at the NFS of its importance in preserving prairie wildlife, especially on its national grasslands, has developed in recent years.

The National Park Service controls about 125,000 square miles of prime natural habitats, with more than 320 designated nationally protected sites, including more than 100 national parks or national monuments, plus additional seashores, lakeshores, rivers, historic sites, recreation areas, and other national preserves. Several of the national parks and monuments contain large areas of prairies, especially shortgrass prairie. Luckily, its lands are inviolate to nearly all destructive uses, and the nation's many national parks and monuments are major refugia for the protection of rare animal and plant species.

The U.S. Fish and Wildlife Service controls about 145,000 square miles of prime wildlife habitat, including nearly 400 national wildlife refuges. In a summary of bird checklists from 210 nature preserves, mostly comprised of national wildlife refuges, John O. Jones has tallied 20 preserves supporting populations of sharp-tailed grouse, 16 having populations of sage-grouse, 12 with greater prairie-chickens, and 3 with lesser prairie-chickens. In a similar but more geographically restricted tally of the Great Plains sanctuaries and prairie preserves I listed in *Prairie Birds*, 15 preserves supported sharp-tailed grouse, at least 6 and probably 9 had greater prairie-chickens (4 North Dakota prairie refuges that probably all support prairie-chickens were grouped in a single list),

and 2 had lesser prairie-chickens, which was listed as follows:

It is clear that these refuges now provide habitat for greater prairie-chickens. The Comanche National Monument and Comanche National Wildlife Refuge in Texas. Both the Comanche National Monument and Comanche National Wildlife Refuge are BLM land. The Comanche National Monument, consisting of 100,000 acres, is managed for oil exploitation. The Comanche National Wildlife Refuge, Mills County, Texas, is a National Monument Area (not only publicly owned but also outside of National Wildlife Refuge). The Black Kettle National Monument and a biological reserve are Kettle lands.

The undisturbed densities of lesser prairie-chickens are good populations. The black-throated blue bird is at a national level. Yet that has been its eradication. Its leaves are not eaten. Effective land species survival treatments must be implemented (micro) sand dunes.

Clearly a national plan is needed for the protection of the now unprotected

ureau of Land Management

ignificant natural heritage, the square miles in nearly 50 separately in regions too arid to habitat for sage-grouse and ranchers, long accustomed and sheep effectively tramped, as well as reducing natives such as various undesirable species. In recent years the BLM has begun to look at oil-and-gas interests as a wildlife habitat, a move long

the largest national domain. It includes 140 national forests, about 100 million acres, some of which are also managed for sage-grouse. It has long been a focus of wildlife conservation far down the West. Many of the grasslands probably offer the best habitat for prairie chickens. As with the BLM, an emphasis on preserving prairie wildlife, especially in recent years.

Some 100 million square miles of prime natural resources are protected sites, including national monuments, plus additional millions of acres, and other national parks and monuments are also managed to preserve plant species.

There are about 145,000 square miles of wildlife refuges. In a summary, they are mostly comprised of national preserves supporting populations of sage-grouse, 12 with sharp-tailed chickens. In a similar but smaller list of sanctuaries and prairie preserves supporting sharp-tailed grouse, at least 4 (North Dakota prairie refuges grouped in a single list),

and 2 had lesser prairie-chickens. Sage-grouse were not included in this survey, which was limited to the Great Plains endemic bird species.

It is clear that fairly large areas of public lands such as those just mentioned now provide substantial habitats for sharp-tailed grouse and sage-grouse; fewer areas exist for greater prairie-chickens; and only a very few offer any secure habitat for lesser prairie-chickens. These latter include the contiguous Cimarron and Comanche National Grasslands (total 530,000 acres) in Kansas and Colorado, respectively, the Optima (4,300 acres) and Washita (8,200 acres) National Wildlife Refuges in Oklahoma, and Muleshoe National Wildlife Refuge (5,800 acres) in Texas. But the birds are now rare in all these refuges, and at the Cimarron and Comanche National Grasslands they are uncommon at best.

BLM lands in New Mexico that support shinnery oak habitat are extensive, consisting of perhaps as much as 1.2 million acres. Yet the lesser prairie-chicken population in the state verges on endangered, as the BLM land is primarily managed for cattle grazing and big game hunting, as well as facilitating gas and oil exploitation. The Black Kettle National Grassland (31,000 acres) in Roger Mills County, Oklahoma, and the state-owned Packsaddle Wildlife Management Area (16,000 acres), in Ellis County, Oklahoma, represent practically the only publicly owned shinnery oak habitat suitable for lesser prairie-chickens outside of New Mexico. Of these, only the latter location might actually have good prairie-chicken populations but as far as I know they are still unmeasured. The Black Kettle grasslands have been too fragmented by the effects of past agricultural disturbances to support prairie-chickens in even small numbers, and a biologist stationed there told me he has never even seen one on Black Kettle lands.

The undisturbed shinnery grassland ecosystem generally supports even higher densities of lesser prairie-chickens than do the sandsage grasslands, as well as good populations of scaled quail, Chihuahuan ravens, loggerhead shrikes, and black-throated sparrows, all of which are seriously declining species at the national level. Yet as Roger Peterson and Chad Boyd noted, most of the research that has been directed toward the shinnery oak ecosystem has been devoted to its eradication, mainly because it may harbor overwintering boll weevils and its leaves are seasonally toxic to cattle. Treating shinnery with defoliant herbicides has been found to sharply decrease prairie-chicken and scaled quail populations. Effects on other breeding bird species are varied, with some open grassland species such as meadowlarks and shrikes substantially increasing. Defoliation treatments may also reduce the endemic and state-endangered (in New Mexico) sand dune lizard (*Sceloporus arenicolus*) population as much as sixfold.

Clearly a new national wildlife refuge, or comparable nature preserve, is needed for the lesser prairie-chicken. Such a preserve could well be located in the now unprotected sandsage grasslands of the Arkansas River Valley from

Garden City, Kansas, west to at least the Colorado border, perhaps the best of the species' remaining range and one not yet seriously affected by cattle overgrazing. Such a preserve would offer the best hope for saving the lesser prairie-chicken from the disastrous recent history of the Attwater's prairie-chicken, when the federal government delayed far too long before starting to acquire critical habitat for its preservation. Protecting the lesser prairie-chicken there would also help protect the rapidly declining national populations of lark, grasshopper, and Cassin's sparrows, burrowing owls, and black-tailed prairie-dogs. The valley is also an extremely important migratory stopover site for several other prairie endemics, the Baird's sparrow, lark bunting, long-billed curlew, and McCown's longspur. It encapsulates the entire sandsage ecosystem, one of the rarest and least studied of the Great Plains vegetational complexes.

MINIMUM HABITAT REQUIREMENTS AND MINIMUM VIABLE POPULATION SIZES

Deciding "how much is enough?" is a problem that everyone faces at times. It is a question increasingly faced by conservation agency administrators, who must frequently decide whether a piece of land is worth trying to save at all, and if so, what is the least area that is acceptable given the constraints of time, resources, and energies needed to achieve as many of the desired goals as possible. It might be a fairly easy choice when the objective is to save a local population of some rare plant whose actual and potential habitat limits may be fairly readily evaluated. It is much more difficult with mobile species, especially migratory ones, where controlling the species' overall yearly habitat needs may be impossible. With prairie grouse the answer probably lies somewhere between these extremes. If not truly migratory, prairie grouse are surprisingly mobile. Seasonal movements of 10 to 20 miles by sharp-tailed grouse and prairie-chickens are not unusual; and annual movements of 25 to 50 miles are known. Those of sage-grouse may easily be twice as great, and annual movements of up to 150 miles may occur.

Thus buffer zones extending well beyond the usual home range of a single viable flock are desirable. Ronald Westemeier and Sharon Gough suggested that for greater prairie-chickens, minimum viable populations of at least 100 males, and preferably more than 250, are desirable, located in areas where demographic and genetic exchange are possible. They also suggested that minimum areas of suitable grasslands for supporting such populations may range from 1,500 to 13,000 acres in various parts of the species' range. An estimate of 4,000 acres of suitable grassland was made by J. Toepfer and others in order to sustain a population of 200 to 250 male greater prairie-chickens in Minnesota and Wisconsin, which might serve as a general compromise estimate for that

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species and possibly also sharp-tailed grouse. Sage-grouse would certainly need larger areas, but lesser prairie-chickens perhaps less.

In regard to minimum preserve sizes, it might be remembered that the area preserved for protecting the heath hen on Martha's Vineyard was less than 2,000 acres. This area proved to be far too small and resulted in the compression of the population in such a way as to make it highly vulnerable to local outbreaks of fire and disease. Although the Attwater Prairie Chicken National Wildlife Refuge in Texas is larger (8,000 acres), it too has proven too small as well as ecologically fragmented and degraded. The overall remaining Attwater's populations are now too isolated and tiny to offer any hope for the birds' long-term survival.

Both these well-documented prairie-chicken populations suffered similar and rather rapid population declines once their populations dropped below a few thousand birds. The vagaries of weather, the resultant uncertainties of reproductive success from year to year, and other often unpredictable mortality factors have meant that more and more of a rare grouse's chances for survival rest on the reproductive fortunes and survival of progressively fewer birds. These problems are exacerbated by the lek breeding system, which works only when populations are dense enough to provide the visual and acoustic stimuli necessary to attract prebreeding females to a functioning lek, and when the lek is large enough to assure that the matings will be performed by the genetically and physically fittest males. Lek breeding also tends to promote inbreeding owing to the limitations caused by only a few males siring offspring. Over prolonged periods this trend can produce "genetic bottlenecks," which seemingly occurred in the Illinois flock of greater prairie-chickens as it spiraled downward. It rebounded once some new blood was introduced by releasing birds from states farther west into the Illinois population.

THE ROLE OF FIRE IN GROUSE MANAGEMENT

Fire is one of those things that must be handled with great care: too much, too little, too early, too late, too hot, and too cool are all variables that conservationists must take into account when contemplating the use of prescribed fire in habitat management for a particular species, to say nothing of the highly varied, if not opposite, effects the same fire might have on different but equally desirable species. The effects of fire are often apparent almost immediately, although it may take years or decades for a piece of land to recover from the undesirable effects of a single unplanned or badly handled fire,

As an example of the complexities involved in fire management, some species of sagebrush such as sandsage regularly resprout following fire and thus may actually benefit from periodic fires. More fire-sensitive sage species such

as big sagebrush and its near relatives are readily killed by exposure to fire. Up to 30 years may be needed for stands of big sagebrush to recover from a single fire. Thus although fires may kill the sagebrush that sage-grouse need for winter foods and nesting, the forbs that are stimulated following fires may be selectively chosen for summer foraging by the birds. Fires occurring at long intervals (up to about 50 years) may also help keep junipers and piñon pines from invading sagebrush; the presence of these conifers in sagebrush habitats seemingly attracts predators and thus reduces their use by sage-grouse. In the sand-sage shinnery community, fires generally stimulate regrowth by both sand-sage and shinnery oak, the latter reaching 3 to 4 feet in height within a few years following fire. As with other mixed shrub and grass communities, the productivity of perennial grasses may also be stimulated by periodic burns, thus improving nesting or brooding cover. *Artemisia* species are generally long-lived plants, with some big sagebrush reportedly surviving for a century or more. Yet it cannot resprout after burning; it is sensitive to flooding; and it can be reestablished only from seeds. With the invasion of annual grasses such as cheatgrass, fires are more frequent and occur earlier than was true in the past, and several less desirable shrub genera (*Chrysothamnus*, *Ephedra*, and *Tetradymia*) that are able to resprout following fires may gradually replace big sagebrush following an episode of fire. Fire at any season is apparently detrimental to sage-grouse in Idaho, judging from observations by J. W. Connelly, K. P. Reese, and others.

In general, controlled burns for prairie-chickens and other prairie grouse should be done a full month before nest initiation, and burns should be performed in a mosaic pattern over a several-year period. Grazing or cutting of burned grasslands should be moderate, and cutting should be done only once per season, after the early brooding season has been completed. Probably no more than half the new growth should be cut for forage, and a small part of each pasture should be left entirely ungrazed and unharvested. Lek sites need to be kept at a low vegetational stature, but nearby grassy areas should be kept tall enough to provide nesting cover.

In more typical grasslands, as in tallgrass prairies, burns likewise typically tend to favor grasses over shrubs. Depending on the severity of the fires, invading shrubs and small saplings may thus be killed or at least controlled, whereas older trees might readily survive occasional ground fires. If the fires are timed properly, warm-season grasses are also favored over the generally less desirable cool-season forms, such as various annual brome grasses that usually have limited value to prairie grouse as cover or food.

Although spring burning usually improves the stands of native, mostly warm-season, grasses, but side-oats grama seems to be harmed by frequent spring fires. Fires later in the growing season tend to reduce both warm-season and

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cool-season grasses. Winter burns are prone to favor cool-season grasses over the generally more desirable warm-season species. For example, an April burn in Nebraska tallgrass prairie provides a charred litter layer on the soil that not only immediately releases valuable nutrients but also helps warm the upper soil layer as sunlight directly warms the soil surface. This in turn favors an early growth spurt by warm-season grasses such as the bluestems, to the disadvantage of cool-season forms such as the bromes and especially to shrubs such as sumacs and invading junipers. However, too-frequent fires will reduce the diversity of legumes and other forbs in prairie communities, many of which provide seeds or leafy parts rich in proteins. They may also reduce the litter layer to the point that some endemic prairie birds such as Henslow's sparrows, which nest in well-developed surface litter, will cease to breed in the area. Further, native warm-season grasses that are left unmanaged and completely unmowed may not provide suitable nesting or brood-rearing habitat for prairie grouse, or may not offer any low-cover sites suitable for lek locations. Planning and conducting prescribed fires is in many ways a case of trying to play God and hoping that the decisions made are going to provide the generally short-term effects hoped for and not have too many unplanned and undesirable long-term effects.

AGRICULTURE AND GRAZING EFFECTS

Ironically small-grain agriculture was primarily responsible for producing the remarkable population explosion and range expansion of the greater prairie-chicken into the central and western plains during the late 1800s and early 1900s, only to cause its decline and near-disappearance toward the end of the 20th century. Like many things in nature, a small degree of change in the form of a new source of fall and winter food was highly beneficial; only when other seasonal habitat needs began to decline and finally disappear did the balance swing in the other direction. As agriculture became more mechanized and the farms larger, fewer and fewer acres were left as weedy edges or spared from increasingly effective pesticides and herbicides, and the prairie grouse began a long, slow, but certain descent into oblivion.

The almost universal declines in prairie grouse populations can be attributed largely to agricultural or grazing influences on habitat quality and quantity. Neither predators, disease, parasites, competitors, nor hunting has had anything approaching the degree of undesirable influence brought about by agriculture and grazing. The federal government's Conservation Reserve Program, in which farmers have been encouraged to plant highly erodible land to grasses, specifically (in recent years at least) native grasses, is one of the few examples of beneficial agricultural practices. This program has been responsible,

at least in part, for regional increases in the prairie grouse populations of western Nebraska and eastern Colorado, and perhaps elsewhere. These grasses may need occasional mowing and prescribed burning to provide optimum wintering and nesting cover.

With heavy cattle grazing of tallgrass prairie, several of the major native prairie plants typical of prairie grouse breeding habitats respond as "decreasers," including little bluestem, big bluestem, Indian grass, and switchgrass, especially the last two. Needle-and-thread, side-oats, and blue grama are typical "increasers," and under heavy grazing, buffalo grass may eventually replace most of the higher-stature grasses. Annual alien grasses such as several bromes, especially cheatgrass (downy brome), become serious and pernicious invaders with overgrazing. Additionally, litter cover declines with overgrazing, increasing runoff and decreasing water infiltration. All these changes are likely to have adverse effects on prairie grouse. Among mixed-grass prairies similar effects occur during grazing, but blue grama, sand dropseed, and paspalum grasses are increasers. Effects of drought on the mixed-grass prairies are nearly the same as those of severe overgrazing, converting mixed-grass communities to shortgrass ones and making them essentially unsuited to plains sharp-tailed grouse.

ECOTOURISM AND THE FUTURE OF PRAIRIE GROUSE

Like fire and wilderness, ecotourism must be treated with great care. Aldo Leopold once wrote that the only way we can enjoy wilderness personally is by visiting it, and in so doing, we help destroy some of the very attributes of wilderness we most appreciate.

Prairie grouse must likewise be handled with great care if they are to be enjoyed in nonconsumptive ways. They are an increasingly rare commodity, and like many other attractive but rare types of wildlife can sometimes be loved almost to death. Some of the richest moments of my life have been spent in grouse blinds, and I fervently believe that a naturalist has never fully lived unless he or she has watched the sun rise on a grouse lek. Yet it is not always a harmless pleasure.

For more than 40 years I have watched such sunrises on a hillside in southeastern Nebraska near Burchard Lake, where each spring morning, perhaps for centuries, prairie-chickens have played out their roles of survival and reproduction. In the early years of the 1960s, more than 40 males could reliably be seen each spring, and the lek was visited by only a few people. But during the 1970s the state's Game and Fish Commission built two large blinds on edges of the leks, blinds that were badly designed, with too-large and noncamouflaged windows, and no screening for concealing approaches or departures. These

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blinds increasingly attracted more and more visitors, many of whom knew little or nothing of the proper etiquette of grouse watching, especially the need to arrive at dark and to stay until the birds had finished their daily routines. Over the years, fewer and fewer males appeared, and those that did became increasingly wary of the blinds. By the late 1990s only about a dozen males regularly used the lek. In 2001, after an experimental hunting season in southeastern Nebraska, only four males appeared. Four males are too few to attract females effectively, and it is likely that this entire lek will eventually disappear.

A somewhat similar downward population progression occurred on the 8,600-acre Konza Prairie in the Flint Hills of Kansas, where greater prairie-chickens were once quite common. From 1980 to 1990 the total number of males in this locally protected population declined 68 percent, and the number of active leks was reduced by 38 percent, while during the same period grouse research projects increased threefold. Meantime, prairie-chicken populations on the nearby grasslands remained stable. The Konza Prairie population of prairie-chickens is still quite low. We can hope that the value of the research gained at Konza and the personal enjoyment and love for prairie wildlife gained by the bird-watchers who have visited Burchard Lake over the past four decades are worth such costs. This may well be the case, for many of the people I have taken to watch the prairie-chickens at Burchard Lake have since become outspoken advocates for the preservation of prairies and prairie wildlife, and one woman told me decades later that visiting it as an ornithology student had provided the most exciting and personally rewarding experience of her entire life. A nonbiologist, indeed a practicing Protestant minister, told me it had been his most religious experience. What might happen to a person when first visiting a grouse lek is impossible to predict, but it is likely to be an unforgettable event.

We cannot foretell how many people's lives might be affected or even fundamentally changed through the magic of observing wild prairie grouse in their natural habitat as they engage in the calls, postures, and behaviors shaped by millions of years of evolution and try their best to pass them on to the next generation. There are promises to be witnessed and given thus: promises on our part to help save the land and its living beings for future generations, and promises on the part of the birds that, so long as they might live, they will try to fulfill their end of the bargain. I can think of none better.

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