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University of Nebraska - Lincoln *Year* 2004

Guidelines for Managing Lesser Prairie-Chicken Populations and Their Habitats

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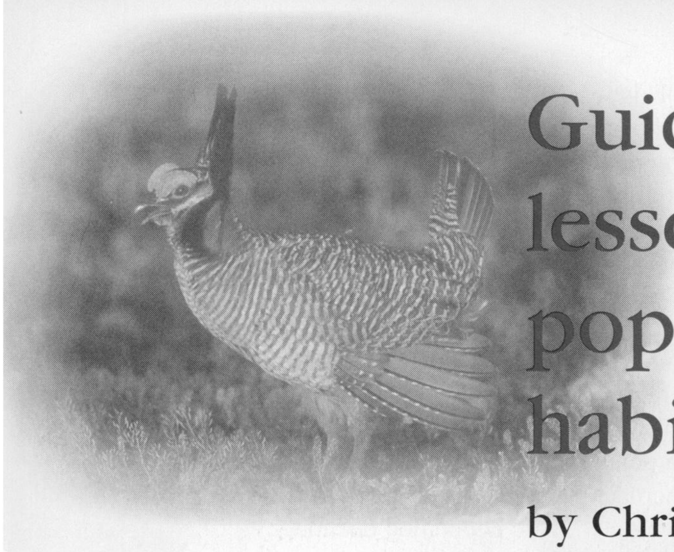

Guidelines for managing lesser prairie-chicken populations and their habitats

by Christian A. Hagen, Brent E. Jamison, Kenneth M. Giesen, and Terry Z. Riley

Abstract Lesser prairie-chicken (*Tympanuchus pallidicinctus*) populations have declined by >90% since the 1800s. These declines have concerned both biologists and private conservation groups and led to a petition to list the lesser prairie-chicken as threatened under the Endangered Species Act. Most of the land in the current range of the lesser prairie-chicken is privately owned, and declines have been primarily attributed to anthropogenic factors. Conversion of native rangeland to cropland and excessive grazing have been implicated as leading causes in the species' decline. Periodic drought probably has exacerbated these problems. Little research on habitat requirements was conducted prior to 1970. Despite recent advances in the knowledge of lesser prairie-chicken ecology, no comprehensive guidelines for management of the species have been published. In these guidelines, we provide a synopsis of our current knowledge of lesser prairie-chicken habitat requirements and suggest management strategies to monitor, maintain, and enhance lesser prairie-chicken populations.

Key Words *Artemisia filifolia,* guidelines, lesser prairie-chicken, management zone, mixed-grass prairie, *Quercus havardii,* sand sagebrush, shinnery oak, *Tympanuchus pallidicinctus*

The distribution of lesser prairie-chicken (*Tympanuchus pallidicinctus*) populations and their occupied habitats have declined by >90% since the beginning of the twentieth century (Crawford and Bolen 1976*a*, Taylor and Guthery 1980*b*, Giesen 1998). Populations currently occur in Colorado, Kansas, New Mexico, Oklahoma, and Texas (Figure 1). Concern for this species has escalated in the twenty-first century as lesser prairie-chicken (LPCH) population indices still suggest long-term declines (Bailey and Williams 2000, Giesen 2000, Horton

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2000, Jensen et al. 2000, Sullivan et al. 2000). Because of recent declines, sport-hunting seasons were closed in New Mexico (1995) and Oklahoma (1998). Currently, LPCHs are state-listed as threatened by Colorado and considered a "warranted but precluded" threatened species by the United States Fish and Wildlife Service (USFWS) (Giesen 1998). Concern for LPCHs has led to research in all 5 states where the species occurs to better understand population trends and habitat requirements.

Mixed-grass prairie communities that historically supported LPCHs were thought to be comprised of regions patchily dominated by sand sagebrush (*Artemisia filifolia*) and sand shinnery oak (*Quercus havardii*). However, northern and eastern fringe areas of their range primarily were mixed-grass interspersed with shrubs including sand sagebrush, plum (*Prunus* spp.), sumac (*Rhus* spp.), and yucca (*Yucca* spp.) (Baker 1953, Copelin 1963, Horak 1985). Currently, LPCHs occupy sand sagebrush and mixed-grass communities in Kansas (south of the Arkansas River) and Colorado, sand shinnery oak and mixed-grass communities in New Mexico and southwest Texas panhandle, an interspersion of these shrub types in Oklahoma and northeast Texas panhandle, and mixed-grass prairie north of the Arkansas River in Kansas. This semi-arid region receives <60 cm of annual precipitation and sustains periodic drought that can affect short-term population trends (Brown 1978, Giesen 2000).

Numerous anthropogenic factors have been implicated in the decline of LPCHs. Conversion of native grassland communities to cropland, fire suppression leading to juniper (*Juniperus* spp.) encroachment, excessive grazing by livestock, suburban developments, and fossil-fuel drilling and exploring are suspected to be the primary factors (Giesen 1998, Woodward et al. 2001). These factors, coupled with periodic drought, may have driven long-term population lows to critical levels. Continued human encroachment and overgrazing likely will exacerbate population declines.

Management guidelines have been published for sage grouse (*Centrocercus* spp.) and Columbian sharp-tailed grouse (*T. phasianellus columbianus*), species of conservation concern (Braun et al. 1977, Giesen and Connelly 1993, Connelly et al. 2000), but not for LPCHs. We provide a synopsis of the current state of knowledge and provide guidelines to monitor, maintain, and enhance LPCH populations and the habitats upon which they depend. Lesser prairie-chickens occupy 3 distinct vegetative communities; however, data are available primarily for populations inhabiting sand shinnery oak and sand sagebrush communities, and our guidelines reflect the available information.

Although the rate of habitat loss has slowed over the past 20 years, LPCH population trends continue to decline, suggesting that it is the quality (i.e., human-induced or drought) of the habitat that may be limiting the recovery of these populations.

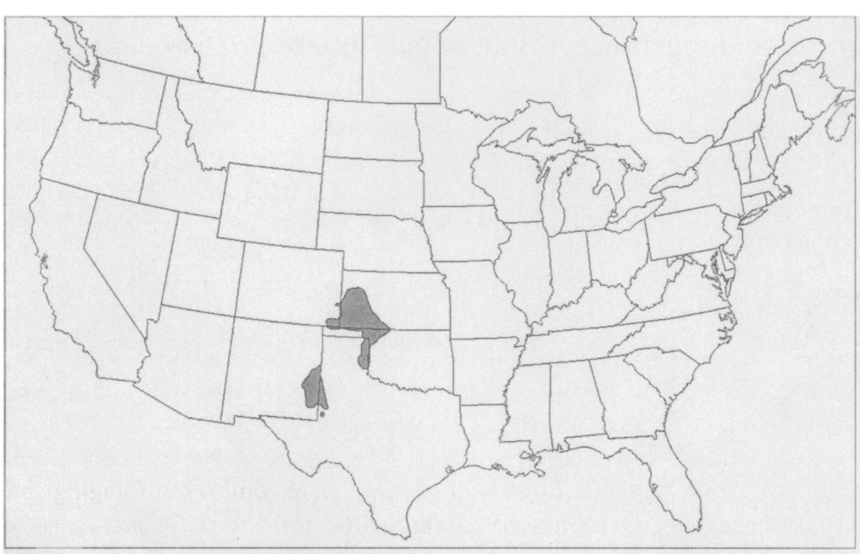

Figure 1. Current (2003) distribution of the lesser prairie-chicken shaded in gray (After Jamison et al. 2002*a*).

Population biology

Population monitoring

Lesser prairie-chicken populations are surveyed annually during the spring when males congregate at lek sites. Surveys of displaying males have been used to provide long-term monitoring of population trends (Giesen 1998). Survey methods and effort vary by state. Harvest statistics from check stations provided production indices (age ratios) and sex ratios in New Mexico (1958–1968, 1988–1989, 1995) (New Mexico Department of Game and Fish, unpublished data) and Texas (1967–1988) (Texas Parks and Wildlife Department, unpublished data). Kansas and Texas currently monitor harvest by using surveys mailed to random samples of hunters. These data are used to estimate the number of birds harvested, but demographic data are not collected.

Survival

Survival estimates for LPCHs are based on short-term studies of selected populations using radiotelemetry and banding data. Annual survival of adult LPCHs is similar to that of other prairie grouse species (Hagen 2003). Campbell (1972) estimated annual survival of banded males in New Mexico to be 35%, and Merchant (1982) estimated survival of radiomarked females for a 5-month period (April–August) at 59%, extrapolated to 12 months =31%. In Kansas, Jamison (2000) estimated annual survival of radiomarked males to be 57%. Male and female 6-month survival curves (April–September) that included breeding and nesting were 74%, and this estimate extrapolated to 12 months=55%. Hagen (2003) documented age-specific annual survival of live recapture data for banded males from 1998–2002 in Kansas, and rankings were: yearling=62%, adult=49%, and older adults=35%. Annual survival (April–April) of radiomarked females was estimated at 53 and 38% for yearlings and adults, respectively (Hagen 2003). Female survival rates were lowest in the months of May and June, but second-lowest rates occurred during winter months. Twenty-nine percent of all female mortality was directly related to nesting activities (Hagen 2003).

Reproduction

Most LPCH females attempt to nest, with 81–100% of radiomarked birds initiating at least one nest (Riley et al. 1992, Giesen 1994, Pitman 2003). Renesting attempts may vary with yearly habitat conditions and condition of females, but 10–30% of females lose their initial clutches (Giesen 1994, Pitman 2003). Nesting success (percent clutches hatching >1 egg) averaged 28% for 10 telemetry studies (Giesen 1998), and hatchability (number of eggs hatched per successful nest) averaged >90% (Copelin 1963, Merchant 1982, Giesen 1998, Pitman 2003). Clutch size is similar rangewide (Giesen 1998), with an overall mean of 11.3 (SE=0.51) and 8 (SE=0.82) eggs for first and second clutches, respectively (Giesen 1998, Pitman 2003). Chick survival is highly variable but averages 39% rangewide (Davison 1940, Schwilling 1955, Copelin 1963, Merchant 1982, Jamison 2000, Pitman 2003). Survival of chicks (54%) from fledging to first breeding (Aug to Apr) was similar to that of adults during the same period in Kansas (Pitman 2003). Annual variation in chick survival and nest success may have the largest impact on LPCH population growth rates (Hagen 2003), as had been documented for greater prairie-chickens (*T. cupido pinnatus*) (Wisdom and Mills 1997) and Attwater's prairie-chicken (*T. c. attwateri*) (Peterson et al. 1998).

Seasonal movements and home range

Lesser prairie-chicken populations are considered nonmigratory, and seasonal ranges and movements of individuals typically are restricted to suitable habitats within an individual's annual range (Giesen 1998). However, movements of LPCHs in southwest Kansas resembled partial migrations; approximately 5% of radiomarked individuals moved 30–50 km from their capture areas during nesting or postnesting and returned to the capture area during winter (Hagen 2003). Prenesting (spring) ranges tended to be larger for females (355–596 ha) than spring ranges for males (120–211 ha) in Colorado and Kansas (Giesen 1998, Jamison 2000, Walker 2000). In Colorado the combined annual ranges (95% ellipses) of all birds, males and females, from a lek were 2,450–5,130 ha (24.5–51.3 km^2) (Giesen 1998). In Kansas summer ranges (95% fixed-kernel) generally were smaller than spring ranges for both males (120 ha) and females (150 ha) (Jamison 2000). Lesser prairie-chickens in New Mexico and Oklahoma moved considerable distances in years of drought, but prenesting, nesting, and postnesting ranges of females had patterns similar to those of Colorado and Kansas, although they were slightly smaller (Copelin 1963, Riley et al. 1994). Winter ranges of male LPCHs in Kansas were 300–700 ha (Jamison 2000) and 331–1,945 ha in Texas (Taylor and Guthery 1980*a*). These enlarged ranges have been attributed to foraging in grain fields, which may be some distance from winter loafing and roosting sites in native rangeland (Taylor and Guthery 1980*a*).

Habitat requirements

Food habits

Insects, seeds, leaves, buds, and cultivated grains dominate the annual diet of LPCHs throughout the range (Schwilling 1955, Jones 1963*a*, Donaldson 1969, Riley et al. 1993). Green leafy forage and insects were the dominant components of LPCH diet from November to April and May to October, respectively (Jones 1963*a*). Adult LPCHs relied heavily on sites of mixed-grass species of 25–80 cm in height, and seeds of 6-weeks fescue (*Vulpia octoflora*), western ragweed (*Ambrosia psilostachya*), and fragrant sumac (*Rhus aromatica*) were important food items (Jones 1963*a*). Wheat, western ragweed, and blue grama (*Bouteloua gracilis*) were common at foraging sites (Donaldson 1969) throughout the year in Oklahoma.

In New Mexico LPCHs foraged nearly exclusively in shinnery oak–tallgrass communities during autumn and

A lesser prairie-chicken nest in a predominantly grass pasture.

A Kansas pasture with a sand sagebrush density of 2,588 plants per ha.

winter (Riley et al. 1993). Fall diets were comprised of seeds (43%), vegetative material (39%), and insects (15%); winter diets were acorns (69%) and wild buckwheat (*Eriogonum annuum*; 14%). Vegetation at foraging sites was dominated by grass and shinnery oak, with shinnery oak more prevalent at winter sites than at autumn sites (Riley et al. 1993). Autumn foraging sites contained more grass and fewer shrubs than did winter sites, reflecting the potential importance of shinnery oak mast and oak insect galls to LPCHs in winter (Davis et al. 1979).

Small grains, short-horned grasshoppers (Acrididae), beetles (Coleoptera), and green wheat were the 4 most common food items found in LPCH diets of southwestern Kansas (Schwilling 1955). Similar to other regions, invertebrates and small grains comprised >90% of LPCH diets in summer and winter, respectively. Lesser prairie-chickens were documented foraging on budding willows and cottonwoods (*Populus* spp.) in riparian areas during winter months (Schwilling 1955).

The birds commonly forage in grain sorghum, corn, and other grain fields adjacent to native pasture from late autumn through early spring (Jamison et al. 2002*a*). Alfalfa was an important food source for prenesting females and lekking males in southwestern Kansas (Jamison 2000). Diets of juveniles <10 weeks old are thought to consist primarily of insects, specifically short-horned grasshoppers (Jones 1963*a*,*b*; Davis et al. 1979; Jamison et al. 2002*b*).

Breeding habitats

Lekking. Leks (breeding and display sites) generally are in open areas of short grasses surrounded by sand sagebrush or sand shinnery oak grassland (Giesen 1998). Other such sites include, but are not limited to, abandoned oil-drilling sites (oil pads) with little or no vegetation, unimproved roads with little traffic, areas treated with shrub-specific herbicide, recently burned areas, heavily grazed areas (e.g., stock tanks, mineral licks), and cultivated fields adjacent to grassland (Jamison et al. 2002*a*). These sites may be located on ridgetops or knolls that are higher than surrounding topography.

Nesting. Lesser prairie-chicken females tend to select nest sites with high visual obstruction readings (VOR) (Robel et al. 1970) and horizontal cover (Giesen 1998), with most females selecting sites within 3.5 km of the nearest lek. High VORs can result from selecting tall residual grass cover (Riley et al. 1992) or selecting various shrub species under which to nest (Table 1). In either case, average vegetation height above the nest was 43–81 cm (Riley et al. 1992). Vegetation height at nest

Table 1. Nest-site characteristics of lesser prairie-chickens from five studies in Texas, New Mexico, Colorado, and Kansas.

State	*n*	VOR[a]	Veg ht (cm)	Shrub[b] %	Shrub ht (cm)	Grass %	Grass ht (cm)	Forb %	Forb ht (cm)	Study[c]
Tex.	13	70	45							1
N.M.	36		51	46		46		8		2
Colo.	29	61		7.2	48	29.4	36	1.4	21	3
Kans.	174	48		15.2	43.8	37.2	19.2	8.4	16.3	4

[a] VOR = visual obstruction reading.

[b] Note methods for estimating percent cover varied across studies; thus, percentages are not directly comparable.

[c] References for measurements: 1, Haukos and Smith (1989); 2, Riley et al. (1992); 3, Giesen (1994); 4, Pitman (2003).

Table 2. Habitat characteristics of successful and unsuccessful lesser prairie-chicken nests from 4 habitat types in 2 studies in New Mexico and Kansas.

	Successful					Unsuccessful				
State	*n*	VOR[c]	Shrub %	Grass %	Forb %	*n*	VOR	Shrub %	Grass %	Forb %
N.M.[a] (1)	5	87.4	32.5	64.0	3.5	3	36.6	31.3	49.6	19.1
N.M.[a] (2)	4	55.9	41.8	55.1	3.1	17	39.5	48.1	44.5	7.4
N.M.[a] (3)	1	50.0	66.2	23.8	10.0	6	31.2	54.7	37.9	7.4
Kans.[b]	42	2.7	18.4	37.6	8.9	113	2.2	13.7	38.9	8.4

[a] Riley et al. (1992) 1 = High Plains Bluestem Subtype (HPBS-1), 2 = HBPS-2, and 3 = HBPS-3 in southeastern New Mexico.

[b] Pitman (2003) quantified vegetation in the sand sagebrush of southwestern Kansas.

[c] Visual obstruction readings (VOR) was measured (cm) by the plant growing nearest to the nest (Riley et al. 1992) and using a VOR pole (dm) by Pitman (2003).

sites was taller than adjacent rangeland sites (Davis et al. 1979, Haukos and Smith 1989, Riley et al. 1992, Giesen 1994, Pitman 2003). In sand sagebrush habitat, successful nests often were located in areas with relatively high shrub densities (>5,000 plants/ha) (Giesen 1994, Pitman 2003). Successful nesting generally required taller and denser stands of vegetation (Table 2). Nest-site selection may be affected by the proximity of human disturbance, as most LPCH nests were placed farther from prairie edge and anthropogenic features (e.g., power lines, pump-jacks, improved roads, and buildings) than expected at random (Pitman 2003).

Brood rearing. Lesser prairie-chicken broods occupy habitats with moderate stands of cover (Table 3). Specifically, they forage for invertebrates in areas with abundant bare ground and approximately 25% canopy cover of shrubs, forbs, or grasses 20–30 cm in height (Jones 1963*a*, Donaldson 1969, Davis et al. 1979, Ahlborn 1980, Riley and Davis 1993). In Kansas, brood habitat was selected based on vegetation that provided high invertebrate biomass with moderate escape cover (Jamison et al. 2002*a*, C. A. Hagen, unpublished data). Brood females selected habitats consisting of 15% forb cover, sagebrush cover of 20% and moderate densities (approximately 4,000 plants/ha) coupled with high invertebrate biomass (C. A. Hagen, unpublished data).

Table 3. Brood habitat characteristics of lesser prairie-chickens from 5 studies in Oklahoma, New Mexico, and Kansas.

State	Study	Veg ht (cm)	Shrub %[a]	Grass %	Forb %
Okla.	Jones (1963*a,b*)		23	8	16
Okla.	Donaldson (1964)		14	51	35
N.M.	Ahlborn (1980)	30	30	50	20
N.M.	Riley and Davis (1993)	25	43	43	15
Kans.	Hagen (unpublished data)	30	17	26	11

[a] Note methods for estimating percent cover varied across studies, thus percentages are not directly comparable.

Fall and winter

Historically, LPCH winter habitat included riparian corridors comprised of deciduous shrubs and young trees in the sand sagebrush regions (Schwilling 1955), and they foraged on acorns of shinnery oaks in southern parts of the range (Copelin 1963, Davis et al. 1979). Cultivation and availability of small grains changed their foraging habits rangewide in the twentieth century (Giesen 1998). LPCHs begin foraging in grain fields (where available) once harvest has begun, usually in October (Schwilling 1955, Taylor and Guthery 1980*a*, Jamison 2000). Despite this shift away from native prairie, rangeland is important for roosting and loafing habitat (Baker 1953, Taylor and Guthery 1980*a*, Jamison 2000). In Oklahoma LPCHs occupied native vegetative communities comprised of grasses >80 cm tall and were documented using wheat, western ragweed, and blue grama (Donaldson 1969). In New Mexico LPCHs foraged almost exclusively in shinnery oak–tallgrass communities during autumn and winter (Riley et al. 1993).

Effects of management

Habitat management

Burning. In shinnery oak grasslands, spring burning may result in increased counts of displaying males and relocation of leks to recently burned areas (Cannon and Knopf 1979). The number of displaying males on one area increased from a preburn total of 26 to a postburn total of 39. A 2-year study on the effects of fire on vegetation in shinnery oak rangelands of Oklahoma suggested that prescribed burning could benefit LPCHs by providing foraging areas, but the immediate effects of fire on nesting cover were negative, particularly when burns were conducted in spring (Boyd 1999, Boyd and Bidwell 2001). A 3-year study on greater prairie-chickens nesting in burned and unburned landscapes in Oklahoma found that 80% of all nests occurred in unburned sites, and those nests ≥200 m from the burn edge had the greatest probability of successfully hatching (Wolfe et al. 2001).

Synder (1997) documented impacts of fire on sand sagebrush communities. Visual obstruction and canopy cover of sagebrush were reduced, and neither had recovered to preburn levels 7 years post-treatment. Forb recovery was highly variable in post-treatment, but perennial forbs tended to increase in the short term and annual forbs responded on a species-by-species basis. Litton et al. (1994) and Snyder (1997) cautioned that burning in areas of loose, sandy soils should be avoided because a lack of adequate precipitation and subsequent lack of revegetation increased the potential for wind erosion.

Brush-beating and herbicides. Mechanical shrub removal is uncommon in habitats typically occupied by LPCH; therefore, no data are available on the effects of brush-beating on the species. Effects of shrub-specific herbicides on LPCHs probably are compounded by interactions with livestock grazing, size of treated area, and resulting herbaceous cover (Jamison et al. 2002*a*). Herbicide treatment kills shrubs and allows an increase in grass cover if grass cover is not reduced by heavy grazing (Donaldson 1966, Doerr and Guthery 1983, Olawsky 1987, Olawsky and Smith 1991). There are no data that demonstrate how herbicides can be used to create an interspersion of different vegetation types or that any herbicide treatments will increase survival or recruitment of LPCHs. Negative effects of herbicide treatment on shrub cover may not become evident until ≥3 years following herbicide applications as the treated shrubs fall and decay (Rodgers and Sexson 1990, Jamison et al. 2002*a*).

Loss of native rangelands to woody cover is insidious as eastern redcedar (*Juniperus* spp.), osage orange (*Maclura pomifera*), and some exotics have transformed native grasslands into shrub or even forested landscapes. Woodward et al. (2001) documented a negative association between landscapes with increased woody cover and LPCH population indices.

Grazing. Overgrazing is a major reason for declines in numbers of LPCHs because of degradation to nesting habitat (Taylor and Guthery 1980*b*, Leslie et al. 1999, Mote et al. 1999, Bailey et al. 2000). However, few data demonstrate the mechanisms by which grazing impacts LPCH demography. In sandy soils heavy grazing may result in a shortage of the tall residual cover (Berg et al. 1997, Sims and Gillen 1999) required for successful nesting (Hoffman 1963, Jackson and DeArment 1963, Litton et al. 1994), and in firmer soils grazing may result in conversion of tall-and mid-grass communities to a short-grass-dominated community (Quinn and Walgenbach 1990). Alternatively, moderate grazing in sandy regions can yield greater basal cover of mid-grasses and forbs (Quinn and Walgenbach 1990, Sims and Gillen 1999) that may be beneficial to both nesting success and brood rearing, respectively. In Oklahoma, Copelin (1963) noted that LPCHs used moderately grazed pastures more frequently than heavily grazed pastures. In New Mexico, LPCHs used lightly grazed habitats during drought years but were able to use more heavily grazed habitats in years of near-average precipitation (Merchant 1982).

Habitat restoration. Prairie restoration from agricultural land to grassland has had mixed results on the LPCH. Conservation Reserve Program (CRP) grasslands may provide suitable habitat, but few data are available that quantify benefits of CRP to LPCHs (Rodgers 2000). Monoculture seedings have not provided additional habitat to LPCHs. One study is in progress to evaluate benefits of CRP fields as nesting habitat, and preliminary analyses suggest that a diversity of native tall grasses and forbs in CRP seed mixes is important (T. L. Fields, Colorado State University, personal communication). A new conservation practice aims to restore rare and declining habitats, but these plantings are not yet well established.

Agriculture. Conversion of native range to cropland probably is most responsible for declines in LPCHs, as it has directly impacted available nesting habitat and reduced numbers of breeding birds (Crawford 1974, Jamison 2000, Hagen 2003). Most agricultural practices in cropland are suspected to affect LPCH populations (Crawford 1974). Maximum numbers of LPCHs were found in areas in which 5–37% of the landscape was planted to grain sorghum using minimum-tillage techniques (Crawford 1974). Recently, conversion of grasslands to agriculture has slowed, as the number of hectares per year converted has not increased (Jensen et al. 2000, Woodward et al. 2001).

Energy development. Although abandoned oil-drilling sites frequently are used as lek sites, exploration and development for gas and oil production eliminated use of 2 leks and disrupted activity on a third lek in New Mexico over a 3-year period (Candelaria 1979, Davis et al. 1979). In Texas displaying males abandoned one lek after an elevated road was built across it (Crawford and Bolen 1976*b*). Power lines placed near leks may negatively affect breeding activity of males (C. A. Hagen, unpublished data) as raptors perching and hunting from these poles may result in reduced lekking activity. Acoustical disturbance (noise pollution) from oil or gas pumps also may affect lekking displays. Proposed wind-power-generation farms also may increase visual fragmentation of rangeland and cause abandonment of lekking sites. Pitman (2003) reported that females selected nest sites in southwestern Kansas that were significantly farther from anthropogenic features (e.g., power lines, pump-jacks, improved roads, and buildings) associated with energy development than expected at random

Table 4. Distances (m) to anthropogenic features from lesser prairie-chicken nest sites, use-sites and areas not likely to be frequented by lesser prairie-chickens (non-use), and areas absent of prairie chickens.

	Mean distances (± SE) to anthropogenic features[a]			
Feature	Nest sites (*n* = 187)	Use (*n* = 44)	Non-use (*n* = 38)	Absent sites (*n* = 46)
Power line	1,320 ± 66	1,106 ± 81	666 ± 80	705 ± 82
Wellhead	564 ± 22	435 ± 31	446 ± 31	323 ± 31
Building	2,129 ± 56	1,397 ± 106	1,061 ± 105	759 ± 108
Unimproved road[b]	214 ± 14	193 ± 18	178 ± 18	184 ± 19
Improved road	2,377 ± 150			
Agricultural edge	1,049 ± 47			
Nearest lek	709 ± 36			

[a] Distances for nests taken from Pitman (2003) and other use sites from Hagen (2003).

[b] Hagen (2003) did not differentiate between type of roads, and these distances likely reflect those of unimproved roads.

(Table 4). Hagen (2003) found that areas used by radiomarked male and nonnesting-female LPCHs were significantly farther from these same features than areas not used by LPCHs (Table 4). These studies indicated that LPCHs likely would use less-disturbed areas even though vegetation composition or structure may be similar between used and unused sites. Much research is needed to determine the effects of energy exploration and development on LPCHs.

Population management

Extrinsic factors

Weather. Impacts of weather on LPCH populations are not well known. However, an association appears to exist between production (i.e., age ratios in harvest) and precipitation (Brown 1978, Giesen 2000). Drier conditions result in sparse nesting cover and less food for chicks. Harvest levels in New Mexico were correlated positively with precipitation from the previous year (Brown 1978). Population trends in Colorado, as measured from lek counts, were correlated positively with the precipitation levels from 2 years prior to census (Giesen 2000).

Translocations. Generally, transplants to restore prairie grouse in unoccupied habitats have been successful (Synder et al. 1999). However, 3 states have conducted translocations of LPCHs with little success. Colorado released 155 birds during spring over a 6-year reintroduction attempt, but the effort was not successful (Giesen 2000). Texas unsuccessfully translocated 46 LPCHs during 2 years to supplement an existing population in a native vegetative community. Oklahoma translocated LPCHs in an attempt to re-establish 2 populations; one of these efforts failed and results of the other were undetermined (Horton 2000). It is likely that the numbers of birds released were too small and the quality of habitat at release areas was unsuitable to sustain these birds (Giesen 2000).

Hunting. The impact of modern-era sport hunting on the LPCH is unknown, although market hunting in the 1800s may have been detrimental to local populations (Jackson and DeArment 1963, Horak 1985, Johnson and Knue 1989). The lesser prairie-chicken once was hunted in all 5 states within its range (Giesen 1998). However, concerns over low populations led to closure of hunting seasons in the early 1900s in Colorado (Giesen 2000) and in the 1990s in New Mexico and Oklahoma (Bailey and Williams 2000, Horton 2000). Prairie-chicken harvests (i.e., harvested birds-per-hunter ratios) have declined over the long term (Figure 2). Currently, a 2-day season and a 2/4-bird bag/possession limit are allowed in Texas and a 2-month season and 1-bird bag and 4-bird possession limit are allowed in Kansas.

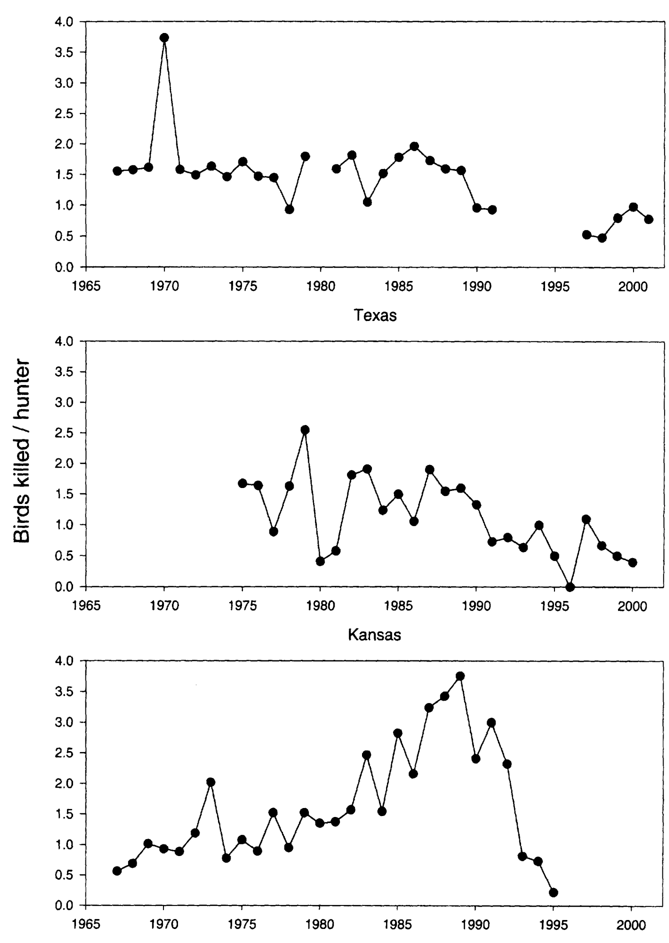

Figure 2. Annual lesser prairie-chicken harvests in Kansas, New Mexico, and Texas expressed as birds harvested per hunter. Note there are a number of years with missing data.

Intrinsic factors

Disease and parasites. There is a potential for intrinsic factors to limit LPCH populations (see Peterson this issue); however, most studies have not documented deleterious effects at the population level. Hagen et al. (2002) found low levels (<5%) of *Mycoplamsa* spp. antibodies in LPCH sera (n=162) in Kansas and concluded that such levels likely were not limiting to the populations. In Texas, Peterson et al. (2002) documented the first incidence of infectious bronchitis (a coronavirus) antibodies in LPCHs. If a coronavirus should become widespread in a population, the effects could be devastating, and Peterson et al. (2002) urged that further work be conducted to assess the prevalence of coronaviruses in LPCHs. Robel et al. (2003) reported the presence of helminthic parasites of *Tetrameres* spp. (stomach worm), *Oxyspirura petrowi* (eye worm), and *Subulura* spp. (caecal worm) in 92, 95, and 59% of LPCH carcasses (n= 93), respectively. Alternatively, incidence was lower in fecal samples of radiomarked individuals (n=46 parasitized birds, n=52 nonparasitized birds), but the presence of helminths did not measurably affect body mass, clutch size, nesting success, daily movements, or survival of radiomarked LPCHs (Robel et al. 2003).

Genetics. Van den Bussche et al. (2003) found that LPCHs in Oklahoma and New Mexico maintained high levels of genetic diversity at both nuclear and mitochondrial loci, but there was some structuring between states. Hagen (2003) extended the mitochondrial work of Van den Bussche et al. (2003) to include 5 populations from Kansas and 1 from Colorado. There was substantial population structuring and genetic diversity across the 4 states; notably, New Mexico had the fewest haplotypes. Much work is needed to identify genetically isolated populations and to determine whether there has been a loss of heterozygosity from population bottlenecks, as has been documented in greater prairie-chickens (Bouzat et al. 1998, Bellinger et al. 2003).

Management guidelines

The following guidelines reflect our current understanding of LPCH population ecology and habitat requirements. Because experimental data on the effects of habitat alterations and other management activities on LPCH populations are lacking or absent, these guidelines should serve as working hypotheses to be tested using the scientific method under the principles of adaptive resource management (Walters and Holling 1990). Using this approach, rigorous monitoring of management actions could provide practical information on effects of management on habitats and population responses.

Conservation strategies

We recommend that each state develop and implement conservation plans for LPCHs. These plans should use local groups comprised of representatives from all interested stakeholders to identify and solve regional issues within ecological regions. Conservation plans should include 1) quantity and quality of LPCH habitat remaining in the state, 2) common problems involved in conserving the LPCH, and 3) conditions needed to maintain healthy populations. Regional variations in vegetative communities (e.g., sand sagebrush, shinnery oak, mixed shrub, or grass dominated), weather, or resource use that affect populations and their management need to be considered in conservation plans. To date, only New Mexico has developed and is implementing such a plan (Massey 2001).

Because LPCH populations are nonmigratory or local migrants (i.e., migrations of ≤60 km), large ecological regions should be identified as LPCH management zones (Figure 3). We recommend that these zones cover ecological regions (e.g., Arkansas River Sand Hills) within a state, and that target areas no smaller than 64 × 64 km be identified in each zone (Figure 3), as this would encompass the longest known movements of individual birds (Hagen 2003). Identifying and prioritizing target areas will facilitate better field management and working relationships with private landowners, thus creating a framework for ensuring connectivity throughout a management zone. Concentrating habitat restoration and management efforts in target areas will ensure that funding and personnel resources are used efficiently. Given the fragmented nature of LPCH habitat, management zones will encompass large areas of unsuitable habitat (Figure 3). Identifying target areas where habitat restoration, management, and population monitoring are the most efficacious will facilitate protection and creation of large habitat blocks and maintain adequate levels of connectivity (Figure 3). These target areas should be ranked for management action based on existing habitat quality and quantity, LPCH populations, and the potential for LPCH to expand into a target area.

Macro-scale management specific to physiognomic and ecological characteristics of LPCH management zones could be conducted. A common set of recommendations that apply to the characteristics of a management zone would specify grazing regimes, furbearer harvest, and CRP plantings. Zone management should include LPCH population monitoring; inventory of habitat quantity, quality, and connectivity; and harvest regulations for states with open seasons.

Habitat guidelines

There is little question that prairie-chickens are area-

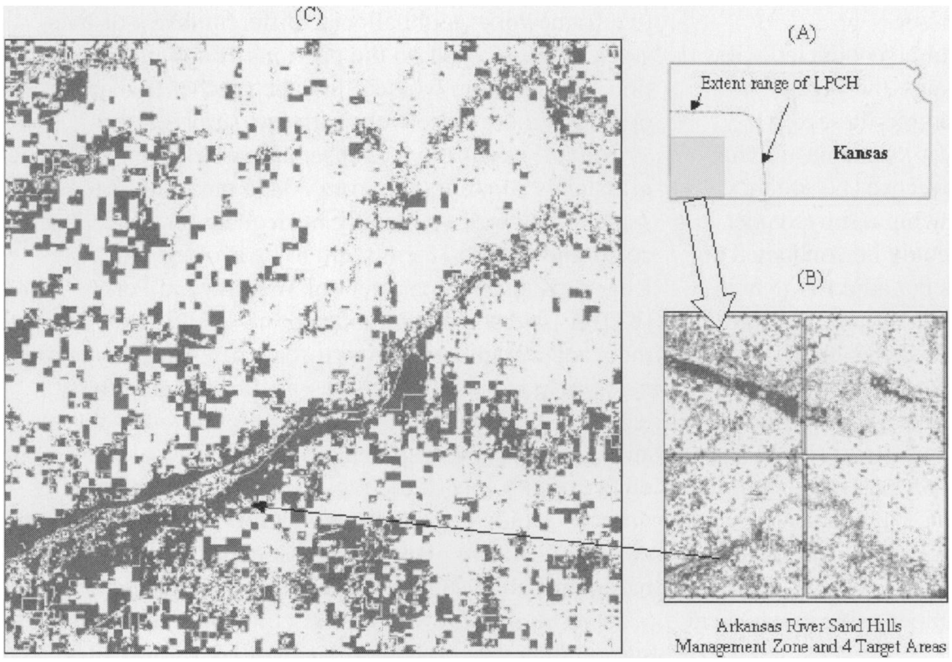

Figure 3. An LPCH Management Zone (gray box) should encompass an ecological region, as in the sand sagebrush prairies of southwestern Kansas (A), target areas are identified based on 64 × 64-km subdivisions (4 black outlines) within the management zone (B), and specific habitat patches (habitat in gray, non-habitat in white) can be monitored and managed within a target area (C). The target area in Figure 1C includes the Cimarron National Grassland along the Cimarron River, Kansas.

sensitive species, and large quantities of habitat are essential for population growth. However, habitat quality is of equal importance. The population ecology of LPCH (i.e., reproductive potential and relatively stable mortality rates in specific habitats) strongly suggests that increasing breeding success is the key to increasing numbers of birds (Bergerud 1988, Wisdom and Mills 1997, Jamison 2000, Hagen 2003). Thus, LPCH habitat management should focus on providing adequate cover for nesting and brood rearing, given the specific cover requirements of certain habitats. Cover needs are greatly increased where predation pressure is high (Bergerud 1988).

Breeding habitat. Protect, maintain, and restore ≥2,000-ha tracts of native shinnery oak–tallgrass or sand sagebrush grassland within LPCH management zones. These areas must be large enough and close enough to other patches (≤30 km) to support viable LPCH populations during drought. However, tracts that are smaller (≥500 and ≤2,000 ha) but with high connectivity (≤10 km spacing) also should be included in such efforts. Maintain ≥63% native grassland (Crawford 1974) and stabilize land-use practices in these landscapes managed for LPCHs, and conserve shrub-dominated or grassland communities within ≥3.5 km of lek sites because most nesting occurs within this radius (Giesen 1998, Woodward et al. 2001, Pitman 2003).

Nesting. Provide dense shrubs and residual bunchgrasses >40 cm tall that provide >75% vertical screening in the first 33 cm above ground and 50% overhead cover for quality nesting habitat. In shinnery oak communities, sand bluestem (*Andropogon* spp.) that is ≥50 cm in height provides suitable nesting cover. Maintain or increase shrub cover in sand sagebrush communities (particularly in areas where taller species of grass have been reduced by grazing practices). Manage grazing to maintain adequate height (≥25 cm) and density of residual grasses and forbs. Consider fencing areas (≥1.6 km^2) to prevent grazing during the nesting season; because breeding females generally space their nests to avoid predation pressure, fencing small areas will not provide nesting cover for significant numbers of females. Evaluate the feasibility of predator removal efforts to enhance nesting success of imperiled populations in small areas (<2,000 ha) of habitat (Bergerud 1988, Schroeder and Baydack 2001). Predator removal can increase nest success of prairie grouse (Lawrence and Silvy 1995) and other ground-nesting birds (Garretson et al. 1996, Witmer et al. 1995), but long-term intensive management may not be economical. Passive predator management, through relaxation of restrictions on harvest, take, or opportunistic gunning of certain furbearers, should be considered within the boundaries of management zones. Nesting habitats should be interspersed with brood habitats to facilitate easier movements of young broods between habitats and reduce predation or starvation rates (Bergerud 1988, Pitman 2003).

Brood rearing. Provide habitat with 20–40% canopy of shrubs, forbs, or grasses that are 24–30 cm in height. In shinnery oak communities, provide vegetation dominated by warm-season grasses and shinnery oak with about 60% bare ground (Riley and Davis 1993). Provide vegetation composed of about 43–60% grasses, 24–43% shrubs (primarily shinnery oak), and 13–26% forbs (Riley and Davis 1993). This diversity of vegetative species and structure is important for providing the proper substrate for insects needed by juvenile LPCHs (Riley and Davis 1993, Jamison et al. 2002*b*).

Burning. Prescribed burns should be conducted with great caution in LPCH habitats because the vegetative response to fire is not well understood in these xeric grasslands (Engle and Bidwell 2001). Some nesting habitats may require 7 years or more to recover before they provide adequate concealment following a fire (Synder 1997). Experimental spring burns could be conducted at sites recently abandoned by LPCHs but adjacent to areas still inhabited. Conserve shinnery oak motts and protect oak bud, mast, and catkin production (Boyd et al. 2001) in relatively mesic shinnery oak communities by discing firebreaks around motts, and avoid annual burning of large areas to conserve residual nesting cover (Boyd and Bidwell 2001, Harrell et al. 2001). Alternatively, burning may be an advantageous tool to reduce juniper (Wright 1974) or mesquite (*Prosopis* spp.) encroachment (Harrell et al. 2001). Given the conservative use of fire in LPCH range, we recommend managing juniper using mechanical removal techniques when possible.

Grazing. A grazing system that maintains middle to late stages of plant succession interspersed with early stages of plant succession is optimal for LPCHs (Bidwell 2003). To achieve this heterogeneity, grazing systems must incorporate periods of rest to prevent excessive grazing. Because excessive grazing yields lower-quality concealment cover and reduces foraging habitat (particularly for nesting and brood rearing) continuous grazing is not recommended (Bidwell 2003). Alternatively, we recommend light or moderate grazing that will ensure 60–70% of key herbaceous species (Holochek et al. 1989) will be available as residual nesting cover (Berg et al. 1997, Snyder 1997, Sims and Gillen 1999). At least 20–30% of a pasture should be rested completely in rotations of about once every 3–5 years (Fuhlendorf and Engle 2001, Bidwell 2003), and this vegetative response can be maintained using patch-burning methods in which 20–30% of an area is burned annually (Bidwell 2003). Livestock preferentially graze recently burned patches, leaving the remaining 70–85% in various successional stages. No data are available on the effects of deferred grazing systems (which postpone grazing until grassland plants have matured) or rest–rotation grazing systems (which involve multiple pastures through which livestock are rotated) on LPCH populations, but appropriate use of these systems probably would create suitable interspersion of different vegetation heights (Manely et al. 1997). Large pastures and fewer livestock water sources also will result in a diversity of grazing pressures at the landscape level. We suggest an adaptive grazing strategy that would adjust stocking rates and season of use based on grazing system and annual precipitation. One such adaptive framework would allocate different levels of livestock grazing based on the previous 12 months' precipitation. This system would allow the rancher to manage the operation more effectively with few surprises.

Habitat restoration. Conservation Reserve Program grasslands should range from 30–75 cm in height, as stands <30 cm are generally inadequate for concealment cover and those >75 cm seem to be avoided (R. D. Rogers, Kansas Department of Wildlife and Parks [KDWP], personal communication). Multispecies seedings create height and growth-form heterogeneity and must include native bunchgrasses, forbs (particularly legumes, important for structure and as a food source), and native shrubs. Aggressive grasses that can crowd out other components of the mixture or grass monocultures must be avoided (R. D. Rogers, KDWP, personal communication). Native plant communities should be restored based on USDA-NRCS Ecological Site Guides.

Agriculture. Prevent further cultivation of grassland surrounding leks and disturbance of lek or nest sites because such activities directly cause habitat loss. However, planting small grains or corn in existing agricultural fields adjacent to native prairie can provide additional winter food sources. Minimum tillage techniques will reduce soil erosion and may benefit LPCHs that are using the fields.

Brush treatments. Much research is needed to demonstrate effects of brush treatments on LPCHs. Minimize the use of herbicides, except to control invasive nonnative vegetation. However, if herbicides must be used, we recommend that such treatments not reduce sand sagebrush or shinnery oak to less than 25% of the canopy within one year after treatment. Shrub removal treatments should create a mosaic of treated and untreated areas to provide an interspersion of vegetative structures dominated by grasses and shrubs for nesting cover and areas with a diversity of vegetation for brood rearing, foraging, and adult autumn and winter cover. To create a mosaic of vegetative structures, apply tebuthiuron in strips ≤10 m wide at rates of 0.2–0.4 kg/ha. Such treatments should be applied with a tractor-mounted sprayer (Snyder 1997). Preserve small (≤10-ha) motts of tall shinnery oak that produce mast crops by excluding these areas from herbicide applications. Treat shrubs in contour strips on a 10-year rotation to provide suitable interspersion of nesting and brood-rearing habitats while reducing wind erosion of sandy soils (Jamison et al. 2002*a*). Avoid annual chemical brush treatment of large areas because this may reduce LPCH production (Wiedenfeld et al. 2001). Woody vegetation >3 m in height also should be thinned using mechanical methods when possible. Similar protocols should be followed with mechanical treatment of

LPCH habitat to ensure that a mosaic of habitats is provided.

Energy development. Oil and natural-gas exploration drill pads may create areas that are suitable for lek sites, but lek sites generally are not limiting to the species. The disturbance associated with exploration and production of petroleum may destroy nesting habitat or cause lek or nest abandonment and should be discouraged. If construction is unavoidable, it should occur outside of the breeding, nesting, or early brood-rearing seasons. Thus we recommend that all construction and extraction be avoided from 15 March–15 July. We also recommend that wind turbines or other large vertical structures be constructed >2 km from known or potentially occupied LPCH habitat. If such structures must be placed in known LPCH habitat, they should be positioned along the prairie edge or clustered in sites with other disturbances.

Population guidelines

Population monitoring. It is imperative that survey methodologies and effort be standardized for estimating spring populations and recruitment across the range. Improvements to lek survey methods are worthwhile (Schroeder et al. 1992, Giesen 2000) but will require time and research to develop. Specifically, future research is needed to determine the relationship of lek surveys to 1) number of nesting females, 2) variation in total population size, and 3) actual densities of leks and breeding birds. In the interim, surveys that attempt to count all leks in areas known to be occupied, where occurrence is likely, and that may be restored should be implemented by wildlife and natural resource agencies rangewide (Davison 1940, Hamerstrom and Hamerstrom 1973). This should include surveying known leks and potential sites at least 3 times during the peak of breeding (approximately 21 March–21 April) and between the 30 minutes before and no later than 1 hour after sunrise (Crawford and Bolen 1975), on days with wind ≤ 16 km/hr and no precipitation.

Once methods have been standardized, spring populations of LPCHs should be monitored using lek survey methods to count all active leks and search potential areas for new or satellite leks within LPCH management zones. Once breeding populations have been identified in these management zones, lek surveys can be used to monitor long-term population trends. Lek surveys may provide an index to the size of the breeding population and may detect long-term changes in policy or land use that impact LPCH populations (Beck and Braun 1980). In the absence of mark–recapture studies and harvest information (sex and age ratios), lek surveys are the primary method of estimating minimum spring breeding populations. In states where LPCHs are hunted, age ratios are difficult to estimate, given the low harvest rates and the trophy status of the species (i.e., hunters probably are not willing to contribute wings or other parts).

Additionally, methods for evaluating recruitment rates are important tools for monitoring management actions. We recommend that brood survey methods be developed that can be implemented and compared within each of 3 habitats of the LPCH. Ideally, such methods could be compared between habitat types.

Hunting. Current levels of harvest in Texas and Kansas appear to be low enough that populations should not be impacted. However, hunter surveys and lek counts should ensure that local areas are not overharvested. We recommend a permit system (similar to that implemented by Texas) specific to hunting LPCHs, which should facilitate more efficient recording of harvests. Where possible, the use of check stations would allow evaluation of hunter success, production of juveniles, and monitoring of sex ratios.

Translocations. Future translocations must first quantify the quality of the nesting and brood-rearing habitat at the release area; then the success of translocations should be evaluated using radiotelemetry, lek monitoring, and brood surveys. Because numbers of meso-mammal predators may be elevated in fragmented landscapes and because those predators may enjoy easier access to females nesting near habitat edges, predator-control efforts implemented immediately before and after releases of birds may prove advantageous to newly supplemented or translocated populations (Lawrence and Silvy 1995). Once populations are established, predator-control efforts may no longer be cost-effective or necessary.

Conclusions

Although the rate of habitat loss has slowed over the past 20 years, LPCH population trends continue to decline, suggesting that it is the quality (i.e., human-induced or drought) of the habitat that may be limiting the recovery of these populations. Reliable knowledge is needed on restoration, the characteristics of healthy grassland and steppe ecosystems, and the relationship of grazing and LPCH production. Field experiments are needed that measure the effects of various levels of grazing pressure on nest success, chick survival, and invertebrate abundance. Other management tools for habitat maintenance (e.g., brush treatments) and restoration (e.g., CRP) also require experimental manipulations to evaluate the best management practices for LPCHs.

Acknowledgments. We thank D. M. Davis, S. J. DeMaso, R. D. Rogers, and T. L. Fields for access to unpublished data sets. R. J. Robel provided useful discussions on area requirements. Two anonymous reviewers and N. J. Silvy provided useful comments on an earlier draft of this manuscript. T. G. Bidwell provided a review and suggestions on the rangeland management content. This project was supported in part by Kansas State University's Division of Biology Colorado Division of Wildlife, and Texas Department of Parks and Wildlife (W-167-R).

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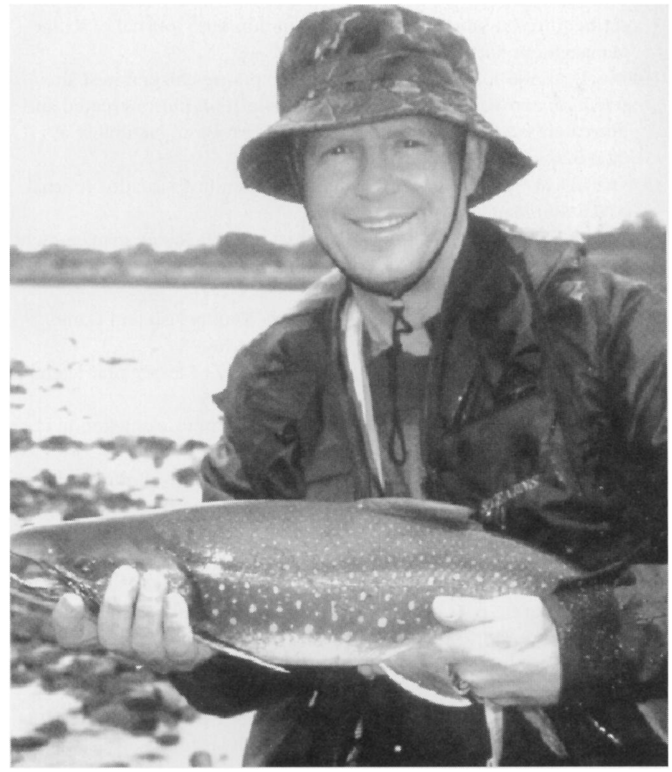

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Special section associate editor: *Silvy*