The Effects of Management Practices on Grassland Birds—Lark Sparrow (*Chondestes grammacus*)

Chapter DD of

The Effects of Management Practices on Grassland Birds

Professional Paper 1842–DD

U.S. Department of the Interior
U.S. Geological Survey

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By Jill A. Shaffer,[1] Lawrence D. Igl,[1] Douglas H. Johnson,[1] Marriah L. Sondreal,[1] Christopher M. Goldade,[1,2] Barry D. Parkin,[1] and Betty R. Euliss[1]

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Edited by Douglas H. Johnson,[1] Lawrence D. Igl,[1] Jill A. Shaffer,[1] and John P. DeLong[1,3]

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Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square meter (m^2)	0.0002471	acre
hectare (ha)	2.471	acre
hectare (ha)	0.003861	square mile (mi^2)

Abbreviations

2,4,5–T	2,4,5–Trichlorophenoxyacetic acid
AUM	animal unit month
BBS	Breeding Bird Survey
CRP	Conservation Reserve Program
DDT	dichlorodiphenyltrichloroethane
spp.	species (applies to two or more species within the genus)

Acknowledgments

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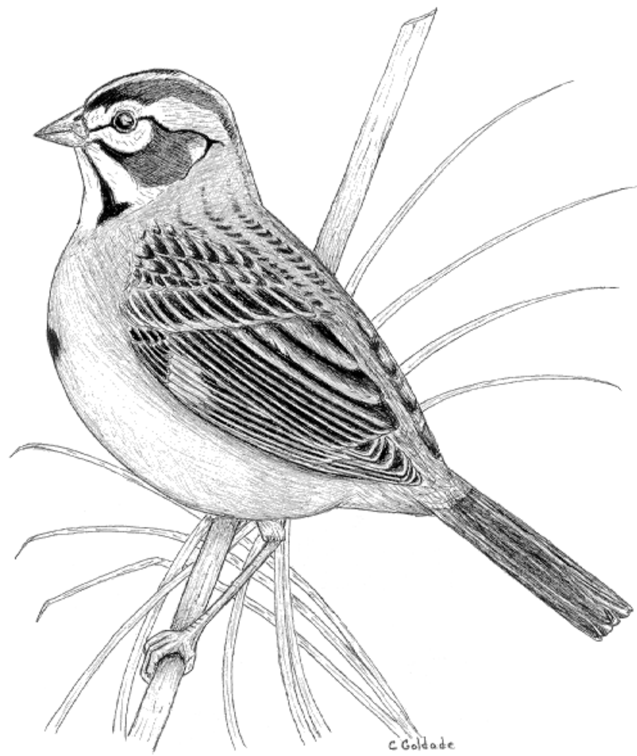
By Jill A. Shaffer,[1] Lawrence D. Igl,[1] Douglas H. Johnson,[1] Marriah L. Sondreal,[1] Christopher M. Goldade,[1,2] Barry D. Parkin,[1] and Betty R. Euliss[1]

Capsule Statement

Keys to Lark Sparrow (*Chondestes grammacus*) management include providing open grasslands with sparse-to-moderate herbaceous and litter cover and a woody component and allowing occasional burning or moderate grazing. Lark Sparrows have been reported to use habitats with 10–63 centimeters (cm) average vegetation height, 10–54 percent grass cover, 9–25 percent forb cover, 4–18 percent shrub cover, 16–38 percent bare ground, 12–45 percent litter cover, and less than or equal to (≤) 1 cm litter depth. The descriptions of key vegetation characteristics are provided in table DD1 (after the "References" section). Vernacular and scientific names of plants and animals follow the Integrated Taxonomic Information System (https://www.itis.gov).



Lark Sparrow. Illustration by Christopher M. Goldade, U.S. Geological Survey.

Breeding Range

Lark Sparrows breed from southern British Columbia to southern Manitoba; south to southern California and southern Texas; and east to western North Carolina, western Ohio, and southern Michigan (National Geographic Society, 2011). Historically, the species' breeding range was limited to western North America, but it expanded northward with the settlement of the prairies (Houston and Houston, 2001) and eastward with the clearing of forests (Fortin and others, 2005). The relative densities of Lark Sparrows in the United States and southern Canada, based on North American Breeding Bird Survey (BBS) data (Sauer and others, 2014), are shown in figure DD1 (not all geographic places mentioned in report are shown on figure).

Suitable Habitat

The Lark Sparrow is a habitat generalist that inhabits grasslands containing or adjoining scattered trees and shrubs (Martin and Parrish, 2020). Lark Sparrows breed in a variety of grassland habitats, including shortgrass, mixed-grass, and tallgrass prairies that are idle, burned, hayed, or grazed (Rand, 1948; Kahl and others, 1985; Walley, 1985; Sample, 1989; Bock and Bock, 1992; Kaspari and Joern, 1993; Bock and others, 1995, 1999; Faanes and Lingle, 1995; Lusk and others, 2003; Fuhlendorf and others, 2006), as well as semiarid grasslands and shrubsteppe and sagebrush (*Artemisia* species [spp.]) habitats (Cameron, 1908; Walcheck, 1970; Wiens and Rotenberry, 1981; Earnst and Holmes, 2012; Holcomb and others, 2014; Andersen and Steidl, 2019; Davis and others, 2019). The species inhabits oak (*Quercus* spp.) savannas and oak barrens (Davis and others, 2000; Cunningham and others, 2006; Wood and others, 2011; Bar-Massada and others, 2012; Vos and Ribic, 2013; Crosby and others, 2015;

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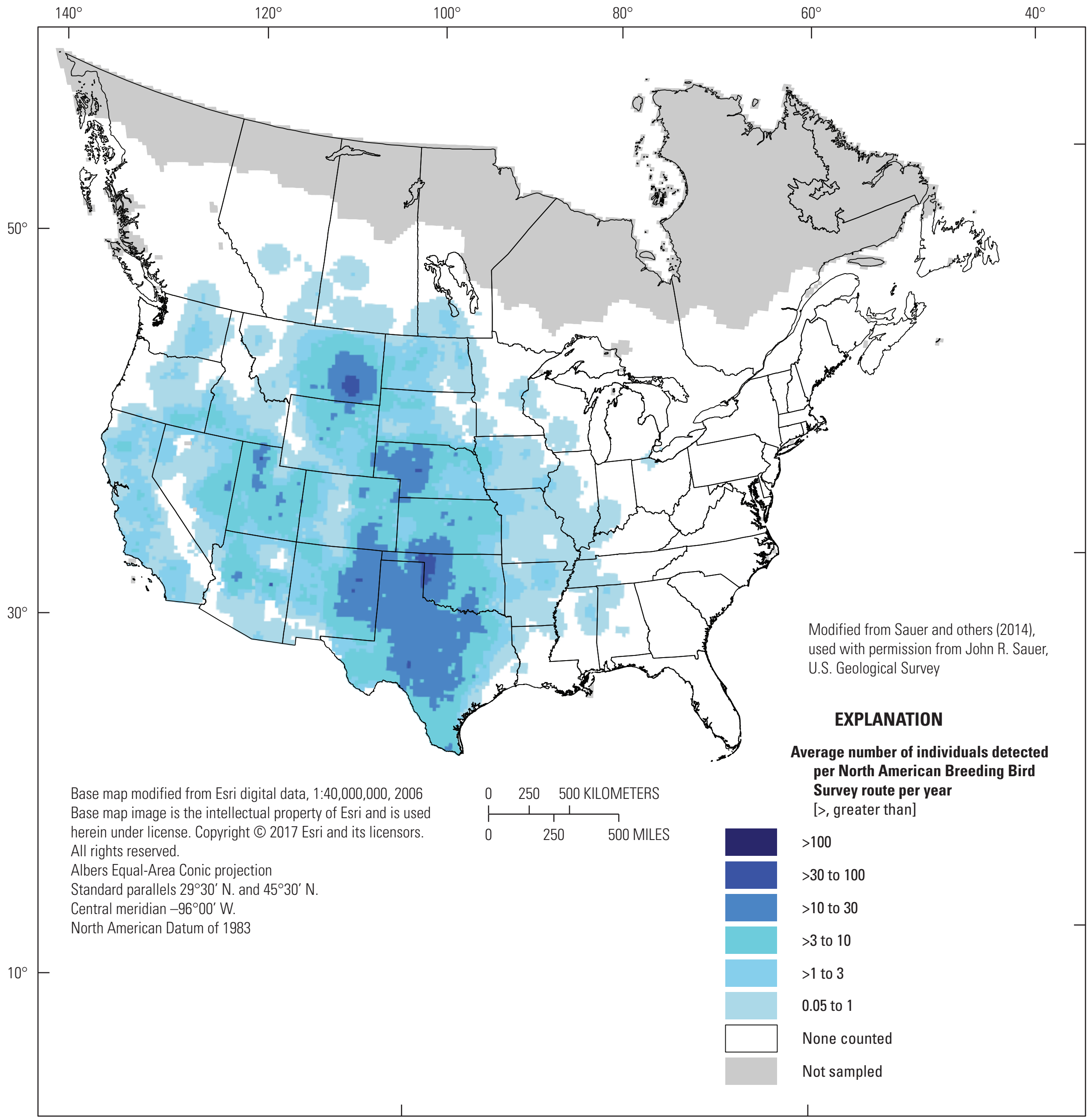

Figure DD1. The breeding distribution of the Lark Sparrow (*Chondestes grammacus*) in the United States and southern Canada, based on North American Breeding Bird Survey (BBS) data, 2008–12. The BBS abundance map provides only an approximation of breeding range edges.

Holoubek and Jensen, 2015; Young and others, 2015), wooded draws, windbreaks, shrub thickets, lowland forests, and pine (*Pinus*)-juniper (*Juniperus*) woodlands (Walcheck, 1970; Stewart, 1975; Salt and Salt, 1976; Faanes, 1983; Wershler and others, 1991; Cable and others, 1992; Faanes and Lingle, 1995; Pavlacky and others, 2012; Fleishman and others, 2014; Drilling and others, 2016). Suitable habitats also include riparian habitats and wet meadows (Helzer, 1996; Prescott, 1997; Helzer and Jelinski, 1999; Tsai and others, 2012). The species inhabits edges between habitat patches, such as those between woodland and grasslands; successional habitats, such as old-fields (that is, idle or neglected arable lands that have naturally reverted back to perennial cover) (Rising, 1974; Dinsmore and others, 1984; Wershler and others, 1991; Zimmerman, 1993; Best, 2001; Martin and Parrish, 2020); cultivated and weedy fields (Newman, 1970; Stewart, 1975; Walley, 1985); black-tailed prairie dog (*Cynomys ludovicianus*) colonies (Barko and others, 1999; Tyler and Shackford, 2002; Smith and Lomolino, 2004; Goguen, 2012); and residential areas (Baepler, 1968; Salt and Salt, 1976).

In western Canada and western United States, the Lark Sparrow readily uses sagebrush habitats. In British Columbia and Washington, Knight and others (2016) categorized the Lark Sparrow as a sagebrush specialist. Within shrubsteppe habitats in British Columbia, Lark Sparrow abundance was negatively related to ponderosa pine (*Pinus ponderosa*) density (Krannitz, 2007), and Lark Sparrows preferred habitats with more bare soil and less grass cover (Krannitz and Rohner, 2000). In southeastern Washington, Lark Sparrow abundance was higher in areas of big sagebrush (*Artemisia tridentata*) than in areas of threetip sagebrush (*Artemisia tripartita*), native bluebunch wheatgrass (*Pseudoroegneria spicata*), or invasive cheatgrass (*Bromus tectorum*) (Earnst and others, 2009; Earnst and Holmes 2012). In another study in southeastern Washington, soil type and range condition of shrubsteppe communities did not affect Lark Sparrows (Vander Haegen and others, 2000). No significant differences in Lark Sparrow abundance were detected among loamy, sandy, or shallow soils and range conditions of good, fair, and poor. Throughout southern and central Idaho, Lark Sparrow occupancy was highest at higher values of shrub height and variability in this height and at moderate levels of shrub coverage. In Oregon and Nevada, Lark Sparrow abundance was positively related to sagebrush cover (Wiens and Rotenberry, 1981). In Nevada, Lark Sparrows preferred crested wheatgrass (*Agropyron cristatum*) plantings that were invaded by sagebrush more so than areas that were dominated solely by sagebrush or crested wheatgrass; Lark Sparrow abundance was negatively associated with sagebrush density (McAdoo and others, 1989). In southeastern Arizona, Andersen and Steidl (2019) found that Lark Sparrow occupancy peaked at 15 percent woody cover; occupancy was lower below and above 15 percent woody cover. In another Arizona study, Bock and Webb (1984) observed that Lark Sparrows usually flushed near mesquite (*Prosopis juliflora*). In northwestern New Mexico, Lark Sparrows inhabited grasslands dominated by big sagebrush and pinyon pine (*Pinus edulis*)-Utah juniper (*Juniperus osteosperma*) woodlands (Ortega and Francis, 2012). In northeastern New Mexico, Lark Sparrows used shortgrass prairies interspersed with broom snakeweed (*Gutierrezia sarothrae*), pricklypear cactus (*Opuntia* spp.), fringed sagebrush (*Artemisia frigida*), cane cholla (*Cylindropuntia imbricata*), and fourwing saltbush (*Atriplex canescens*) (Goguen, 2012).

Throughout the Great Plains, the Lark Sparrow inhabits grasslands with a woody component. In Alberta, Lark Sparrows occupy semi-open grasslands and parklands, particularly ecotones between grassland and areas dominated by eastern cottonwood (*Populus deltoides*) and sagebrush, such as found in river valleys, coulees, and sandhills, as well as at the edge of cultivated uplands, but are absent on open prairies (Rand, 1948; Salt and Salt, 1976; Wershler and others, 1991). In southern Manitoba, Taylor (2018) described the species' habitat as lightly wooded, sandy terrain, whereas Maher (1974) wrote that the Lark Sparrow was an uncommon resident of wooded and brushy coulees. In Montana, Lark Sparrows inhabit mixed-grass prairies, badlands, pine-juniper woodlands with a sagebrush and greasewood (*Sarcobatus vermiculatus*) component, and big sagebrush shrubsteppe (Cameron, 1908; Walcheck, 1970; Bock and Bock, 1987). In North Dakota, Lark Sparrows inhabit weedy fields and grassland/woodland edges that include some woody vegetation, including Rocky Mountain juniper (*Juniperus scopulorum*), green ash (*Fraxinus pennsylvanica*), bur oak (*Quercus macrocarpa*), chokecherry (*Prunus virginiana*), red-fruited hawthorn (*Crataegus chrysocarpa*), silver buffaloberry (*Shepherdia argentea*), Woods' rose (*Rosa woodsii*), and silver sagebrush (*Artemisia cana*) (Stewart, 1975). In South Dakota, Lark Sparrows primarily use edge habitats near woodlots, shelterbelts, and pastures (Drilling and others, 2016). Sieg (1991) recorded the species within Rocky Mountain juniper woodlands in Badlands National Park in South Dakota, and Pavlacky and others (2012) recorded the species within the ponderosa pine forests along the South Dakota and Wyoming border.

Along the Platte River in Nebraska, Faanes and Lingle (1995) observed the species most often in native grasslands that were experiencing encroachment by Rocky Mountain juniper and that contained an abundance of soapweed yucca (*Yucca glauca*). In wildlife management areas in southern Nebraska, Stuber and Fontaine (2018) estimated that the ideal proportion of grassland and woodland for Lark Sparrows was 0.53 and 0.31, respectively. Williams and others (2011) examined the relationship between Lark Sparrow density and rangeland ecological-site characteristics for Colorado shrubsteppe habitats. Lark Sparrow densities were highest in loamy and sandy soils that were characterized by open-canopy plant communities with short (less than [<] 100 cm), scattered shrubs. Lark Sparrows were rarely found in saline lowland sites characterized by tall, dense shrubs. The species responded more strongly to the horizontal and vertical characteristics of the plant communities than to species composition (Williams and others, 2011). Within the Nebraska Sandhills, Lark Sparrow abundance was most strongly related to ecological sites; abundance was highest at 5 birds per plot on choppy sands ecological sites, 3 birds on sands or choppy sands complex sites, <2.5 birds on sands ecological sites, and <2 birds on sandy ecological sites (Sliwinski and others, 2019).In Colorado, Kansas, Nebraska, and Oklahoma, Lark Sparrow occurrence was 11 percent in shortgrass prairies and 4 percent in both dryland agriculture and Conservation Reserve Program (CRP) fields; mean occurrence of Lark Sparrows was greatest in grasslands where greater than (>) 75 percent of the grass was taller than 15 cm and shrub coverage was 3–10 percent (McLachlan, 2007). In the sand sagebrush (*Artemisia filifolia*) grasslands of northwestern Oklahoma, Lark Sparrow abundance was negatively related to vegetation height and positively related to coverage of dead eastern redcedar (Doxon, 2009).

Within the Rolling Plains ecoregion of the Texas Panhandle, a transition zone between mixed-grass and shortgrass prairies, Lark Sparrows inhabit grasslands invaded by woody plants and forbs such as honey mesquite (*Prosopis glandulosa*), cholla cactus (*Cylindropuntia* spp.), catclaw mimosa (*Mimosa aculeaticarpa*), sand sagebrush, pricklypear (*Opuntia phaeacantha*), common broomweed (*Amphiachyris dracunculoides*), and soapweed yucca (Long and others, 2012; Roberts and others, 2012; Tsakiris and others, 2013). In central Texas, Lark Sparrows inhabit areas with tobosagrass (*Hilaria mutica*) and an overstory of honey mesquite and lotebush (*Ziziphus obtusifolia*) (Renwald, 1977). In southern Texas, Lark Sparrows inhabit grassland and mesquite woodlands (Davis and others, 2019). In southern Texas mixed-brush shrublands, Lark Sparrows were 73 percent more abundant on areas in which >50 percent of grass species were native compared to areas in which >50 percent of grass species were nonnative (Flanders and others, 2006). In another southern Texas study, Lark Sparrow occurrence increased 27 percent for every 10 percent increase in tanglehead (*Heteropogon contortus*), a native grass species that has invaded and become dominant in areas with clay loam soils (Bielfelt, 2013).

Throughout their range, Lark Sparrows commonly inhabit savanna habitats. Within the tallgrass prairies of the Sheyenne National Grassland of North Dakota, Lark Sparrows were most likely to occur in bur oak savannas containing <40 percent tree coverage within 200-meter (m) belt transects (Cunningham and Johnson, 2012). In open landscapes in the Sheyenne National Grassland, Lark Sparrow probability of occurrence increased in response to increasing levels of proximate tree cover (that is, within 100 m around sample locations), whereas in wooded landscapes, probability of occurrence decreased in response to increasing levels of proximate tree cover (Cunningham and Johnson, 2011, 2016). In the Anoka Sandplains of Minnesota, Lark Sparrows inhabited oak savannas and woodlands dominated by bur oak, northern pin oak (*Quercus ellipsoidalis*), and northern red oak (*Quercus rubra*) (Davis and others, 2000; Au and others, 2008; Davis and Miller, 2018). In Wisconsin, Lark Sparrows inhabited oak savannas (defined as 5–50 percent tree cover) and woodlands (>50 percent tree cover) dominated by bur oak, pin oak, red oak, white oak (*Quercus alba*), black oak (*Quercus velutina*), jack pine (*Pinus banksiana*), and black cherry (*Prunus serotina*) (Wood and others, 2011; Bar-Massada and others, 2012; Vos and Ribic, 2013). In the Cross Timbers ecoregion of Kansas, Lark Sparrow occupancy in oak savannas declined as shrub density within 50 m of point counts increased, indicating a preference for savannas (defined as 1–25 percent canopy cover) over woodlands (25–60 percent canopy cover); dominant oak species were blackjack oak (*Quercus marilandica*) and post oak (*Quercus stellata*) (Holoubek and Jensen, 2015). In northern Texas, Lark Sparrows occupied shrubland savanna pastures dominated by honey mesquite and lotebush (Lee, 2006). In California, oak woodlands occupied by Lark Sparrows were dominated by blue oak (*Quercus douglasii*) (Young and others, 2015).

In the eastern portion of their range, Lark Sparrows are generally considered a species of transitional and marginal habitats, such as the edges between agricultural fields and brushy and sandy grasslands (Graber and Graber, 1963; Dinsmore and others, 1984; Best, 2001). In Nebraska, Puckett and others (2009) determined the primary use area (that is, the functional edge) for birds foraging in crop fields adjacent to woody edges; Lark Sparrows foraged in crop fields at all five distances (0–10, 10–20, 20–30, 30–40, and 40–50 m) outward from adjacent woody edges but typically foraged near the edge within 10–20 m.

Lark Sparrows are occasionally found in fields enrolled in the CRP or Permanent Cover Program or in fields of dense nesting cover (Johnson and Schwartz, 1993; Hull and others, 1996; Best and others, 1997; Klute and others, 1997; McMaster and Davis, 1998; McLachlan, 2007; Riffell and others, 2008, 2010; Igl, 2009). In north-central Missouri, Lark Sparrows were reported using CRP fields planted to cool-season grasses and CRP fields planted to warm-season grasses (McCoy and others, 2001). In Nebraska, Kansas, and Missouri, Lark Sparrow abundance was negatively related to patch density of CRP grass-based practices (as opposed to tree-based practices) and negatively related to recently established CRP grass habitat where succession had not yet progressed beyond an early seral stage (<4 years since establishment), indicating a preference for clumped arrangements of CRP habitat and older CRP habitat, respectively (Riffell and others, 2010). In Colorado, Kansas, Nebraska, and Oklahoma, McLachlan (2007) found that Lark Sparrows were significantly more abundant in shortgrass prairies than in CRP grasslands that were planted to tame or native grass and legume species (plant species not provided). In south-central Kansas (Hickman and others, 2006) and north-central Oklahoma (Chapman and others, 2004; George and others, 2013), Lark Sparrows were more abundant in native mixed-grass prairies than in CRP fields planted to monocultures of tame yellow bluestem (*Bothriochloa ischaemum*).

Lark Sparrows place their nests on the ground or close to the ground in woody vegetation (Ely, 1957; Baepler, 1968; Newman, 1970; McNair, 1985). Ground nests may be located in areas of sparse ground cover such as those areas associated with burning, moderate-to-heavy grazing, and poor or eroded soils (Fitch, 1958; Graber and Graber, 1963; Baepler, 1968; Kahl and others, 1985; Walley, 1985; Sample, 1989; Zimmerman, 1993; Prescott, 1997; Grigore, 1999), or in idle fields, lawns, and cemeteries (Baepler, 1968; Salt and Salt, 1976; Walley, 1985). Ground nests often are placed at the base of a plant (Rand, 1948; Ely, 1957; Baepler, 1968; Rising, 1974). In Montana, Cameron (1908) found an unspecified number of nests within pine hills, badlands, and open mixed-grass prairies and remarked that nests were always under sagebrush. Also in Montana, Walcheck (1970) found seven of eight nests placed under big sagebrush and observed that the granular soil under big sagebrush was a characteristic of the species' nest site; the eighth nest was placed under greasewood. In North Dakota mixed-grass pastures, Lark Sparrows built their nests in areas with greater litter depth than was available at random points, but daily nest survival declined with an increase in litter depth (Mack, 2017). A habitat simulation model produced by Lusk and others (2003) for Lark Sparrows in Oklahoma grazed mixed-grass prairies characterized nest sites as areas with <87 percent bare ground, <74 percent litter cover, and >9 percent structural vegetation cover (that is, plants that provided suitable nesting substrates); and that were <270 cm away from structural elements (that is, any plant that provided nesting structure similar to woody plants, regardless of whether the plant was woody or herbaceous). Successful nest sites had less bare ground cover and more litter cover than unsuccessful nests (means of 6 compared with 17.5 percent and 18 compared with 10 percent, respectively). In an Oklahoma study within oldfields, tame pastures, and residential lawns, five of 13 nests were placed on the ground and 8 were placed in woody vegetation <4 m above the ground (Ely, 1957). In Oklahoma tallgrass prairies, 14 Lark Sparrow nests were built from 0 to 210 cm above the ground (Reinking and others, 2009). In Oklahoma sand sagebrush grasslands, ground-nesting Lark Sparrow nests had higher grass, forb, shrub bare ground, and live vegetation cover and less litter and shorter plant height than random sites (Doxon, 2009).

Above-ground nests may be in various species of shrubs, saplings, small trees, and cactus (Baepler, 1968; Newman, 1970; McNair, 1985; Igl and Kantrud, 2003; Suedkamp Wells and Fuhlendorf, 2005; Doxon, 2009; Long and others, 2012). In Ohio oak (*Quercus* spp.) savannas, Grigore (1999) reported that litter cover and vegetation density were the major determinants of successful Lark Sparrow nests. Successful nests had a median of 9 percent grass cover, 19 percent dewberry (*Rubus* spp.) cover, <51 percent bare ground cover, and <20 percent shrub cover; an average of 6.5 percent litter cover; and higher vegetation density than unsuccessful nests. In sand sagebrush grasslands, tree-nesting Lark Sparrows nests had higher forb, shrub, and live vegetation cover and visual obstruction readings than random sites, but lower grass cover; the species nested within the skeletons of dead cedar trees (Doxon, 2009). In a shrubland savanna pasture in northern Texas, Lark Sparrow nest sites had higher visual obstruction and lower percentage grass cover than random sites; successful (fledged at least one Lark Sparrow young) nests had lower percentage grass cover than unsuccessful nests (Lee, 2006). In a nesting study of four vegetation types in southern Texas, Davis and others (2019) found Lark Sparrows nesting in early-seral vegetation (for example, doveweed [*Croton* spp.], sandbur [*Cenchrus* spp.], and spotted beebalm [*Monarda punctata*]), native grasslands (for example, arrowfeather threeawn [*Aristida purpurascens*], Pan American balsamscale [*Elionurus tripsacoides*], and seacoast bluestem [*Schizachyrium scoparium* variety *littorale*]), and honey mesquite woodlands (woody plants >3 m tall), but no nests were found within catclaw acacia (*Senegalia greggii*) shrublands (woody plants <3 m tall). Two nests have been reported in humanmade structures: one nest in a hollow formed by the attachment point of a metal brace to a fence post (McNair, 1984) and one nest in a hollow formed in the ledge of structural channel beam in a carport (Johnson and others, 2016).

The future distribution of Lark Sparrows and their breeding habitat may be affected by climate-induced changes to temperature and precipitation (Langham and others, 2015). Under projected greenhouse gas emission scenarios described by the Intergovernmental Panel on Climate Change (2000), Langham and others (2015) categorized the Lark Sparrow as a climate-stable species, indicating that the species would retain more than 50 percent of its current distribution by 2050 across all Intergovernmental Panel on Climate Change scenarios, with potential for range expansion. Using a combination of BBS, eBird (https://ebird.org; Sullivan and others, 2009), and point-count data, Nixon and others (2016) modeled the impact of future climate-change scenarios on Lark Sparrow breeding distribution along the boreal forest-prairie ecotone in Alberta. Nixon and others (2016) predicted that the Lark Sparrow's breeding range would expand by 50 percent and that expansion largely would occur northward, originating in the Parkland Region of Alberta, with little southward expansion. In California, Jongsomjit and others (2013) projected that a future increase in temperature, reduction in annual precipitation, and increase in housing densities would decrease Lark Sparrow occurrence. Fleishman and others (2014) estimated the current location, quality, and connectivity of habitat for Lark Sparrows in four mountain ranges in the central Great Basin and projected the future location, quality, and connectivity of habitat for the species given different scenarios of climate-induced land-cover change. The area occupied by Lark Sparrow was projected to increase by >25 percent given a scenario of expansion of pinyon-juniper woodland by the year 2100.

Spatial and temporal variation in precipitation and temperature may affect the occurrence and distribution of Lark Sparrows. Using BBS data from the Badlands and Prairies Bird Conservation Regions, Gorzo and others (2016) reported that Lark Sparrow abundance was not significantly related to a standardized temperature index or standardized precipitation index for the same year and the previous year. Using BBS and standardized precipitation evapotranspiration index data for the South Central Semi-Arid Prairies ecoregion, Cady and others (2019) reported that Lark Sparrow presence and the probability of local colonization or extinction in the ecoregion were not related to drought conditions. Tingley and others (2012) compared historical bird survey, temperature, and precipitation data gathered in the early 20th century to BBS data and current climate data to evaluate elevational breeding range shifts within three regions of the Sierra Nevada Mountains; they concluded that Lark Sparrows shifted >1 kilometer (km) upslope within the two regions that they occupied. Travers and others (2015) compared historical bird data on species' spring-arrival dates in eastern North Dakota in the early to mid-20th century to dates in the early 21st century and concluded that Lark Sparrows were arriving later in the recent period than in the historical period.

Area Requirements and Landscape Associations

Male Lark Sparrow are strongly territorial near the nest during peak courtship, nest-site selection and construction, egg laying, and early incubation (Martin and Parrish, 2020). Thus, their territories are relatively small. In Kansas, estimated territory sizes for three male Lark Sparrows ranged from 0.0066 to 0.0248 hectares (ha), although one pair was observed occupying 6.3 ha (Fitch, 1958; Martin and Parrish, 2020). In oak openings in Ohio, male territory sizes ranged from 0.40 to 1.21 ha (Grigore, 1999).

Lark Sparrows have variable responses to patch size and landscape fragmentation. No studies have investigated a relationship between patch size and nest success or patch size and rates of brood parasitism by Brown-headed Cowbirds (*Molothrus ater*). In a study evaluating the effects of agricultural fragmentation on shrubsteppe bird communities in British Columbia in Canada and Washington in the United States, Knight and others (2016) found that Lark Sparrows were a weak indicator of edge habitat, which is consistent with the species' known preference for ecotones and disturbed areas. In North Dakota mixed-grass pastures, Lark Sparrows avoided selecting nest sites in edges between prairie dog colonies and woody cover (Mack, 2017). In Colorado, Lark Sparrows occurred more frequently on interior plots (more than 200 m from edge) than on edge plots (the interface between suburban development and upland or lowland habitats), but the difference was not significant because of high variation in numbers of Lark Sparrows among plots (Bock and others, 1999). In a 2-year study in Colorado, Kansas, Nebraska, and Oklahoma, Lark Sparrow response to landscape variables was inconsistent between years (McLachlan, 2007). Lark Sparrow occurrence was positively related to the amount of woodland in the surrounding landscape at the spatial scales of 600, 1,200, and 2,400 m in both years and 300 m in the first year; positively related to the number of land-cover patches in the surrounding landscape at all spatial scales in the second year; and negatively related to the amount of grassland at all spatial scales in the first year. In western Oklahoma, species occurrence models indicated that high shrubland and cropland cover within 800 m of BBS stops were indicators of Lark Sparrow occurrence (Coppedge and others, 2004). In an oak savanna in northwestern Ohio, Coulter (2008) assessed Lark Sparrow habitats at three scales (landscape, habitat patch, and territory), and found that Lark Sparrows responded to different habitat parameters at different spatial scales. At the landscape scale, habitat patch size and shape were important; habitat patch size was larger and perimeter-to-area ratio was lower in sites occupied by breeding Lark Sparrows than in former breeding sites no longer occupied by the species. At the habitat patch scale, percent tree cover was lower and vegetation height-density was higher in occupied sites than in currently unoccupied sites. At the territory scale, percent tree cover, percent shrub cover, vegetation height-density, and distance to closest occupied territory were lower in occupied territories than in areas in which Lark Sparrows were absent (Coulter, 2008).

Brood Parasitism by Cowbirds and Other Species

Lark Sparrows are a common host of the Brown-headed Cowbird (Friedmann and others, 1977; Martin and Parrish, 2020) and also may be a host of the Bronzed Cowbird (*Molothrus aeneus*) in the southwestern United States and Mexico (Martin and Parrish, 2020). Rates of brood parasitism vary from 0 percent of 18 nests (Erickson, 2017) to 82 percent of 11 nests (Hill, 1976). Rates of cowbird brood parasitism for Lark Sparrow are summarized in Shaffer and others (2019). Lark Sparrows may be multiply parasitized (Newman, 1970; Igl and Johnson, 2007). Abandonment of parasitized nests has been reported by Baepler (1968) and Walley (1985).

In a phenomenon that McNair (1984) termed "proto-parasitism," Lark Sparrows may attempt to share nests built by other species and may end up raising young of these other species. Conversely, the host species may evict the adult Lark Sparrows and raise the young Lark Sparrows alongside the host young (McNair, 1984). Nest-sharing generally results in a high rate of nest failure. Ellison and others (2013) documented a potential case of intraspecific nest parasitism, in which a young Lark Sparrow was not genetically related to the adult female attending the nest. For unknown reasons, individual Lark Sparrows occasionally reuse their own or other Lark Sparrow's nests from previous years (McNair, 1984), as well as old nests of other species (Martin and Parrish, 2020).

Breeding-Season Phenology and Site Fidelity

Lark Sparrows are migratory and arrive on their southern breeding grounds as early as mid-March and on their northern breeding grounds from mid-April to May (Cameron, 1908; Fitch, 1958; Maher, 1974; Stewart, 1975; Dinsmore and others, 1984; Walley, 1985; Zimmerman, 1993; Martin and Parrish, 2020). Lark Sparrows depart for their wintering grounds in the southern United States and Mexico from mid- to late September (Maher, 1974; Dinsmore and others, 1984; Walley, 1985; Martin and Parrish, 2020). Some Lark Sparrows may depart as early as mid-July or as late as mid-November (Dinsmore and others, 1984; Zimmerman, 1993; Martin and Parrish, 2020). Renesting attempts after a nest failure are common (Baepler, 1968; McNair, 1985; Martin and Parrish, 2020). Although no evidence exists (Baepler, 1968), some authors have suggested that double-broodedness occurs (Cameron, 1908; Newman, 1970; Joern, 1992; Kaspari and Joern, 1993). Klimkiewicz and Futcher (1987) reported that a banded bird was recaptured 8 years later at the same site where it was banded. Ross and others (2014) reported that 61.7 percent of 81 adults that were color-banded during a 4-year period returned to their Ohio breeding grounds. Ross and others (2014) also equipped 21 adult Lark Sparrows with light-level geolocators in 1 year to track their movements between their Ohio breeding grounds and their wintering grounds. Ten (47.6 percent) of the 21 Lark Sparrows tagged with geolocators were resighted on the breeding area during the following 2 years. Also in Ohio, nine (16.1 percent) of 56 banded fledglings returned to nest in their natal areas in oak savanna habitats (Grigore, 1999).

Species' Response to Management

Burning of habitats may be beneficial to Lark Sparrows, but the benefits may depend on habitat and the amount of time postburn. In Washington shrubsteppe, Lark Sparrow abundance increased the first year postburn but then declined to preburn levels or lower by the third year (Earnst and others, 2009). The authors suggested the increase in abundance in the first year after the burn could be attributed to an increase in bare ground. In Montana shrubsteppe, Lark Sparrows avoided a grassland burned 2 years previously that was devoid of woody vegetation, preferring instead an unburned grassland dominated by big sagebrush and specifically areas with little ground cover (Bock and Bock, 1987).

Studies encompassing a number of grassland biomes and conducted throughout the Great Plains to evaluate the effect of burning, often in concert with grazing, indicate the importance of periodic management in maintaining populations of Lark Sparrows. In the Nebraska Sandhills, Lark Sparrow abundance was similar between areas primarily burned during the dormant season and unburned areas within a pasture grazed by American bison (*Bison bison*) (Griebel and others, 1998). In a Kansas study of CRP fields planted to native grass species, abundance of Lark Sparrows was low on spring-burned fields and nearly zero on unburned fields (Robel and others, 1998). In the Oklahoma tallgrass prairies of the Flint Hills, Lark Sparrows were nearly equally abundant in the traditional annually spring-burned pastures stocked from mid-April to mid-July as they were in patch-burned pastures (that is, patches averaging 100 ha burned once in either spring or autumn every 3 years with cattle stocked at 1.2 ha per 270-kilogram steer) burned within the past 2 years, but Lark Sparrows were not found in burned patches that had not been disturbed for >2 years (Fuhlendorf and others, 2006). In the Tallgrass Prairie Preserve of Oklahoma, Patten and others (2006) reported that Lark Sparrows preferred nesting in tallgrass prairies more so than in roadsides, and more nests were located in burned (prescribed fire in spring followed by intensive grazing), and grazed prairies than in undisturbed prairies. However, Patten and others (2011) reported higher cowbird parasitism rates of Lark Sparrow nests in burned tallgrass prairies (16.7 percent parasitism of 18 nests) than in grazed-only and undisturbed tallgrass prairies (0 percent parasitism of 4 nests). In an Oklahoma study in sand sagebrush grasslands, Lark Sparrow abundance was five times higher in patch-burn pastures (that is, applying growing-season prescribed burns in a spatially and temporally variable mosaic and allowing livestock to select among burned and unburned patches in the landscape) than in traditional pastures (that is, summer-long grazing at 24.7 animal unit days per ha and no burning) (Doxon, 2009; Holcomb and others, 2014). Lark Sparrow density was highest in current-year burns. Nest survival was similar between patch-burn pastures and traditional pastures (Holcomb and others, 2014). Lark Sparrows initiated their nests earlier in the current-year burn patches than in the traditional patches and the other patch-burn patches (Doxon, 2009). Lark Sparrows nested 4 days earlier in current year burns than in ≥3 years postburn patches, 8 days earlier than in 1–2 years postburn patches, and 12 days earlier than in traditional patches. Clutch sizes did not differ among years or time since burn but were higher in traditional patches than in patch-burn treatments (Doxon, 2009). Lark Sparrows fledged a higher proportion of nests in the patch-burn treatment, and no association was found between time since burn and cowbird parasitism rate. For sage-nesting Lark Sparrows, losses to weather were higher in burned patches than in unburned patches, and depredation was highest in traditional patches. Weather loss in cedar-nesting Lark Sparrows was highest in current-year burns, but depredation was the principal cause of nest failure among treatments. There was more variety in the causes of nest failure in thistle (*Cirsium* spp.)-nesting lark sparrows; however, depredation and weather were the most common cause of nest failure in all patches (Doxon, 2009).

Within Arizona desert grasslands, Lark Sparrow abundance increased in native vegetation 2 years postburn; abundance was positively correlated with percentage of herbaceous cover (Bock and Bock, 1992). A nonsignificant increase in abundance occurred 2 years postburn in fields composed of Lehmann lovegrass (*Eragrostis lehmanniana*) and weeping lovegrass (*Eragrostis curvula*). Lark Sparrows also were found 1–2 years postburn in tame grasslands, where they were absent before burning and 3–4 years postburn (Bock and Bock, 1988, 1992). In Arizona floodplains dominated by big sacaton (*Sporobolus wrightii*), there was no difference in Lark Sparrow abundance between burned and unburned stands (Bock and Bock, 1988). In a grassland of honey mesquite and tobosagrass in central Texas, Lark Sparrow abundance was highest in areas that had most recently been burned and decreased as litter and grass coverage increased (Renwald, 1977). Number of nests was negatively correlated to percentage cover of tobosagrass; Lark Sparrows nested in tobosagrass ranging from 32 to 55 percent cover. In Texas Panhandle shortgrass prairies encroached by honey mesquite and cholla cactus, daily nest survival was 1.55 times more likely in experimental units burned every 2 years during the dormant season than in units burned every 10 years and 1.4 times more likely than in units burned every 4 years (Long and others, 2012). Nest survival was not related to shrub density at nest sites. In that same study, Long and others (2014) found no significant differences in mean relative abundance of Lark Sparrows across three experimental treatments: burned every 2 years, burned every 4 years, and unburned controls. In the same area studied by Long and others (2012, 2014), Jacobson and others (2011) reported that daily survival of Lark Sparrow nests decreased with interval length (evaluated durations were every 2, 4, or 10 years) between dormant-season prescribed burn frequency and the date of the nesting season (Jacobson and others, 2011). In the Texas Panhandle but east of the studies of Long and others (2012, 2014) and Jacobson and others (2011), two large wildfires burned shortgrass and mixed-grass prairies in spring (Roberts and others, 2012, 2017). Lark Sparrow densities were higher in shortgrass prairies 2–3 years postburn (first and later summers were not included in analysis) than in unburned grasslands; in mixed-grass prairies, however, Lark Sparrow densities did not differ between burned and unburned grasslands (Roberts and others, 2012). Lark Sparrow nest success was greater on burned sites in the second summer than the third summer postburn. Forbs, woody vegetation, and bare ground were higher around nests in the second than in the third summer, but litter cover was higher in the third summer (Roberts and others, 2017). In a grazed shrubland savanna in northern Texas, Lark Sparrow abundance was negatively related to the number of years since the last burn; abundance increased with more brush cover and bare ground cover (Lee, 2006).

In east-central Minnesota, Lark Sparrow abundance increased after an oak savanna was restored using growing-season prescribed burns that reduced tree density and increased the abundance of dead trees (Davis and others, 2000; Davis and Miller, 2018). In a Missouri study examining avian composition within 53 sites spanning hardwood forests, oldfields, and grasslands, Lark Sparrows were found on only a single grassland site that was recently cleared of most trees and burned; the site was characterized by sparse litter coverage and few (24–50 stems per ha) woody stems greater or equal to 2.5 cm diameter at breast height (Kahl and others, 1985).

Lark Sparrows are common within grazed grasslands, and Lark Sparrow densities appear to be unaffected by grazing system or species of grazing mammal. In North Dakota mixed-grass pastures, Lark Sparrows reached their highest densities in a transitional pasture (that is, a pasture in which black-tailed prairie dog occupancy was reduced because of an unplanned reduction by poisoning) and their lowest densities in a pasture with no black-tailed prairie dogs (Mack, 2017; Geaumont and others, 2019). In the north-central portion of the Nebraska Sandhills, Kempema (2007) examined the effect of grazing-system duration on Lark Sparrow density. Average values during the growing season (May 1 to September 30) for short duration grazing system was a rotation of 3 days of grazing at 1.4 animal unit months (AUMs) per ha; medium duration was 23 days at 1.3 AUMs per ha, and long duration was 78 days at 1.4 AUMs per ha. Lark Sparrow density was not significantly affected by grazing system, but the highest density occurred on the long-duration grazing system and lowest on the medium-duration system. The model providing the best explanation for variation in density included growing-season stocking rate and the amount of shrub, prostrate litter, and bare soil (Kempema, 2007). Within the same area of the Nebraska Sandhills, Sliwinski and others (2019, 2020) examined the relationship between five grazing systems (season-long continuous, deferred rotation, management intensive, dormant season only, fixed rotation) and avian diversity. Lark Sparrows were among the five most common bird species within the study area. Sliwinski and others (2019, 2020) reported that grazing system did not influence avian community structure more than the management unit (that is, the individual ranch), and this finding was probably not related to grazing management but rather was related to landscape features (such as, distance to wetlands, forests, or shrubs). In another Nebraska study in the county east of the studies conducted by Kempema (2007) and Sliwinski and others (2020), Lark Sparrow abundance was higher on an area both burned and grazed year-round by American bison at 1.2 AUMs per ha than on an area grazed by cattle at 1 AUM per ha from May 15 to November 15 (Griebel and others, 1998). In shortgrass prairies in northern Colorado, Wilkins and others (2019) evaluated the effect of bison reintroduction at 0.05 AUM per ha on Lark Sparrow densities and reported that densities were similar to those in cattle-grazed reference sites as measured 2 years after bison reintroduction. In Oklahoma mixed-grass prairies and sand sagebrush, Lark Sparrows seemed to prefer moderately (0.2 animal unit per ha from April to August) and heavily grazed (0.4 animal unit per ha) pastures over ungrazed pastures (Lusk and others, 2003). In Arizona, Lark Sparrow abundance was significantly higher on grazed than on ungrazed desert grasslands (Bock and Webb, 1984; Bock and others, 1984, 1993; Bock and Bock, 1988).

The establishment of planted grasslands such as CRP may provide suitable habitat for the Lark Sparrow. In a 12-State study of the north-central Plains, Lark Sparrow populations increased after the establishment of CRP fields (Herkert, 2009). Riffell and others (2008) studied the effects of CRP usage by grassland birds across seven ecological regions and found that Lark Sparrow presence was related to the presence of CRP fields across the entire study area, but not by individual region. In Nebraska, Kansas, and Missouri, a 10-percent increase in patch density of new CRP grasslands caused a 1.4-percent decline in Lark Sparrow abundance (Riffell and others, 2010). In Iowa, Schulte and others (2016) examined the effectiveness of planting strips of native perennial vegetation within rowcrops to increase numbers of grassland songbirds. Treatments were 100 percent rowcrop (that is, the reference), 10 percent of area planted to native vegetation in one strip on the footslope, 10 percent in multiple strips on the contour, or 20 percent in multiple strips on the contour; previous land use before experimental manipulation was tame grassland. Overall abundance, species richness, and diversity of grassland birds were higher on native vegetation strips than the reference treatment, but the abundance of Lark Sparrows was unaffected by treatments. In the Oklahoma Panhandle, Lark Sparrow habitat increased by 32 percent after the establishment of CRP habitat in the landscape; mean patch size and total edge habitat increased by 34 and 12 percent, respectively (Lungu, 2007).

Little information is available concerning the response of Lark Sparrows to mechanical treatments, such as brush mowing and disking, to control vegetative growth. In southwestern Colorado, mechanical treatments undertaken to improve sagebrush habitat for Gunnison Sage-Grouse (*Centrocercus minimus*) by removing encroaching woodland species by mechanical and chemical means and by burning had no effect on Lark Sparrow density (Lukacs and others, 2015). Within pinyon-juniper woodlands in central Colorado, thinning of the woodlands by mastication (mechanical cutting and mulching) and hand-thinning increased the occupancy of Lark Sparrows (Magee and others, 2019).

Savannas and grasslands encroached by woody vegetation are suitable habitat for Lark Sparrows, and total removal of woody vegetation may be detrimental. In southeastern Minnesota, Lark Sparrows were more abundant in savannas than in burned woodlands (Au and others, 2008). In an Ohio study in oak savannas, new sites created by land management were readily colonized by Lark Sparrows, but male territory size was significantly larger and the number of young fledged was significantly lower on new sites than on established sites (Grigore, 1999). In Oklahoma and Kansas mixed-grass and sand prairies encroached upon by eastern redcedar (*Juniperus virginiana*), Lark Sparrow abundance increased with increasing canopy cover of redcedar (Doxon, 2009; Schmidt, 2014). In Arizona, Lark Sparrows were more abundant in grasslands undergoing early invasion by juniper and in developing woodland than in undisturbed native grasslands (Rosenstock and Van Riper, 2001). In another Arizona study within semiarid grasslands undergoing a gradient of woody-plant encroachment by mesquite, Lark Sparrows were most abundant within moderately encroached grasslands (Andersen and Steidl, 2019).

Few studies have evaluated the impact of pesticides on Lark Sparrows. In North Dakota, levels of acetylcholinesterase in Lark Sparrow brains did not differ between areas treated with carbaryl (an acetylcholinesterase inhibitor) bait and untreated areas (George and others, 1992). Bartuszevige and others (2002) measured organochlorine pesticides and metabolites in carcasses of grassland-nesting passerines collected in Illinois; two Lark Sparrow carcasses showed no detectable levels of 17 organochlorine compounds evaluated. Quinn and others (2017) examined the response of grassland birds to multiple measures of agricultural change over a 40-year period along the 41st parallel within Colorado, Wyoming, Nebraska, and Iowa. Within this region and time period, total land area planted to cropland increased 40 percent, biomass yield increased 100 percent, and chemical use increased 500 percent. The abundance of Lark Sparrows declined with increased area farmed and more intensive biomass production but not with chemical use, although the findings were not statistically significant (Quinn and others, 2017). In a Texas study examining the effects on avian density of disking, spraying of the herbicide 2,4,5–Trichlorophenoxyacetic acid (2,4,5–T) about 14 years earlier, and construction of brush shelters, there were no effects on brushland sparrows as a group (Gruver and Guthery, 1986). Lark Sparrows were included in a group with other grassland and brushland sparrows, but the effects on individual species were not examined. In a Texas study examining the effects of applying dichlorodiphenyltrichloroethane (DDT) dust to control Lone Star ticks (*Amblyomma americanum*), numbers of nesting Lark Sparrows decreased in both the treated and untreated areas (George and Stickel, 1949).

Residential and urban development may impose limits on the abundance of Lark Sparrows (Haire and others, 2000; Lenth and others, 2006; Jongsomjit and others, 2013). In an area of residential development in California, Stralberg and Williams (2002) reported that Lark Sparrow densities were negatively associated with development density; the species would be nearly nonexistent at densities of 0.4 ha per parcel. In Colorado, Lark Sparrow abundance was highest at <5 percent urban index, as measured by summing the percentage urban vegetation and percentage buildings and paved area within a rectangular landscape that included the city of Boulder, Colorado, and a 1-km buffer surrounding the City of Boulder Open Space (Haire and others, 2000). In a second study around Boulder, Colo., Lenth and others (2006) evaluated differences in avian density between clustered and dispersed housing developments; although Lark Sparrow densities were higher in clustered developments and undeveloped areas than in dispersed developments, the differences were not significant.

There is limited information on the effects of energy development on Lark Sparrows. In New Mexico, Ortega and Francis (2012) reported that Lark Sparrows were detected at a significantly higher proportion on sites in which gas wells had compressors running during the surveys than on sites in which gas wells with compressors were turned off during the surveys. Between August 1992 and June 2005, remains of 172 species were identified in oil pits (that is, fluid-filled pits and tanks that store waste fluids from oil production) in the United States (Trail, 2006). Remains of 11 Lark Sparrows were identified in oil pits in Kansas, Oklahoma, Texas, and New Mexico. Beston and others (2016) developed a prioritization system for 428 avian species to identify those species most likely to experience population declines in the United States from wind facilities based on the species' current conservation status and the species' expected risk from wind turbines. The Lark Sparrow scored a 2.98 out of nine; 6.83 percent of the Lark Sparrow breeding population in the United States was estimated to be exposed to wind facilities. Wulff and others (2016) examined diurnal flight heights of Lark Sparrows and determined that the species' mean flight height was 8 m, which would likely not be within the rotor-swept zone of wind-turbine blades. Loss and others (2013) reviewed published and unpublished reports on collision mortality at monopole wind turbines (that is, with a solid tower rather than a lattice tower) in the contiguous United States; one Lark Sparrow mortality was reported at one wind facility. In Oklahoma mixed-grass prairies, Piorkowski (2001) found 11 bird carcasses, including one Lark Sparrow carcass, at a wind facility across two summers. DeVault and others (2014) examined bird use between five pairs of solar arrays and airport grasslands in Arizona, Colorado, and Ohio over 1 year; Lark Sparrows were observed in low numbers at 2 arrays and not observed at airport grasslands.

Management Recommendations from the Literature

Management activities that reduce sagebrush, scattered trees and shrubs, and edge habitats may be detrimental to Lark Sparrows (Bock and Bock, 1987; Martin and Parrish, 2020). Studies of the impact on burning and grazing indicate that Lark Sparrows are tolerant of these types of disturbances as long as some degree of woody vegetation remains (Robel and others, 1998; Fuhlendorf and others, 2006; Sliwinski and others, 2020). Conversion of grasslands to cropland or monocultures of exotic grasses are not well-tolerated (McMaster and Davis, 1998; Riffell and others, 2010; Earnest and Holmes, 2012).

Intense and infrequent fires are more detrimental than frequent fires in that the former kill the native sagebrush and shrubs that make grasslands suitable for Lark Sparrows (Renwald, 1977; Martin and Parrish, 2020). In shrubsteppe communities, the maintenance of native bunchgrasses decreases the risk of intense and large fires that can occur when native species are converted to cheatgrass monocultures (Earnst and Holmes, 2012). Within burned grasslands, fires that produce the combination of some woody vegetation and bare ground provide preferred substrates for Lark Sparrows (Bock and Bock, 1987; Earnst and Holmes, 2009).

Rangeland practices for livestock production within the tallgrass prairies of the central Great Plains, such as the traditional practice of annual spring burning of pastures in eastern Oklahoma, may be beneficial for Lark Sparrows but may not be beneficial to other grassland species (Fuhlendorf and others, 2006). Fuhlendorf and others (2006) suggested that rotational burning of patches in 1–2 year rotational cycles in pastures may benefit Lark Sparrows, but altering the spatial and temporal pattern of burning to increase variability in vegetation structure will likely benefit more than one grassland bird species. About 300 km east in Oklahoma sand sagebrush pastures, Holcomb and others (2014) recommended a 3-year fire interval to enhance habitat for Lark Sparrows and other shrubland birds.

In a northern Texas grassland encroached with honey mesquite and cholla cactus, Long and others (2014) reported that repeated applications of dormant-season prescribed burns at 2- and 4-year intervals did not alter shrub density and did not influence Lark Sparrow abundance, although Long and others (2012) reported that daily nest survival was higher in patches burned at 2-year intervals than in patches burned at 4- or 10-year intervals. Long and others (2012, 2014) suggested that the intensity of the prescribed burns was too moderate to influence the degree of shrub encroachment and further reductions would require conducting more-intense burns under conditions of higher biomass or during droughts or the growing season, or would require using chemical or mechanical means to remove shrubs. For central Texas mesquite grasslands in which the rejuvenation of tobosagrass stands was a priority, Renwald (1977) described characteristics of burns that might enhance Lark Sparrow management: conducting burns before Lark Sparrows arrive on the breeding grounds to prevent disruption of breeding activities; conducting burns at moderate temperatures to prevent removal of all woody substrates and provide patches of unburned habitat, both of which are good for nesting Lark Sparrows; and conducting burns at 5–8-year intervals, an interval that eliminates decadent stands of tobosagrass that removes Lark Sparrow foraging areas (Renwald, 1977).

In mixed-grass and tallgrass prairies, moderate-to-heavy grazing is compatible with the vegetation structural requirements of nesting Lark Sparrows, regardless of whether the grazing mammals are cattle (Bock and Webb, 1984; Lusk and others, 2003; Kempema, 2007), bison (Griebel and others, 1998; Wilkins and others, 2019), or a combination of livestock and prairie dogs (Mack, 2017; Geaumont and others, 2019). The creation or maintenance of abundant structural cover with moderate levels of litter accumulation and bare-ground exposure below 12 percent should benefit the species (Lusk and others, 2003). Maintaining a variety of grazing systems may provide heterogeneity of vegetation structure, and maintaining range in good condition will help ensure habitat recovery after drought conditions subside (Kempema, 2007). Sliwinski and others (2019) cautioned that the landscape context within which individual pastures are located may be a more important factor in maintaining structural heterogeneity than grazing system.

Complete removal of woody vegetation, whether through burning, chemical means, or mechanical means, is detrimental to the species (Renwald, 1977). In Arizona, removal of juniper trees from grasslands would have reduced or eliminated Lark Sparrow occupancy (Rosenstock and Van Riper, 2001). Lark Sparrows were present in developing woodland in which average tree density ranged from 42 to 92 trees per ha and tree size averaged 2.7 to 3.4 m in height. In Nevada sagebrush, McAdoo and others (1989) recommended leaving about 10 percent brush cover for Lark Sparrows. In southern Texas, Davis and others (2019) recommended open grasslands with sparse mesquite mottes of about 10 percent shrub cover per 100 square meters, not exceeding 60 percent.

Within savanna habitats, thinning of trees may be necessary to prevent succession to woodlands (Holoubek and Jensen, 2015). In North Dakota savannas, Cunningham and Johnson (2012) reported that the upper threshold for suitable tree cover for Lark Sparrows was 40 percent. In Minnesota, Davis and others (2000) advocated for prescribed burning of savanna habitat to restore vegetation to a condition suitable for Lark Sparrows. In Wisconsin savannas and woodlands, Bar-Massada and others (2012) recommended maintaining tree canopy cover <50 percent to maximize avian species richness. To benefit Lark Sparrows in Kansas, Holoubek and Jensen (2015) recommended that savannas undergoing succession to forest should be thinned to <25 percent canopy coverage or <200 trees per ha. In contrast, in California, Young and others (2015) recommended practices that maintain oak woodlands for Lark Sparrows; these practices included retaining or planting native species of shrubs and native bunch grasses, protecting young oak trees, and maintaining a ground layer. In South Dakota woodlands of Rocky Mountain juniper, Sieg (1991) suggested monitoring woodland stands for overuse by livestock that cause erosion issues and decreasing livestock numbers, protecting damaged areas with fences, or offering livestock feed away from imperiled woodland stands.

To make oil production waste fluids inaccessible to Lark Sparrows and other birds, Trail (2006) recommended replacing open oil pits with closed tanks or other closed containment systems. If open pits are retained, Trail (2006) recommended increased netting to exclude wildlife. To be effective, netting should be sturdy and supported by a steel frame to provide complete enclosure and should be maintained and monitored to ensure that it remains effective under all conditions.

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Table DD1. Measured values of vegetation structure and composition in Lark Sparrow (*Chondestes grammacus*) breeding habitat by study. The parenthetical descriptors following authorship and year in the "Study" column indicate that the vegetation measurements were taken in locations or under conditions specified in the descriptor; no descriptor implies that measurements were taken within the general study area.

[cm, centimeter; %, percent; --, no data; >, greater than]

Study	State or province	Habitat	Management practice or treatment	Vegetation height (cm)	Vegetation height-density (cm)	Grass cover (%)	Forb cover (%)	Shrub cover (%)	Bare ground cover (%)	Litter cover (%)	Litter depth (cm)
Bock and Webb, 1984	Arizona	Semi-desert grassland	Grazed, ungrazed	12.9[a]	--	54.2	7	3.8	38.2	--	--
Fuhlendorf and others, 2006[b]	Oklahoma	Tallgrass prairie	Annual complete burn and grazed	14.7	--	63	18	--	20.3	8	--
Fuhlendorf and others, 2006[b]	Oklahoma	Tallgrass prairie	Patch-burn and grazed	21.7	--	55.7	19	--	14.7	50.3	--
Kahl and others, 1985	Missouri	Tallgrass prairie	Burned	--	--	--	--	--	--	40–45	0.1–1.0
Long and others, 2012[c]	Texas	Shortgrass prairie	Two years postburn	10.1	--	63.2	10.5	--	36.8	--	--
Long and others, 2012[c]	Texas	Shortgrass prairie	Four years postburn	22	--	69.9	12.3	--	30	--	--
Long and others, 2012[c]	Texas	Shortgrass prairie	Ten years postburn	26.5	--	75.9	16.2	--	23.9	--	--
Lusk and others, 2003 (nests)	Oklahoma	Mixed-grass prairie	Multiple	37.4	--	9.6	9.1	--	16	11.6	0.3
Renwald, 1977 (nests)	Texas	Tobosagrass (*Hilaria mutica*)	Burned	--	--	32[d]	--	--	--	--	--
Walcheck, 1970 (nest sites)	Montana	Greasewood (*Sarcobatus*)-sagebrush (*Artemisia*) shrubland	Grazed	--	--	45[e]	--	15	31	--	--
Walcheck, 1970 (nest sites)	Montana	Pine (*Pinus*)-juniper (*Juniperus*) woodland	Grazed	--	--	44[e]	--	18	36	--	--
Walcheck, 1970	Montana	Greasewood-sagebrush shrubland	Grazed	--	--	24	25	17	20	--	--
Walcheck, 1970	Montana	Pine-juniper woodland	Grazed	--	--	45	9	18	28	--	--
Walcheck, 1970[c]	Montana	Sagebrush steppe	Grazed	--	--	49	6	53	3	--	--
Williams and others, 2011[b]	Colorado	Sagebrush steppe	Loamy soil	39.4[f]	--	4.2	--	17.3	42	42.5	--

Table DD1. Measured values of vegetation structure and composition in Lark Sparrow (*Chondestes grammacus*) breeding habitat by study. The parenthetical descriptors following authorship and year in the "Study" column indicate that the vegetation measurements were taken in locations or under conditions specified in the descriptor; no descriptor implies that measurements were taken within the general study area.—Continued

[cm, centimeter; %, percent; --, no data; >, greater than]

Study	State or province	Habitat	Management practice or treatment	Vegetation height (cm)	Vegetation height-density (cm)	Grass cover (%)	Forb cover (%)	Shrub cover (%)	Bare ground cover (%)	Litter cover (%)	Litter depth (cm)
Williams and others, 2011[b]	Colorado	Sagebrush steppe	Saline lowland soil	63.2[f]	--	1.7	--	45.9	27.1	52.1	--
Williams and others, 2011[b]	Colorado	Sagebrush steppe	Sandy soil	31[f]	--	0.9	--	16	39.8	40.2	--
Williams and others, 2011[b]	Colorado	Sagebrush steppe	Sandy-skeletal soil	28.9[f]	--	3	--	22.4	41.6	39.5	--

[a]Mean grass height.

[b]The sum of the percentages is >100%, based on the modified point-quadrat technique as described by the authors.

[c]The sum of the percentages is >100%, based on methods described by the author.

[d]Tobosagrass cover.

[e]Value represents grass and forb cover combined.

[f]Sagebrush height.

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