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The Effects of Management Practices on Grassland Birds—Eastern Meadowlark (*Sturnella magna*)

Chapter MM of

The Effects of Management Practices on Grassland Birds

Professional Paper 1842–MM

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

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By Scott D. Hull,[1,2] Jill A. Shaffer,[3] and Lawrence D. Igl[3]

Chapter MM of

The Effects of Management Practices on Grassland Birds

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U.S. Department of the Interior
DAVID BERNHARDT, Secretary

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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
square kilometer (km^2)	247.1	acre
square meter (m^2)	10.76	square foot (ft^2)
hectare (ha)	0.003861	square mile (mi^2)
square kilometer (km^2)	0.3861	square mile (mi^2)
	Mass	
kilogram (kg)	2.205	pound (lb)

Abbreviations

BBS	Breeding Bird Survey
CRP	Conservation Reserve Program
HSI	Habitat Suitability Index
spp.	species (applies to two or more species within the genus)
VOR	visual obstruction reading
WPA	Waterfowl Production Area

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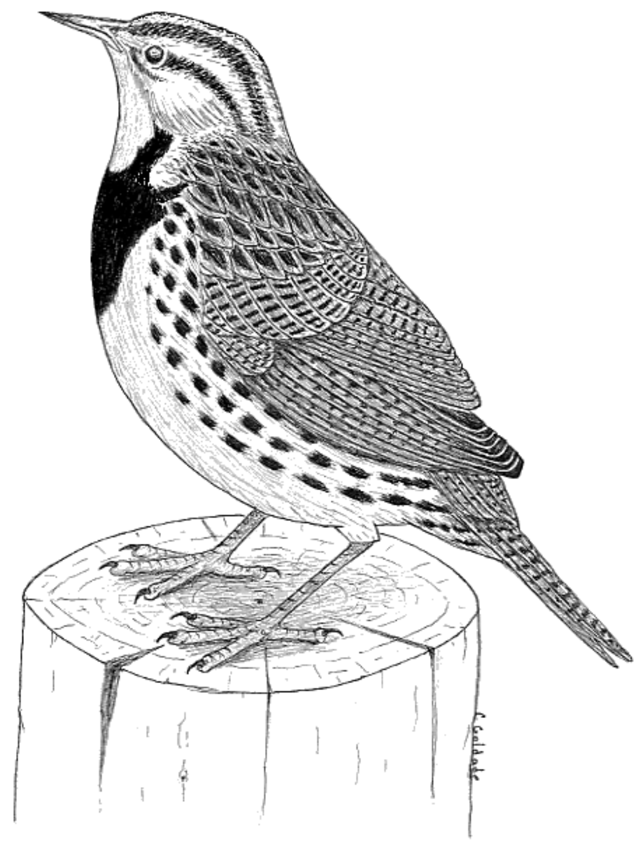
By Scott D. Hull,[1,2] Jill A. Shaffer,[3] and Lawrence D. Igl[3]

Capsule Statement

The key to Eastern Meadowlark (*Sturnella magna*) management is providing large areas of contiguous grassland of moderate height with significant grass cover and moderate forb density. Eastern Meadowlarks have been reported to use habitats with 10–187 centimeters (cm) average vegetation height, 6–88 cm visual obstruction reading (VOR), 53–86 percent grass cover, 4–50 percent forb cover, less than or equal to (≤) 4 percent shrub cover, less than (<) 38 percent bare ground, 6–23 percent litter cover, and ≤13 cm litter depth. The descriptions of key vegetation characteristics are provided in table MM1 (after the "References" section). Vernacular and scientific names of plants and animals follow the Integrated Taxonomic Information System (https://www.itis.gov).



Eastern Meadowlark. Illustration by Christopher M. Goldade, U.S. Geological Survey.

Breeding Range

Eastern Meadowlarks breed from southern Ontario, eastern Minnesota, Iowa, extreme southwestern South Dakota, Nebraska, and extreme northeastern Colorado; east to Quebec, New Brunswick, and Nova Scotia; south throughout the eastern United States to Texas; and west to Arizona, Oklahoma, and east-central Kansas (National Geographic Society, 2011). The relative densities of Eastern Meadowlarks in the United States and southern Canada, based on North American Breeding Bird Survey (BBS) data (Sauer and others, 2014), are shown in figure MM1 (not all geographic places mentioned in report are shown on figure).

Suitable Habitat

Eastern Meadowlarks prefer moderately tall grasslands with abundant litter coverage, large proportion of grass, moderate to high forb density, and small coverage of woody vegetation (Wiens, 1969, 1974; Roseberry and Klimstra, 1970; Rotenberry and Wiens, 1980; Skinner and others, 1984; Sample, 1989; Bollinger, 1995; Evrard and Bacon, 1995; Granfors and others, 1996; Hull and others, 1996; Klute and others, 1997; Scott and others, 2002; Hubbard and others, 2006). The Habitat Suitability Index (HSI) for the Eastern Meadowlark is a model based on species-habitat relationships, although cause and effect relationships are untested (Schroeder and Sousa, 1982). The HSI for this species indicated that optimal habitat contains dense grasses of moderate height (12.5–35 cm), low shrub coverage (<5 percent is optimal; greater than [>] 35 percent is too dense), low forb coverage, and adequate

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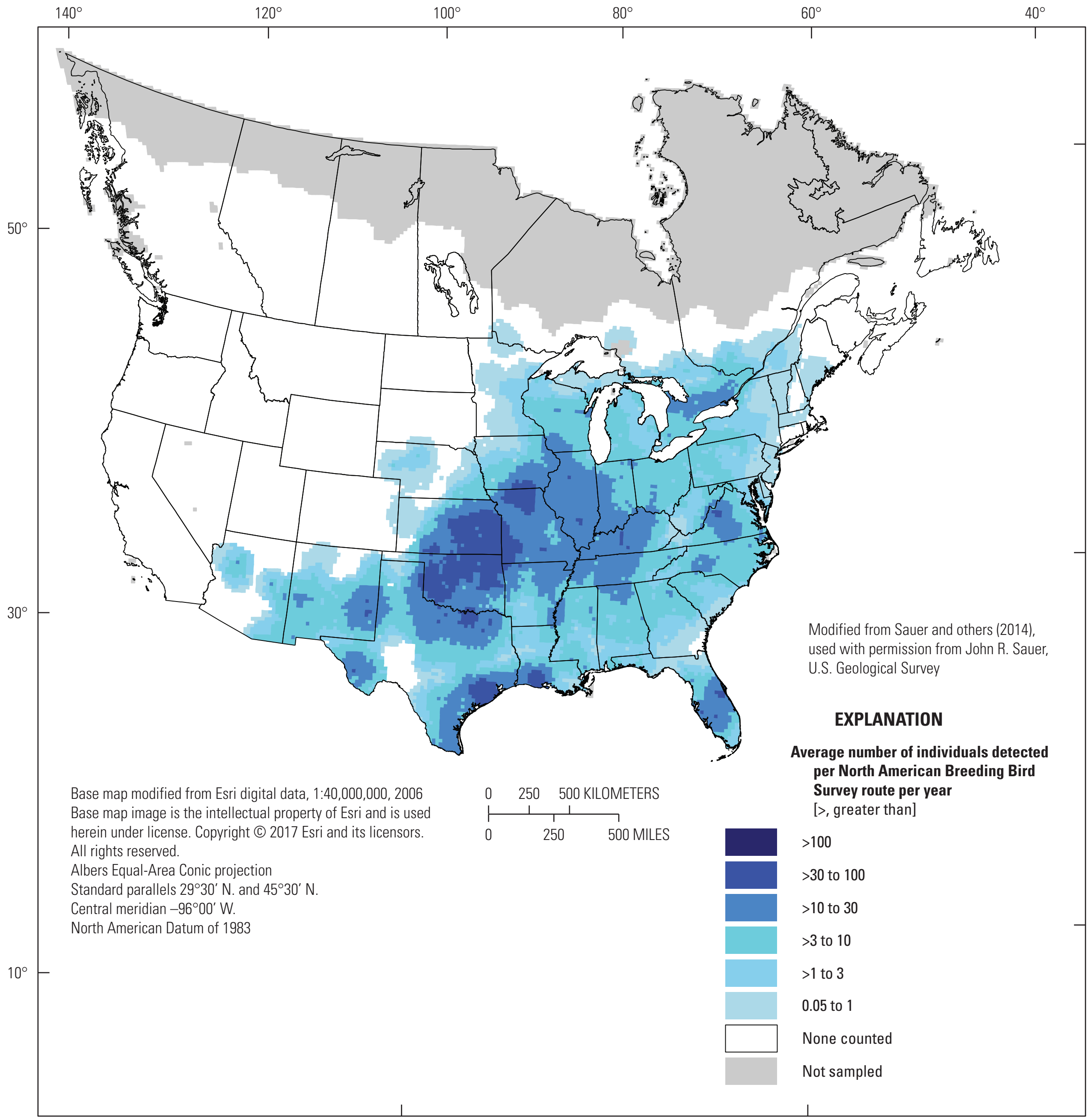

Figure MM1. The breeding distribution of the Eastern Meadowlark (*Sturnella magna*) in the United States and southern Canada, based on North American Breeding Bird Survey (BBS) data, 2008–12. The BBS abundance map provides only an approximation of breeding range edges.

perches. Optimal total herbaceous (including grass) coverage is >90 percent, whereas <20 percent may be inadequate as nesting habitat. Optimal proportion of herbaceous coverage that is grass is >80 percent, whereas <20 percent may be inadequate as breeding habitat. Variation in canopy height is desirable, because optimal vegetation heights for foraging and loafing are between 10 and 30 cm. Ideal vegetation heights for nesting are between 25 and 50 cm. Optimal conditions for the species may be met where most of the habitat is suitable for foraging and loafing. Average vegetation heights <2.5 cm or >76 cm may be unsuitable. Hays and Farmer (1990) modified the HSI by eliminating distance to perch as a variable and adding average height of herbaceous canopy in mid-spring (estimated by averaging pregreenup and mid-summer VORs and then converting readings into height). In former pastures and former hayfields in West Virginia, Eastern Meadowlarks selected nest sites with more standing dead vegetation, deeper litter, and a greater maximum vegetation height; Eastern

Meadowlarks typically incorporated standing vegetation into their nest to create a dome over the nest for concealment (Warren and Anderson, 2005).

Song perches, such as woody vegetation or human-created perches (for example, fence posts, barbed wire, powerlines), are used by Eastern Meadowlarks (Wiens, 1969; Harrison, 1977; Kahl and others, 1985). Although Eastern Meadowlarks tend to avoid areas with heavy woody invasion, the species tolerates the presence of some woody vegetation (Kahl and others, 1985; Sample, 1989). Based on the HSI, suitable perches generally are either around the periphery or within suitable habitat, but average distance between suitable cover and perch sites is typically <30 meters (m) (Schroeder and Sousa, 1982). Of 12 Eastern Meadowlark territories in Wisconsin, 67 percent included posts, 67 percent included fence lines, 33 percent wire bales or tangles, and 58 percent trees (Wiens, 1969). Harrison (1977) reported that Eastern Meadowlarks preferred artificial perches that were 2 m tall more so than artificial perches that were 1.5 m tall. In Maine, Vickery and Hunter (1995) reported that Eastern Meadowlarks used artificial song perches but that the additional perch sites did not increase meadowlark density. In Missouri, areas around song perches had few woody stems <2.5 cm diameter at breast height and no woody stems greater than or equal to (≥) 2.5 cm diameter at breast height, dense (>90 percent) ground vegetation, and moderate-to-dense litter coverage (Kahl and others, 1985).

Eastern Meadowlarks breed in a variety of native grasslands, including wet meadows (Boyer and Devitt, 1961; Johnsgard, 1979; Cink and Lowther, 1989; Mossman and Sample, 1990; Faanes and Lingle, 1995; Helzer, 1996; Helzer and Jelinski, 1999), semidesert grasslands (Bock and others, 1986), and tallgrass prairies that are idle, burned, hayed, or grazed (Easterla, 1962; Graber and Graber, 1963; Eddleman, 1974; Johnsgard, 1979; Zimmerman and Finck, 1983; Herkert, 1991; Sample and Hoffman, 1989; Rohrbaugh and others, 1999; Renfrew and Ribic, 2008; With and others, 2008; Pillsbury, 2010; Jacobs and others, 2012). Planted cover, such as Conservation Reserve Program (CRP) fields, Permanent Cover Program fields, dense nesting cover, Soil Bank Program fields, and Waterfowl Production Areas (WPAs), also provide suitable habitat (Roseberry and Klimstra, 1970; Sample, 1989; Welsh and Kimmel, 1991; King, 1991; Caito, 1993; Niesar, 1994; Hull and others, 1996; McCoy and others, 1999; Swanson and others, 1999; Riffell and others, 2008).

Eastern Meadowlarks occasionally breed in agricultural areas, such as rowcrop fields (Best and others, 1997), small-grain fields (Dambach and Good, 1940; Johnsgard, 1979; Sample, 1989), grassed waterways (Bryan and Best, 1991), herbaceous fencerows (Best and Hill, 1983), stubble, and grassed islands among plowed fields (Gross, 1965). The species also uses farmstead shelterbelts during the breeding season (Yahner, 1982), perhaps as perch sites. In a multi-State midwestern study comparing bird use of CRP grasslands and cropland, abundance of meadowlarks (Eastern and Western [*Sturnella neglecta*] meadowlarks combined) in CRP grasslands was greater than or equal to abundances in cropland in all six States studied (Best and others, 1997). In Iowa, Schulte and others (2016) evaluated grassland bird use of native perennial vegetation planted in strips within rowcrops. 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, and previous land use before experimental manipulation was tame grassland. Overall abundance, species richness, and diversity of grassland birds were greater on native vegetation strips than the reference treatment, but the abundance of Eastern Meadowlarks was unaffected by treatments. In Indiana, Eastern Meadowlarks were more abundant in no-tillage fields (that is, seeds planted directly into crop residue) than in conventional-tilled fields (that is, fields tilled in the spring before planting) (Castrale, 1985).

Eastern Meadowlarks have been found in orchards, golf courses, grassed roadsides, airport grasslands (Jaster and others, 2012), colonies of Gunnison's prairie dogs (*Cynomys gunnisoni*) (Clark and others, 1982), reclaimed surface mines (Whitmore, 1980; Scott and others, 2002; Galligan and others, 2006), oak savannas, shrub-carr wetlands (Faanes, 1981), commercial cranberry (*Vaccinium macrocarpon*) beds (Jorgensen and Nauman, 1993), and fields of burned and unburned broomsedge (*Andropogon virginicus*) (Shugart and James, 1973).

Where populations of Eastern and Western meadowlarks are sympatric in the Great Plains, Eastern Meadowlarks are found in wet lowland areas, such as valleys and river bottoms, whereas Western Meadowlarks are found in dry uplands (Lanyon, 1956a, 1957; Dinsmore and others, 1984). In desert grasslands, the usual ecological relationship of the two species is reversed; Western Meadowlarks inhabit irrigated land and Eastern Meadowlarks inhabit arid, natural grasslands (Lanyon, 1962).

The importance of topography has been examined in relation to nest survival and breeding density. In the Flint Hills of Kansas and Oklahoma, Frey and others (2008) examined the effect of topography on daily nest survival. Topographic position was less important to daily nest survival than VOR, because meadowlarks selected nest sites with greater VORs than were typically available. Although Eastern Meadowlarks predominantly nested on slopes, the use of lowlands relative to uplands shifted over the course of a nesting season. Meadowlarks nested in lowlands early in the season and switched to uplands later in the season. In Wisconsin, Eastern Meadowlark density did not differ between uplands and lowlands (Sample, 1989; Renfrew and Ribic, 2002). In Illinois, Roseberry and Klimstra (1970) observed that nests were built on slopes more than on crests of hills or in valleys.

The entrances of Eastern Meadowlark nests are primarily oriented to the north, northeast, or east. In Wisconsin, Wiens (1969) reported that the entrances of all 13 Eastern Meadowlark nests in his study were oriented to the north and east. Similarly, in Wisconsin, Lanyon (1957) determined that the entrances of 55 percent of 64 Eastern Meadowlark nests were oriented to the north, northeast, or east; the orientation of these nests was predominantly to the north and east and was not correlated with the position within a territory or location of song perches (Jaster and others, 2012). Lanyon (1957) attributed orientation to the effect of prevailing winds that depressed vegetation to the north and east, an explanation also accepted by Roseberry and Klimstra (1970), who found 350 Eastern Meadowlark nests, 48.9 percent of which were oriented to the north, northeast, or east. In the Flint Hills in Kansas and Oklahoma, Long and others (2009) reported that the entrances of 272 Eastern Meadowlark nests were significantly nonrandom and primarily oriented to the northeast. The prevailing wind during the breeding season was from the south, and the nests were generally oriented downwind; the orientation of the nest entrances shifted northward as the nesting season progressed and coincided with a southeastward shift in prevailing wind direction.

Although Eastern Meadowlarks use both native and tame grasslands, no consistent pattern of preference between the two grassland types has been documented (Hayden, 1985; Walk and Warner, 1999). In Wisconsin, Eastern Meadowlark densities were larger in tame CRP fields, remnant prairie patches, and pastures than in alfalfa (*Medicago sativa*) hayfields or cropland (Ribic and others, 2009a). In Minnesota, Eastern Meadowlarks were found in tame WPAs but not in native grasslands or woody vegetation ≤1.5 m tall (Niesar, 1994). In Illinois, densities of Eastern Meadowlarks were larger in upland prairies than in an area planted to Kentucky bluegrass (*Poa pratensis*) (Birkenholz, 1973). Grass height (51 cm), ground cover (100 percent), and litter depth (10 cm) were similar in both habitats, but native prairies had higher values for soil moisture (60 percent compared to 40 percent), foliage cover at 30.48 cm (60 percent compared to 30 percent), and variation in grass height (standard deviation of 5.5 compared to 3.4) than grasslands planted to Kentucky bluegrass. In another Illinois study, Eastern Meadowlarks were present in both tame and native grasslands (Walk and Warner, 1999). In Missouri, Eastern Meadowlarks were found in prairie fragments and in pastures planted to tame grasses (Hayden, 1985). Also in Missouri, meadowlarks (Eastern and Western meadowlarks combined) were more abundant in CRP grasslands planted to a mixture of tame grass species than in CRP grasslands planted to a monoculture of native switchgrass (*Panicum virgatum*), presumably because of shorter vegetation height in tame fields (VOR and maximum live vegetation height in July in tame CRP were 71 cm and 76 cm, respectively, compared to 107 cm for both measurements in native CRP) (McCoy, 1996; McCoy and others, 2001). In a third Missouri study, Eastern Meadowlark density was larger in grazed native and tame pastures and hayfields than in cool- or warm-season CRP grasslands (Jacobs and others, 2012). In a fourth Missouri study, daily nest survival rates did not differ between warm- and cool-season grass restorations (Jaster and others, 2014). In Pennsylvania, Eastern Meadowlark abundance was not statistically different in pastures and hayland planted to either cool- or warm-season grass species (Giuliano and Daves, 2002). In a study of tame and native CRP fields, native prairies, and sorghum fields in Nebraska, Eastern Meadowlarks were found only in native prairies, possibly because vegetation in CRP fields was tall and dense and did not provide adequate perch sites (King, 1991; King and Savidge, 1995). In June, maximum vegetation height and VOR in prairie ranged from 33 to 49 cm and 22 to 25 cm, respectively, compared to ranges of 66 to 156 cm and 24 to 78 cm, respectively, in CRP fields. However, in another CRP study in Nebraska, meadowlark (Eastern and Western meadowlarks combined) abundances were similar between CRP fields planted to a mixture of native grasses and CRP fields planted to tame grasses (Delisle, 1995; Delisle and Savidge, 1997). In Kansas, Missouri, and Nebraska, Eastern Meadowlark abundance was positively related to CRP fields planted to nonnative grasses (Riffell and others, 2010). In Kansas and Oklahoma, Eastern Meadowlarks were least abundant in CRP fields (burned and unburned) planted to native grasses (burned and unburned) and were moderately abundant in native pastures and hayfields (Rahmig and others, 2009). In WPAs in Ohio, Eastern Meadowlarks were more abundant in areas planted to tame grasses than in areas planted to monocultures of native switchgrass (Caito, 1993). Vegetation height was shorter and vegetation diversity was greater in tame plantings than in switchgrass fields, although there were no relationships between Eastern Meadowlark density and vegetation height or vegetation diversity. In 18 WPAs, the average vegetation height over 3 months (May, June, and July) in areas planted to tame grasses was 54 cm compared to 115 cm in areas planted to switchgrass; the Shannon-Wiener diversity index in tame stands was 1.70 compared to 1.12 in switchgrass stands. In Pennsylvania, no difference was reported in Eastern Meadowlark abundance between tame and seeded-native (restored) grasslands (Davies, 1997). In southeastern Arizona, Eastern Meadowlarks were more abundant in areas of native grasses than in areas planted to tame grasses (Bock and others, 1986; Bock and Bock, 1988). Tame grasslands had significantly less coverage of native grasses, forbs, and shrubs, and similar coverage of bare ground than in native grasslands.

The response of Eastern Meadowlarks to vegetation structure varies among studies. In tallgrass prairies in several States, the largest densities of Eastern Meadowlarks were in areas where vegetative heterogeneity was low (Wiens, 1974). Abundance of Eastern Meadowlarks was positively correlated with grass and litter coverage, maximum and effective vegetation height, litter depth, and total vegetation contacts, which was measured by recording the number of contacts or “hits” in each decimeter height interval of a thin rod passed vertically through the vegetation at each sample point (Rotenberry and Wiens, 1980). Abundance was negatively correlated with percentage of bare ground, variation in total number of vegetation contacts, variation in litter depth, and variation in forb and shrub heights. In Wisconsin, occupied territories had smaller vertical vegetation density, average effective vegetation height, and litter depth but had greater forb density than unoccupied areas (Wiens, 1969). In another Wisconsin study, density was positively correlated with percentage cover of standing vegetation, prostrate residual vegetation, woody cover, total number of dead stems, and plant-species richness; density was negatively correlated with maximum vegetation height and height-density (Sample, 1989). In a third Wisconsin study, abundance was positively associated with litter depth and vegetation height density in 1 of 2 years (Renfrew and Ribic, 2002); however, in CRP grasslands in Illinois, Eastern Meadowlark density was positively associated with greater percentage of bare ground coverage (Osborne and Sparling, 2013). In Illinois tallgrass prairies, density of Eastern Meadowlarks was positively correlated with percentage of living vegetation contacts and negatively correlated with grass height, total vegetation height, and total number of vegetation contacts of grasses, forbs, and dead vegetation (Herkert 1991). Density was negatively correlated with total vegetation species richness, abundance of forbs and shrubs, and a structural heterogeneity index (described as the variability in litter depth, vegetation height, and vegetation density). In another Illinois study, occurrence was positively associated with live vegetation, but the species avoided areas with a high average grass height (Herkert, 1994b). In a fourth study within Illinois grasslands, Eastern Meadowlark density was negatively related to the amount of dead vegetation (Buxton and Benson, 2016). In tallgrass prairies in Missouri, density of Eastern Meadowlarks was not affected by vegetation characteristics (Winter, 1998; Winter and Faaborg, 1999). In another Missouri tallgrass prairie study, however, home range size of Eastern Meadowlarks was affected by the variability in grass coverage (Suedkamp Wells and others, 2008). In CRP fields in Missouri, presence of meadowlarks (Eastern and Western meadowlarks combined) was negatively correlated with percentage of canopy cover of dead vegetation (McCoy, 1996). Abundance was positively correlated with percentage of grass canopy cover and negatively correlated with vertical obstruction values and litter coverage. In Missouri grasslands, including hayed and grazed native and tame grasslands and idle CRP grasslands, counts of Eastern Meadowlarks decreased 12 and 23 percent over the range of increasing shrub cover (0–1,600 square meters) and vegetation height-density (0–60 cm), respectively, and increased 71 percent over the increasing range of litter depth (0–60 cm) (Jacobs and others, 2012). In tallgrass prairies of Nebraska and Iowa, Eastern Meadowlark occurrence and density were positively related to the average number of grass contacts (or “hits”) and negatively related to average vegetation height (McLaughlin and others, 2014). Within native and tame CRP fields in Nebraska, meadowlark (Eastern and Western meadowlarks combined) abundance was negatively correlated with litter depth (Delisle, 1995; Delisle and Savidge, 1997). In Kansas, Zimmerman (1992) reported that areas with the greatest vegetative heterogeneity supported the largest densities of grassland bird species, including the Eastern Meadowlark. Also in Kansas, meadowlark (Eastern and Western meadowlarks combined) abundance was greatest in CRP fields that had the highest occurrence of forbs (61 percent compared to 21–50 percent) (Hull, 1993; Hull and others, 1996).

In Maine, Eastern Meadowlark abundance was positively correlated with taller grass and low growing (0–60 cm) shrub coverage and negatively correlated with tall (60–200 cm) shrub coverage (Vickery and others, 1994). In New York hayland, abundance of Eastern Meadowlarks increased linearly with field age (Bollinger, 1988, 1995). Abundance was positively associated with plant-species richness and negatively associated with percentage of vegetation cover, vegetation patchiness, and percentage of bird’s-foot trefoil (*Lotus corniculatus*) cover. As fields aged, plant diversity and patchiness increased, whereas vegetation height decreased. Fields with meadowlarks had 61.7 percent total cover and 1.2 percent bird’s-foot trefoil cover. In southeastern Arizona, abundance was positively correlated with shrub coverage (Bock and Bock, 1992).

Moisture levels may affect the abundance of Eastern Meadowlarks, but as Niemuth and others (2017) indicated, the biological meaning of climate variables in models characterizing bird-environment relationships is unclear; climate variables are likely correlates of other factors (for example, plant community composition, primary and secondary productivity) that more directly affect species occurrence, likely in concert with other factors such as soils and landform. Using North American BBS data for Kansas and Nebraska, Niemuth and others (2017) reported that the occurrence of Eastern Meadowlarks exhibited a positive relationship with long-term January temperature and with current-year and previous-year precipitation anomalies. Current-year precipitation anomaly was defined as the difference between current-year March–June precipitation and the long-term average to create a variable reflecting the deviation in precipitation for each examined time period, and previous-year precipitation anomaly was defined as the difference between previous year’s precipitation and the long-term average precipitation. The best-supported model for Eastern Meadowlark also included a quadratic relationship for long-term (30-year) precipitation, indicating that intermediate values of this climatic variable best explained the species’ distribution. In another assessment of BBS data, O’Connor and others (1999) reported a positive relationship between Eastern Meadowlark abundance and the 30-year average for July temperature. In a comparison of Eastern Meadowlark breeding distribution during 1980–85 and 2000–05 from the New York Breeding Bird Atlas, Jarzyna and others (2016) concluded that the persistence of Eastern Meadowlarks in New York was positively related to increasing maximum temperature during the breeding season in areas with abundant grasslands, but the probability of localized extinction increased with increasing temperatures in areas with sparse grasslands.

Eastern Meadowlarks nest on the ground (Roseberry and Klimstra, 1970; Jaster and others, 2012) in litter or under dense, overhanging grasses (Easterla, 1962; Wiens, 1969). In Wisconsin WPAs, nest density was negatively correlated with spring and summer VOR (Evrard and Bacon, 1995). In Illinois, nest sites had more dead grass (33 percent of grass cover) and less bare ground than nonnest sites (0 and 4.2 percent, respectively) (Kershner and Bollinger, 1996). Also in Illinois, height of cover at 204 nests ranged from 5 to 76 cm tall, with 67 percent of nests in cover 25–51 cm tall (Roseberry and Klimstra, 1970). Presence of dead grass stems and absence of woody vegetation appeared to be important nesting habitat requirements. Few nests were found in wheat (*Triticum* species [spp.]), fallow, or idle areas because of lack of adequate grass coverage in the first two habitats and invasion of woody plants in the latter habitat. Of 307 nests, 65 percent were in pasture (0.5 nest per hectare [ha]), 17 percent in hayland (0.3 nest per ha), 8 percent in fields enrolled in the Federal Soil Bank Program (0.1 nest per ha), 7 percent in idle fields (0.1 nest per ha), 2 percent in fallow fields (0.1 nest per ha), and 1 percent in winter wheat (0.1 nest per ha). Of 220 nests, 44.5 percent were partially concealed from above, 38.2 percent had full canopy coverage, and 17.3 percent were open from above. Path rush (*Juncus tenuis*), cheatgrass (*Bromus tectorum*), meadow fescue (*Schedonorus arundinaceus*), Canada bluegrass (*Poa compressa*), Kentucky bluegrass, Japanese clover (*Kummerowia striata*), and Korean lespedeza (*Kummerowia stipulacea*) were commonly used in constructing the nest bowl. On reclaimed coal mines in southwestern Indiana, Eastern Meadowlarks nested in grasslands, shrub/savanna, and the transitional habitat between the two; daily nest survival was higher in shrub/savanna and transitional habitats than in grasslands (Galligan and others, 2006). In Missouri, Eastern Meadowlarks nested in grasslands of short-to-moderate stature (about 50 percent cover 1 cm above ground and about 20 percent cover 25 cm above ground) that were moderately to heavily grazed (Skinner and others, 1984). Nests usually were under clumps of grasses or forbs.

Several nesting studies have been completed within the tallgrass prairies in the Flint Hills of Kansas and Oklahoma. Nest sites (0.25 square meter around the nest) in tallgrass hayland had significantly less bare ground than the area 1–10 m around the nest sites (Jensen, 1999). Granfors and others (1996) indicated that Eastern Meadowlarks selected nest sites with significantly greater litter coverage and litter depth, a higher proportion of grass, and more structural homogeneity than available on random plots. Hubbard and others (2006) reported no significant differences in vegetation between nest sites and random sites; in general, nest sites were characterized by high litter depth, small bare ground cover, and low woody vegetation and edge habitat. Eastern Meadowlark nest survival increased with increasing vertical vegetation structure at nest sites (Frey and others, 2008).

Area Requirements and Landscape Associations

Eastern Meadowlarks have large multipurpose territories (that is, defended areas in which feeding, mating, and rearing of young occur) (Jaster and others, 2012). In Wisconsin, Wiens (1969) reported an average territory size of 2.3 ha for 18 territories. Also in Wisconsin, Lanyon (1956b, 1957) reported a range of 1.2–6 ha for an unspecified number of territories, with most between 2.8 and 3.2 ha. In Oklahoma, two territories in tallgrass pasture averaged 2 ha (Wiens, 1971). In Kansas, Francq (1972) reported territory sizes ranging from 1.2 to 4.8 ha; large (size not given) territories were in grazed grasslands with few trees and shrubs, whereas small (size not given) territories were in ungrazed grasslands with lush ground cover and numerous scattered trees.

Eastern Meadowlarks generally are considered area sensitive (that is, preferring large grassland areas over small grassland areas) (Herkert, 1994a, 1994b, 1994c; Vickery and others, 1994; O'Leary and Nyberg, 2000), although some researchers that examined this topic did not find sensitivity. Ribic and others (2009b) reviewed published studies of area sensitivity and concluded that Eastern Meadowlark occurrence and density were positively associated with grassland patch size. In Illinois, Eastern Meadowlarks were considered moderately sensitive to habitat fragmentation (Herkert and others, 1993; Herkert, 1994c), and density and occurrence of Eastern Meadowlarks were positively associated with grassland area (Herkert, 1991, 1994c). The grassland area required for Eastern Meadowlarks was estimated at 5 ha (area required was defined as the grassland "area at which a species' probability of occurrence equals 50 percent of its maximum") (Herkert, 1994b, p. 494). In Missouri, home range size of postfledging juvenile Eastern Meadowlarks was 81 ha, suggesting larger areas are needed during at least part of the breeding season (Suedkamp Wells and others, 2008). In a second Missouri study, nesting success was not related to grassland patch size (Winter, 1998). In Maine, density was positively affected by an increase in grassland area; Eastern Meadowlarks reached <40 percent incidence at 500 ha in grassland barrens (Vickery and others, 1994). However, in Missouri (Winter and Faaborg, 1999) and New York (Bollinger, 1995), Eastern Meadowlarks were not considered area sensitive because density was not affected by grassland patch size. Eastern Meadowlarks were not affected by edge density; distance to another patch of grassland or forest; or cover, grassland patch size, or core area (>50 m from an edge) of grassland or forest (Winter, 1998). Eastern Meadowlark density was not related to grassland patch area in Wisconsin (Renfrew and Ribic, 2002). Vos and Ribic (2013) reported that patch vegetation, not grassland patch size, was important to Eastern Meadowlarks in Wisconsin prairies; abundance was affected by proportion of grass and VOR. In Illinois CRP grasslands, Eastern Meadowlark densities were not associated with field size or edge-to-area ratio (Osborne and Sparling, 2013). In Nebraska and Iowa tallgrass prairies, grassland area and edge-to-interior ratio had little effect on density or occurrence (McLaughlin and others, 2014). Within a rural/suburban interface of Boston, Massachusetts, the presence of Eastern Meadowlarks was positively related to area of open grassland patches (that is, 84 patches varying from 2 to 34 ha and 100 m average width) (Forman and others, 2002). Eastern Meadowlarks were present in 14 of the 84 grassland patches and were assumed to be breeding in two grassland patches with areas of 9.6 and 20.4 ha. Presence was unaffected by distance to nearest open patch. In comparing the relative importance of open-patch area to area of quality habitat (that is, hayfield, pasture, oldfield), area of quality habitat was a better predictor for meadowlark presence and use for breeding than was area of open grassland patches.

The effects of edges on Eastern Meadowlark density or nest success vary by study. In Wisconsin CRP grasslands, density of Eastern Meadowlarks did not change at edges or within field interiors after removal of tree rows (Ellison and others, 2013). Nest density increased near edges after removal of tree rows, with some nests within 1 m of the area where trees were formerly growing. Compared to control sites, daily nest survival rate was not affected the first 2 years after tree removal. Although survival rate decreased the third year, likely because of an increase in grassland predators, the number of successful nests was similar to that of controls and sites before the removal of the trees, and survival rates increased with increasing distance from edge. In Wisconsin pastures, although meadowlark (Eastern and Western meadowlarks combined) nest densities were smaller near edges, no statistically significant relationship was reported between nest density and distance to edge (Renfrew and others, 2005). In Wisconsin pastures, the best model for predicting daily nest survival rate included nesting stage but did not include variables related to distance of nest to an edge (Ribic and others, 2012). Walk and others (2010) reported that nest survival in small grassland patches (3–142 ha) in southeastern Illinois was not related to proximity to edges or patch size (<150 m). The researchers compared daily survival rate for nests <50 m from cropland or woodland edges to nests 50–100 m to cropland or woodland edges. Fewer meadowlark nests were found within 100 m of wooded edges than beyond 100 m, a pattern not observed for cropland edges. In northeastern Illinois, Eastern Meadowlarks were present in the interior of fields more than within the 50 m between the interior of the field and the wooded boundary (O'Leary and Nyberg, 2000). Of 12 breeding territories in Wisconsin, the average distance from the territory boundary to woods was 165.8 m, to cultivated field was 45.8 m, and to a fence line was 11.6 m (Wiens, 1969). On the Fort Riley military installation in Kansas, Eastern Meadowlarks selected nest sites significantly farther from habitat edges than random sites (Hubbard and others, 2006). Distances to nearest military vehicle track, shrub/tree, and perch were not significantly different from random sites. In a second Kansas study, successful nests were not farther from edges (that is, fencelines, changes in type of vegetation cover, roads, or ponds) than unsuccessful nests, but nest success was poor throughout the study area (Granfors and others, 1996).

Predation and brood parasitism of Eastern Meadowlark nests generally increase in smaller grasslands or near edges. In Illinois, Kansas, Missouri, North Dakota, and Oklahoma, predation of Eastern Meadowlark nests was negatively associated with habitat patch area and was least in patches >1,000 ha in size (Herkert and others, 2003). Brown-headed Cowbird (*Molothrus ater*) brood parasitism was not associated with patch area. In Oklahoma, Patten and others (2006) examined edge avoidance and brood parasitism in four different treatments: undisturbed prairies, grazed prairies, burned prairies, and roadside strips of woody vegetation. Eastern Meadowlarks experienced the highest rates of brood parasitism along roadside strips (19 percent of 26 nests). After accounting for edge effect, higher rates of parasitism were in grazed plots, particularly those burned in spring to increase forage, than in undisturbed prairies. In Kansas, Eastern Meadowlarks that nested within 100 m of woodland edges experienced significantly higher rates of brood parasitism than did meadowlarks that nested farther from woodland edges (Jensen, 1999). The average nest distance from agricultural edges was about 44 m, and the average nest distance from woodland edges was about 50 m. In Wisconsin, predation rates were lowest for nests within 50 m of nonwooded edges than for nests near wooded edges, yet this pattern did not persist when examined within 100 m of edges (Renfrew and others, 2005).

Eastern Meadowlark abundance is positively affected by the amount of grassland in the surrounding landscape, as indicated by several midwestern studies. Niemuth and others (2017) investigated the relationship between Eastern Meadowlark occurrence and land use within an 800-m landscape of BBS points within Nebraska and Kansas; occurrence was positively associated with percent coverage of grasslands (native and tame), pastures and hayland (native and tame), CRP grasslands, shrubland, and emergent wetlands, and was negatively associated with percent coverage of forests and developed land. Ribic and others (2009a) reported larger densities in Wisconsin fields with a greater proportion of grassland within 200 m. Murray and others (2008) indicated that the abundance of Eastern Meadowlarks in Wisconsin was positively related to the proportion of idle grasslands, pastures, hayland, and strip crops encountered along survey routes and negatively related to proportion of forest. At the 800-ha level, meadowlark abundance was positively related to proportion of grassland and to land-cover diversity. A grassland-by-forest interaction also was included in the final model. Ribic and Sample (2001) reported that the density of Eastern Meadowlarks along transects was positively correlated with the distance of transects to woodlots and the total length of hedgerows within 200-m and 400-m buffers around transects and, in contrast to other Wisconsin studies, was not significantly correlated with the amount of grassland area within a 200-m buffer.

In Michigan, Minnesota, and Wisconsin, Corace and others (2009) reported that the loss of pasture or hayland at the county scale was positively correlated with declining Eastern Meadowlark abundance. In Minnesota, meadowlark (Eastern and Western meadowlarks combined) abundance was positively correlated with percentage of land in grass cover (Kimmel and others, 1992). In Minnesota, the species was in landscapes with various amounts of planted cover, from 0 percent to at least 18 percent cover within 23.4-square-kilometer study sites (Welsh and Kimmel, 1991). In Iowa, Eastern Meadowlark abundance was positively correlated with large amounts of pasture, alfalfa hayland, and herbaceous fencerow in the surrounding landscape and with moderate amounts of rowcrops (Best and others, 2001). In another Iowa study, occurrence of Eastern Meadowlarks decreased with increased amount of woodland within 300 and 800 m (Robles, 2010). In Missouri, Jacobs and others (2012) determined that grassland type, the percentage of grassland cover and density of edge within 1 kilometer (km) of survey points, and vegetation structure were important for Eastern Meadowlarks.

In Illinois CRP grasslands, Eastern Meadowlark densities were negatively associated with the percentage of forest cover within 250 m (Osborne and Sparling, 2013). In Kansas, Missouri, and Nebraska, Eastern Meadowlark abundance was positively related to CRP patch density, suggesting that CRP distribution in small patches within a landscape is favorable to the species (Riffell and others, 2010). In Nebraska, King and Savidge (1995) reported no difference in Eastern Meadowlark abundance between landscapes consisting of about 20 percent CRP grasslands within 23-square-kilometer blocks of agricultural land and landscapes consisting of <5 percent CRP grasslands. In CRP fields in Missouri, abundance of meadowlarks (Eastern and Western meadowlarks combined) was negatively correlated with core area of hay and core area of grassland within 1 km (McCoy, 1996). Core area was defined as area of grassland >50 m from a non-CRP edge. Abundance was positively correlated with length of pasture-hayland edge.

Brood Parasitism by Cowbirds and Other Species

Shaffer and others (2019) summarized rates of Brown-headed Cowbird brood parasitism in Eastern Meadowlark nests from the literature; cowbird parasitism rates varied from 0 percent (Galligan and others, 2006; Giocomo and others, 2008; Walk and others, 2010; Vos and Ribic, 2013; Jaster and others, 2014) to 70 percent of 40 nests (Elliott, 1978). Eastern Meadowlark nests may be multiply parasitized (that is, contain two or more cowbird eggs) by one or more female cowbirds (Eifrig, 1919; Francq, 1972; Elliott, 1976; Granfors, 1992; Rivers and others, 2010), and the species will occasionally abandon nests because of cowbird brood parasitism (Roseberry and Klimstra, 1970; Elliott 1976, 1978). Eastern Meadowlarks are considered intermediate rejectors of cowbird eggs; in response to experimental nest parasitism in Illinois, Eastern Meadowlarks rejected 36 percent of 14 mimetic artificial cowbird eggs and 40 percent of 10 nonmimetic artificial cowbird eggs (Peer and others, 2000). In Kansas, no significant differences in vegetation variables were indicated between parasitized and unparasitized nests (Granfors, 1992). In Illinois, Kansas, Missouri, and Oklahoma, Brown-headed Cowbird brood parasitism of Eastern Meadowlark nests was positively associated with cowbird abundance (Herkert and others, 2003). In Oklahoma, parasitism rates were highest in prairies that had been burned and grazed than in prairies that were only grazed or that were undisturbed (Patten and others, 2006, 2011). For Eastern Meadowlarks, the few nests placed above 16 cm (usually on a bunchgrass tussock) were parasitized more heavily than nests below this height (Patten and others, 2011). Other nest attributes, such as distance to woody vegetation and proximity to edges, perches, or livestock, had little effect on parasitism rate. In Kansas and Oklahoma, Eastern Meadowlark nests had a smaller probability of being parasitized in unburned hayland than in the six other management types (burned and unburned CRP grasslands and season-long pastures, burned intensive-early stocked cattle pastures, and burned hayland), but differences were significant in only 1 of 2 years (Rahmig and others, 2009). None of these management practices significantly affected Eastern Meadowlark daily nest survival.

Breeding-Season Phenology and Site Fidelity

Eastern Meadowlarks are year-round residents throughout most of their range, except in the northernmost portion of their breeding range (Jaster and others, 2012). Migrants in the northern portions of the species' range generally arrive on the breeding grounds from early January to late May and depart for the wintering grounds from early August to late December (George, 1952; Batts, 1958; Gross, 1965; Beason, 1970; Harrison, 1974; Johnsgard, 1980; Faanes, 1981; Janssen, 1987; Kent and Dinsmore, 1996; Jaster and others, 2012).

Breeding is from late March to August (Jaster and others, 2012). Peak breeding season ranges from early May in Kansas and southern Illinois to mid-May in Wisconsin, New York, and Massachusetts (Roseberry and Klimstra, 1970). The earliest recorded date of egg laying in southern Illinois was April 14 (Roseberry and Klimstra, 1970). Eastern Meadowlarks may be double brooded (Lanyon, 1956b, 1957; Easterla, 1962; Gross, 1965; Wiens, 1969; Roseberry and Klimstra, 1970; Francq, 1972; Johnsgard, 1979; Kershner and others, 2004a), especially when the first nest is started early in the nesting season (Roseberry and Klimstra, 1970). Unsuccessful females will attempt to renest within a single season (Lanyon, 1956b, 1957; Easterla, 1962; Kershner and others, 2004a). In Illinois, Kershner and others (2004a) reported no differences in nest-site characteristics between successful and failed nests or between initial nests and renesting attempts.

Both sexes of Eastern Meadowlarks exhibit site fidelity to previous breeding areas (Lanyon 1956b, 1957; Jaster and others, 2012). During a 3-year period, 57 percent of 14 banded males returned to the area where the males had been banded; only one did not return to his former territory (Lanyon, 1957; Jaster and others, 2012). None of the six males that failed to return were in a 1.6-km zone around the study area; these males were presumed to have died. Of 22 banded females, 55 percent returned, with only three birds failing to return to the previous year's territory. Two of the three moved because no males occupied the territory, and one moved because the previous year’s territory was defended by a Western Meadowlark.

In Illinois, Kershner and others (2004a) indicated that an annual adult survival rate of 59–61 percent was necessary to maintain a stable population of Eastern Meadowlarks. During radio-telemetry studies of summer movements of postfledging Eastern Meadowlarks, Suedkamp Wells and others (2007) in Missouri and Kershner and others (2004b) in Illinois estimated the cumulative probability of a juvenile surviving the summer study period as 63 percent and 56–69 percent, respectively.

Eastern Meadowlarks may be polygynous (Wiens, 1969; Lanyon, 1957; Jaster and others, 2012). In Ontario, Knapton (1988) reported that nest success of females mated with a polygynous male was significantly higher than females mated with a monogamous male.

Species’ Response to Management

Numerous studies have evaluated the effects of burning, mowing, grazing, and combinations thereof on Eastern Meadowlarks. The following studies were in the tallgrass prairies of the Flint Hills of Kansas and Oklahoma, where livestock producers employ a combination of burning and grazing to maximize forage production. Zimmerman (1992, 1993, 1997) was one of the first researchers to examine the impact of burning of grasslands in the Flint Hills on Eastern Meadowlarks. Although relative abundance was not affected by burning in moist years, Zimmerman (1992) indicated that Eastern Meadowlark abundance may be reduced in drought years. Relative abundance did not differ among annually spring-burned tallgrass prairies, prairies burned less frequently (interval length not given), and unburned prairies (Zimmerman, 1993, 1997); however, the average production of young per attempted nest was larger in unburned, ungrazed prairies than in burned, ungrazed prairies (Zimmerman, 1997). Powell (2006, 2008) evaluated the effect of season since last burn and long-term fire frequency on abundance and reported that Eastern Meadowlarks were least abundant in the nesting season immediately following a burn. Abundance was high 1–3 years after the most recent burn. Abundances in annually burned and 4-year burn-frequency transects were about equal, and abundance was largest in transects with 20-year burn frequencies. Eastern Meadowlark densities were smaller in burned idle grasslands than in unburned idle, grazed, or hayed grasslands (Powell and Busby, 2013). In 2004 and 2005 in Kansas and Oklahoma, With and others (2008) examined the long-term viability of Eastern Meadowlark populations, and Rahmig and others (2009) evaluated density and nest success, within burned and unburned pastures and native hayfields of the Flint Hills. Pastures were classified as intensively early stocked (one head of cattle per 0.8 ha for 90 days, mid-April through mid-July) and season-long stocked (one head of cattle per 1.6 ha for 180 days, mid-April through mid-October). Intensively early stocked pastures were burned; season-long stocked pastures were further classified as burned or unburned. Nest density and survival of Eastern Meadowlarks were not affected by management treatment (Rahmig and others, 2009). Likelihood of regional viability for Eastern Meadowlarks in the Flint Hills during the 2-year study was <25 percent, with predicted declines of 12–24 percent per year (With and others, 2008).

The following five studies were in tallgrass prairies within the Tallgrass Prairie Preserve of Oklahoma. Rohrbaugh and others (1999) reported that the number of nests, clutch size, and number of young fledged from successful nests did not differ significantly among tallgrass plots that were idle, burned, or grazed; however, fewer nests were found on idle plots in the second and third year of the study than in the first year, possibly because of increased vegetation density caused by lack of either fire or grazing. Nesting success was significantly higher on undisturbed plots in the brood-rearing period but did not vary significantly during the incubation period. Coppedge and others (2008) reported that Eastern Meadowlark abundance was similar on annually burned and patch-burned pastures, but the species was more abundant in areas with larger percentages of litter, tallgrass, and shortgrass cover, and a lower angle of vegetation obstruction (that is, an index of visual obscurity that is a function of vegetation density and horizontal and vertical structure). Fuhlendorf and others (2006) indicated that Eastern Meadowlark abundance was greater 1–2 years postburn in patches burned at varying intervals (0 to >36 months) to promote vegetative heterogeneity than in areas burned annually; both treatments also were grazed. Patten and others (2006) reported that nests in grazed pastures managed with prescribed fire had higher rates of brood parasitism than those in idle prairies. Hovick and others (2015) established seven experimental pastures with various levels of patchiness ranging from annually burned with spring-only fires to a 4-year fire-return interval to examine the interaction of fire and grazing; Eastern Meadowlark abundance was not related to fire-return interval but was positively affected by number of patches, and hence increasing heterogeneity, and was positively related to litter cover.

In Illinois tallgrass prairies, abundances did not differ 1–3 years postburn (Herkert, 1994a). In Illinois restored and native grasslands, Eastern Meadowlarks showed no preference among areas that were burned, hayed, high-mowed (stubble >30 cm tall remained on the field), or idled (Westemeier and Buhnerkempe, 1983). In an Illinois study that compared counts of birds in warm- and cool-season grasses and annual weeds with several treatment types (burning, haying, mowing, grazing, and idle), Eastern Meadowlarks were most abundant in grazed warm-season grasses (Walk and Warner, 2000). In Iowa, Hovick and Miller (2016) compared Eastern Meadowlark nest survival in a patch-burn grazed treatment (that is, interacting fire and grazing) with nest survival in a grazed-and-burned treatment (that is, burned every third year and moderately stocked with cattle). Average daily nest survival was similar across treatments, but patch-burn grazing resulted in more stable survival rates from 1 year to the next, whereas the grazed-and-burned treatment created an apparent boom-and-bust survival cycle. In Iowa and Missouri, Pillsbury (2010) evaluated the effect of fire-grazing interactions on Eastern Meadowlark densities by comparing grasslands assigned to treatments of burn-only patches, patch-burn grazing, or grazing and burning of the entire fields. Eastern Meadowlark density was largest on both of the burn-grazed treatments than burned-only fields. In Missouri tallgrass prairies, patch-burn grazed sections had significantly greater densities of Eastern Meadowlarks than annually burned sections (Stroppel, 2009). Patch-burn grazed sections had greater densities in all 3 years of the study with greatest densities 1–2 years after burning. In Missouri, density of Eastern Meadowlarks was not affected by time since last burning or haying, although density tended to be smaller in areas the first year postburn than in areas after the first year postburn (Winter, 1998). Similarly, in another Missouri study, Wood and others (2013) reported that Eastern Meadowlark abundance was not affected by time since a prescribed fire, although abundances tended to be higher as time progressed. In Wisconsin, Eastern Meadowlarks appeared on a restored prairie the third year after the restored prairie was reseeded, which also was the year that restored prairie had been burned (Volkert, 1992); the timing of the burn treatment in relation to the age of the restoration confounds conclusions related to Eastern Meadowlark response to burning.

In native grasslands in Arizona, Eastern Meadowlarks were more abundant in unburned than in burned fields; burned fields had less grass and shrub coverage and more forb coverage and bare ground than unburned fields (Bock and Bock, 1988). Meadowlarks preferred burned, native flood-plain grasslands of big sacaton (*Sporobolus wrightii*) over unburned grasslands; burned sacaton grasslands had significantly less coverage of sacaton grass, no difference in coverage of other grasses, and greater forb coverage and bare ground than unburned sacaton grasslands (Bock and Bock, 1988). In another study at the same study site, Eastern Meadowlark abundance was significantly smaller the first year postburn on native grasslands compared to unburned native grasslands (Bock and Bock, 1992). No differences in abundance between burned and unburned tame grasslands were detected. Abundance was positively correlated with shrub coverage; Eastern Meadowlarks were observed singing from shrubs and probably avoided areas where fire reduced shrub coverage.

Hayland provides grassland habitat for Eastern Meadowlarks during the breeding season, but haying operations may be detrimental to the species' productivity. In Kansas, mowing resulted in nest failure and in some cases abandonment of mowed fields (Granfors, 1992). In Michigan, Eastern Meadowlarks successfully fledged one brood before mowing but ceased breeding activities in those fields after the fields were mowed (Harrison, 1974). For Eastern Meadowlarks nesting at rural Illinois airports, nest success decreased as mowing frequency and percentage of grass cover increased (Kershner and Bollinger, 1996). Nest success increased as percentages of cover by clover (*Trifolium* spp.) and other forbs increased. Mowing was the primary disturbance responsible for poor nest productivity. Kershner and Bollinger (1996) indicated that rural airports may be ecological traps because nest density of Eastern Meadowlarks was large, but nest success was poor. Mowed fields continued to be used as foraging sites. Mowing destroyed 18 percent of 182 nests in Illinois hayfields (no information is provided on the timing of mowing) (Roseberry and Klimstra, 1970). Eastern Meadowlarks preferred tame hayland consisting of several grass species over hayfields of red clover (*Trifolium pratense*) or alfalfa. Meadowlarks probably nested in clover fields because of grass invasion that provided some nesting cover, whereas alfalfa fields had poor grass coverage. In another study in Illinois hayfields, abundance of Eastern Meadowlarks was similar between mowed and unmowed areas (Herkert, 1991). Mowed sites were cut 1–4 months before May 1, whereas unmowed sites had been uncut for at least 12 months before May 1. In the Midwest, Hays and Farmer (1990) indicated that mowing in the previous year can be beneficial to meadowlark (Eastern and Western meadowlarks combined) habitat in the next breeding season, based on the HSI. Hays and Farmer (1990) reported that, across the United States, emergency mowing (because of severe drought) of CRP grasslands in the previous breeding season enhanced the habitat suitability for meadowlarks in the next breeding season by causing an increase in herbaceous canopy cover and in the proportion of grasses composing the herbaceous canopy. Mowing in the previous year also resulted in more grass coverage than in unmowed fields. In Ohio, no difference in nest densities was documented between mowed and unmowed portions of reclaimed strip-mine grasslands (Ingold, 2002).

Eastern Meadowlarks generally respond positively to moderate grazing in grasslands with taller vegetation and respond negatively to heavy grazing in grasslands with shorter vegetation (Bock and others, 1993). In a southwestern Wisconsin study, Eastern Meadowlarks were present in lightly grazed fields that were adjacent to riparian areas and that were under both continuous grazing and rotational grazing regimes (neither regime was defined in the study) (Renfrew and Ribic, 2001). In southwestern Wisconsin, Eastern Meadowlark territories were observed on ungrazed pastures but not on continuously grazed or rotationally grazed pastures (Temple and others, 1999). In Illinois, Roseberry and Klimstra (1970) examined meadowlark use of lightly grazed and heavily grazed pastures, a pasture that had been ungrazed for 2 years, and a tame hayfield. Roseberry and Klimstra (1970) reported that as grazing intensity increased, bird density declined, indicating that heavily grazed pastures were not suitable as Eastern Meadowlark habitat. Of 200 nests, 60 percent were found on grazed areas at a density of 0.3 nest per ha, and 40 percent were found on the ungrazed field at a density of 2.5 nests per ha. A total of 51 nests were found in tame hayland at a density of 0.3 nest per ha. In one 16-ha tame pasture, cattle grazed vegetation to heights ranging from 2.5 to 7.6 cm. During 3 years of heavy grazing, eight nests were found in that pasture. During a year when grazing was less intense, vegetation was more abundant and uniformly distributed, attaining heights of 12.7 cm. Eleven nests were found in that year. Nests were built in vegetation clumps. In another tame pasture, which was heavily grazed for 2 years, three nests were found the two years. The next year, grazing pressure was reduced, and 13 nests were found. In the following year, the pasture was reseeded to Kentucky bluegrass and meadow fescue, and 12 nests were found. In the third and fourth years, no grazing occurred, and 41 and 39 nests were found, respectively (Roseberry and Klimstra, 1970).

In Missouri, Eastern Meadowlarks were observed in grasslands of short to medium stature (about 50 percent coverage 1 cm above ground and about 20 percent coverage 25 cm above ground) that were moderately to heavily grazed (grazed to heights 0–10.2 cm, 10.2–20.3 cm, 20.3–30.4 cm, and >30.4 cm) (Skinner and others, 1984). In Missouri and Oklahoma tallgrass prairies, density of Eastern Meadowlarks increased in response to moderate grazing (10.2–30.4 cm tall) (Skinner, 1975; Risser and others, 1981). Also in Oklahoma tallgrass prairies, birds were more abundant in a moderately grazed pasture than in an idle pasture (Risser and others, 1981). Risser and others (1981) indicated that heavy grazing would reduce meadowlark densities. The ungrazed field was characterized by dense, homogeneous vegetation cover, thick litter, and few forbs. The grazed field was characterized by reduced vegetation cover and litter depth, increased vegetation heterogeneity, and greater density of forbs. In another Oklahoma study, meadowlarks (Eastern and Western meadowlarks combined) nested more frequently in moderately grazed tallgrass pastures than in undisturbed prairies (Smith, 1940). Heavily grazed sites were not used for nesting, but they were used as foraging sites, possibly because of large abundances of grasshoppers (Acrididae, Tettigoniidae, Phasmatidae, Gryllidae, and Mantidae). In Kansas, Eastern Meadowlarks were common on moderately grazed pastures with open areas and mid-height (no values given) grasses (Eddleman, 1974). In another Kansas study, low-intensity cattle grazing (one cow-calf pair per 3 ha) had a positive effect on abundance (Powell, 2008). In Kansas tallgrass prairies, Eastern Meadowlark densities did not differ between pastures grazed year round and those grazed only in winter (Johnson and Sandercock, 2010). In Kansas, Francq (1972) reported that of 14 nests in a pasture, 21 percent were destroyed because of trampling by cattle. In Texas, Eastern Meadowlark abundance was greater in moderately grazed shortgrass pastures than in heavily grazed shortgrass pastures in both sandy loam and clay soils (Baker and Guthery, 1990). In southeastern Arizona, abundance was similar between grazed and ungrazed upland native pastures (Bock and others, 1984; Bock and Bock, 1988). Grazed grasslands had significantly less grass and shrub coverage, greater bare ground coverage, and no difference in forb coverage than ungrazed grasslands (Bock and Bock, 1988).

Eastern Meadowlarks readily occupy CRP grasslands during the breeding season. In a study relating grassland bird abundance from BBS data to CRP grasslands across seven ecological regions spanning the eastern United States, Riffell and others (2008) reported a positive relationship with CRP grasslands for Eastern Meadowlark abundance in all ecological regions. Using BBS data from the Great Plains, Veech (2006) characterized the landscape within a 30-km radius of populations of Eastern Meadowlarks that were increasing or decreasing; CRP grasslands constituted a greater proportion of the landscape for increasing populations than for decreasing populations. The proportion of rangeland and of urban lands did not differ between increasing and decreasing populations. In Wisconsin, Eastern Meadowlarks were indicator species for CRP habitat in 1 of 2 years (Ribic and others, 2009a). McCoy and others (1999) reported that fecundity of Eastern Meadowlarks over 3 years in Missouri CRP fields was large enough to maintain a stable population. In contrast, use of CRP fields within the Flint Hills of Kansas and Oklahoma was very low (With and others, 2008). In eastern Kansas, meadowlark (Eastern and Western meadowlarks combined) abundances in tallgrass pastures were greater than abundances in CRP fields planted to native grasses, probably because of greater forb and insect abundance and shorter vegetative height in pastures than in CRP grasslands (Klute, 1994; Klute and others, 1997). Both CRP grasslands and native pastures were burned annually in spring. Nest success and number of young fledged did not differ between nests in burned tallgrass prairies and CRP fields (Granfors and others, 1996). In CRP grassland fields in eastern Kansas, abundance of meadowlarks (Eastern and Western meadowlarks combined) was similar on unburned and burned CRP fields (Robel and others, 1998). Abundance was not significantly different between the year of burn and 1 year later, but abundance was larger in the year of burn than 2–4 years later. In Wisconsin CRP fields planted to switchgrass, abundance of Eastern Meadowlark was highest in the postharvested fields, followed by the unharvested fields, and the species was not present within the preharvested fields; the species was only in the unharvested switchgrass field with the lowest vegetation height-density (Roth and others, 2005). In CRP grasslands in Illinois, Osborne and Sparling (2013) detected no difference in densities of Eastern Meadowlarks among idle CRP fields compared to fields that were either disked, sprayed with glyphosate, or sprayed and interseeded with legumes. In Iowa, Schulte and others (2016) examined bird response to experimentally integrated strips of native perennial vegetation planted within rowcrops. Treatments were 100 percent rowcrop (that is, 0 percent prairie, the control), 10 percent of area planted to native vegetation in one strip on the footslope, 10 percent in multiple strips on the contour, and 20 percent in multiple strips on the contour. The abundance of Eastern Meadowlarks was unaffected by treatments.

Insecticide and herbicide treatments may directly or indirectly affect Eastern Meadowlark populations. In Oklahoma, eight Eastern and Western meadowlarks died from exposure to two organophosphate insecticides (disulfoton and phorate; Griffin, 1959). At the Pawnee National Grassland in Colorado, malathion and toxaphene were applied at rates of 0.6 kilogram (kg) per ha and 1.1 kg per ha, respectively (McEwen and Ells, 1975). Two dead meadowlarks contained toxaphene residues of 4.5 and 2.7 parts per million. In a long-term study in Maine, lowbush blueberries (*Vaccinium angustifolium*) were sprayed with the herbicide hexazinone at a rate of 4 kg per ha (Vickery, 1993). Territory density of Eastern Meadowlarks decreased and did not recover during the 8-year duration of the study; territory density appeared to be limited by herbicide-induced reduction in graminoid coverage and increased blueberry coverage. In New Mexico, Eastern and Western meadowlark density did not differ among control plots and those grazed or treated with herbicide (tebuthiuron) (Smythe and Haukos, 2010).

Eastern Meadowlarks appear to be fairly intolerant of urban development. In a suburban/rural interface near Boston, Mass., the presence of Eastern Meadowlarks was positively related to the distance from busy roads (≥30,000 vehicles per day) and negatively related to percent developed area (primarily houses with yards) adjacent to survey patches (Forman and others, 2002). The presence of Eastern Meadowlarks was unaffected by roads with 3,000–30,000 vehicles per day, although breeding may be reduced within 400 m of roads with 8,000–15,000 vehicles per day and within 1,200 m for roads with ≥30,000 vehicles per day. In Nebraska and Iowa tallgrass prairies, level of urbanization negatively affected Eastern Meadowlark occurrence and density (McLaughlin and others, 2014). Urbanization was defined as the percentage of land occupied by lawn, roads, impervious surfaces, and buildings; high urbanization was 50.2 percent, moderate was 17.5 percent, and low was 3.7 percent. In tallgrass prairie patches near Chicago, Illinois, Eastern Meadowlark density was unaffected by a gradient of urbanization (Buxton and Benson, 2016).

Little or no evidence has been reported of behavioral displacement or sensitivity of Eastern Meadowlarks to wind energy development during the breeding season (Piorkowski, 2006; Piorkowski and O'Connell, 2010; Hale and others, 2014; Hale, 2016; Johnson, 2016). In the southern Great Plains, Wulff and others (2016) indicated that meadowlarks (Eastern and Western meadowlarks combined) fly at greater heights during the summer (June–August) than in the winter (December–February), spring (March–May), and autumn (September–November); higher flights of meadowlarks during the summer place them at greater risk of collision with wind turbines during the breeding season. In Oklahoma, Piorkowski (2006) and Piorkowski and O'Connell (2010) reported 11 bird mortalities, including one Eastern Meadowlark, that resulted from collisions with wind turbines. Stevens and others (2013) indicated no evidence of displacement by wind facilities for meadowlarks (Eastern and Western meadowlarks combined) during the winter in Texas.

Management Recommendations from the Literature

Eastern Meadowlarks are affected by both landscape and local features. For the Eastern Meadowlark and other bird species that may be restricted to larger grassland fragments, Herkert (1994a) and Faanes and Lingle (1995) recommended protecting large, native prairies and wet meadows from conversion to agricultural production. Herkert (1994c), however, cautioned that conservation plans or policies that address only the issue of grassland area are likely to meet with limited success because both grassland area and vegetation structure significantly influence populations of Eastern Meadowlarks and other grassland birds. Reverting agricultural fields back to perennial grasslands will be beneficial to Eastern Meadowlarks (Veech, 2006). Reclaimed coal mines may be good targets for land preservation and grassland bird conservation in the eastern United States, as reclaimed mines are large (>2,000 ha), owned by a single entity, and typically are not desirable for agricultural uses (Galligan and others, 2006); the nesting success of Eastern Meadowlarks at Indiana reclaimed mines was comparable with that in nonmined grassland habitats at other midwestern grassland sites.

Eastern Meadowlarks typically avoid areas with heavy woody invasion (Kahl and others, 1985; Sample, 1989), and thus limiting the encroachment of woody vegetation into grasslands will benefit Eastern Meadowlarks (Sample, 1989; Herkert, 1994a; Winter, 1998; Hubbard and others, 2006; Patten and others, 2006). Removal of woody vegetation within and along the periphery of grassland fragments will enlarge the amount of interior grassland, reduce the amount of edge habitat, and discourage predators that may use woody vegetation as travel corridors (Winter, 1998; O'Leary and Nyberg, 2000; Winter and others, 2000; Ellison and others, 2013). However, removal of woody edges may shift the predator community from woodland to grassland predators, so characterization of the predator community and activity before and after woody removal may be necessary to gauge management success (Ellison and others, 2013). Ellison and others (2013) recommended that the guidelines for Federal and State agricultural conservation programs (for example, CRP) should be designed such that the planting of trees is not incentivized or encouraged in or adjacent to upland grassland habitats, especially those in open grassland landscapes of high conservation priority. Small CRP fields surrounded by forest are of less value to grassland birds than larger fields that are not surrounded by forest (Osborne and Sparling, 2013).

Habitat quality and food sources (for example, insects) can be improved in managed grasslands (for example, CRP, WPA) for Eastern Meadowlarks and other grassland birds by promoting greater forb density and diversity (Hull, 1993; Klute, 1994; Niesar, 1994; Hull and others, 1996; Klute and others, 1997). Greater forb density and diversity may be accomplished by allowing natural succession to proceed for a period of time or by interseeding forb species in grassland plantings (Klute, 1994; Niesar, 1994).

Periodic fires may be used to maintain or create suitable grassland habitat for Eastern Meadowlarks (Herkert, 1994a). A variety of grassland habitat conditions can be maintained by providing a mosaic of burned and unburned habitats (Volkert, 1992; Herkert, 1994a; Rohrbaugh and others, 1999; Powell, 2008; Stroppel, 2009; Wood and others, 2013). Herkert and others (1993) recommended that prairie patches >80 ha should be burned on a rotation schedule, with 20–30 percent of the area treated annually; a rotational burning system will ensure the availability of suitable habitat for birds at either end of the management spectrum in every year and for those bird species, such as the Eastern Meadowlark, whose habitat preferences fall between the two extremes (Herkert, 1994a). Herkert and others (1993) recommended that small, isolated prairie patches should not have more than 50–60 percent of the total area burned at a time; where several small prairie patches are present in close proximity, a rotating burn schedule also can be implemented to provide adjacent burned and unburned areas. Burning may be preferred over haying, because vegetation recovers more quickly after burning than after haying (Winter, 1998).

Burning to control woody invasion and to maintain grassland vegetation is beneficial to Eastern Meadowlarks, but annual burning followed by grazing may have adverse effects (for example, smaller abundances or poorer nest survival) on Eastern Meadowlarks and other grassland birds because of the intense cropping by domestic and native grazers on recently burned grasslands (Zimmerman, 1997). Zimmerman (1997) recommended that grazing should be discouraged on burned grasslands to allow regrowth of herbaceous vegetation. After accounting for the effects of wooded roadside edges, Patten and others (2006) reported that grazing after annual spring burns in Oklahoma tallgrass prairies increased the probability of cowbird brood parasitism in nests of some grassland bird species. Erickson (2017) concluded that, in tallgrass prairies in Kansas and Oklahoma, annual burning coupled with heavy grazing may not create suitable nesting habitat for the Eastern Meadowlark. Hovick and Miller (2016) determined that restoring heterogeneity to fragmented Iowa grasslands through patch-burn grazing can positively affect Eastern Meadowlark populations by stabilizing nest survival rates over time; the authors recommended focusing management on patch burning with moderately stocked cattle in that region. Westemeier and Buhnerkempe (1983) recommended that tallgrass prairies should be burned every 3–5 years or mowed only at intervals of at least 3 years. Burning is particularly recommended for areas where grazing is not used as a management tool. Powell and Busby (2013), however, reported the smallest densities of Eastern Meadowlarks in fields burned every 3–4 years.

Prescribed fires can be used as an alternative to haying management to periodically invigorate vegetation in CRP grasslands (Granfors and others, 1996). Prescribed fires also may be used to thin vegetation that has become too dense. Robel and others (1998) recommended burning CRP grasslands every 2–3 years, and Kimmel and others (1992) and King and Savidge (1995) recommended burning every 3–5 years. Cool burns (that is, low-intensity fires) may allow some bunchgrasses and forbs to remain after the burn (Granfors and others, 1996). In tallgrass prairies and plantings, prescribed fires in late spring may reduce or eliminate competition from nonnative cool-season grasses and weeds (Skinner, 1975).

Periodic disturbances, such as haying or grazing, will increase floristic and structural diversity of seeded-native CRP grasslands, making them more attractive to meadowlarks (McCoy, 1996). Haying of CRP grasslands may enhance habitat quality for meadowlarks in the next breeding season; habitat quality may decline if CRP grasslands are not rejuvenated by some type of disturbance every few years (Hays and Farmer, 1990). Hays and Farmer (1990) indicated that the optimal haying management in CRP grasslands should be no more often than every 3–5 years, take place in late summer, and include raking to reduce and loosen the litter layer. Delaying prescribed fires and mowing activities in CRP and other grasslands until later in the breeding season will enhance suitable nesting habitat, prevent nest destruction, and allow young to fledge (Sample, 1989; Bryan and Best, 1991; Granfors, 1992; Herkert, 1994a; Granfors and others, 1996; Powell and Busby, 2013). If CRP management is required to control weeds, spot mowing and spot spraying after July 15 may reduce nest destruction (Granfors and others, 1996; Delisle and Savidge, 1997).

In Missouri, Skinner (1975) and Skinner and others (1984) recommended moderate grazing in grasslands in which the average vegetation height is 20.3–30.4 cm; moderate grazing intensity will enhance both avian species and plant height diversity. Plant vigor in tallgrass prairies can be maintained by not grazing warm-season grasses to <25 cm tall during a growing season. Rotating livestock among two or more grazing units will provide a diversity of plant heights.

Soil type, annual precipitation, length of the growing season, and grazing intensity are all important factors to consider during management decisions involving grazing (Baker and Guthery, 1990). Depending on soil type, grazing intensity differentially affects the amounts of vegetation cover and bare ground, which in turn affects use by Eastern Meadowlarks.

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[cm, centimeter; %, percent; --, no data; CRP, Conservation Reserve Program; WPA, Waterfowl Production Area; >, greater than; <, less than; ≥, greater than or equal to]

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)
Birkenholz, 1973	Illinois	Tallgrass prairie	--	51	--	--	--	--	--	--	10
Bollinger, 1988	New York	Tame grassland	Hayed	17.7	--	--	--	--	--	--	--
Caito, 1993	Ohio	Wildlife Production Area	Multiple	54–115	--	--	--	--	--	--	--
Delisle, 1995	Nebraska	Tame grassland (CRP)	Cool-season seeding mixture	29–48[a], 20–24[b]	30–48[c]	82.1–86.1	3.8–8.5	0	2	7.4–8.1	2.1–2.4
Delisle, 1995	Nebraska	Tame grassland (CRP)	Warm-season seeding mixture	14–78[a], 61–65[b]	63–88[c]	84.5–85.3	3.6–6.3	0	2.9–4.6	5.6–7.2	1.9–3.2
Evrard and Bacon, 1995	Wisconsin	Tame grassland (WPA)	Burned	28.8–87.1	6.4–47.4[c]	--	--	--	--	--	2–6.4
Frey and others, 2008 (nests)	Kansas, Oklahoma	Tallgrass prairie	Intensively early grazed and burned	--	22.8[c,d]	--	--	--	--	--	--
Frey and others, 2008 (nests)	Kansas, Oklahoma	Tallgrass prairie	Season-long grazed and burned	--	24.7[c,d]	--	--	--	--	--	--
Frey and others, 2008 (nests)	Kansas, Oklahoma	Tallgrass prairie	Season-long grazed and unburned	--	25.3[c,d]	--	--	--	--	--	--
Fuhlendorf and others, 2006[e]	Oklahoma	Tallgrass prairie	Annual complete burn and grazed	14.7	--	63	18	--	20.3	8	--
Fuhlendorf and others, 2006[e]	Oklahoma	Tallgrass prairie	Patch burn and grazed	21.7	--	55.7	19	--	14.7	50.3	--
Giuliano and Daves, 2002	Pennsylvania	Tame grassland	Cool-season seeding mixture	26.1–82.6	--	--	--	--	--	--	--
Giuliano and Daves, 2002	Pennsylvania	Tame grassland	Warm-season seeding mixture	43.6–133.5	--	--	--	--	--	--	--
Granfors, 1992[f] (nests)	Kansas	Tallgrass prairie	Burned, grazed	--	--	67	--	--	--	78	3.1

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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)
Granfors, 1992[f] (nests)	Kansas	Tame grassland (CRP)	Mowed	--	--	82	--	--	--	77	2.7
Harrison, 1974 (territories)	Michigan	Tame grassland	Hayed	57	--	--	--	--	--	65	--
Hubbard and others, 2006 (nests)	Kansas	Tallgrass prairie, tame grassland	Multiple	--	35[c]	--	--	--	3.8	--	8.3
Hull and others, 1996[g]	Kansas	Tame grassland (CRP)	Burned	--	--	42	8	--	56	--	--
Jensen, 1999 (nests)	Kansas	Tallgrass prairie	Multiple	0.4–41.2[h]	--	55.4	11.1	0.1	8.6	19.1	--
Jensen, 1999 (nest vicinity)	Kansas	Tallgrass prairie	Multiple	0.6–38.3[h]	--	52.6	9.1	0.2	15.9	19	--
Kahl and others, 1985 (territories)	Missouri	Multiple	Multiple	--	--	--	--	--	--	>65	--
Kershner and Bollinger, 1996 (nests)	Illinois	Tame grassland	Hayed	--	--	83.5	16.4	--	0	--	--
Kershner and others, 2004a[i] (nests)	Illinois	Cool- and warm-season grasslands	Multiple	31.9–59	22–31.6[c]	55–67.9	10.7–21.6	--	0.5–5	7.6–23	2.8–4.7
King and Savidge, 1995	Nebraska	Tallgrass prairie	Hayed or burned	33–49	22–25[c]	--	--	--	--	--	--
King and Savidge, 1995	Nebraska	Tame grassland (CRP)	Cool-season seeding mixture	33–75	24–44[c]	--	--	--	--	--	--
King and Savidge, 1995	Nebraska	Tame grassland (CRP)	Warm-season seeding mixture	65–156	34–78[c]	--	--	--	--	--	--
McCoy and others, 2001[g]	Missouri	Tame grassland (CRP)	Cool-season seeding mixture	--	51[c]	46	33	1	12	75	2.6
McCoy and others, 2001[g]	Missouri	Tame grassland (CRP)	Warm-season seeding mixture	--	80[c]	54	27	<1	11	74	2.2
Osborne and Sparling, 2013[g]	Illinois	Tame grassland (CRP)	Idle	--	56.5[c]	47.4	23.3	--	8.5	--	6

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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)
Osborne and Sparling, 2013[g]	Illinois	Tame grassland (CRP)	Disked	--	52[c]	47.7	22.5	--	16.1	--	5.4
Osborne and Sparling, 2013[g]	Illinois	Tame grassland (CRP)	Glyphosate-sprayed	--	56.7[c]	23.8	37.5	--	12.9	--	4.1
Osborne and Sparling, 2013[g]	Illinois	Tame grassland (CRP)	Glyphosate-sprayed and seeded	--	53.7[c]	29.3	31.3	--	15.5	--	3.6
Pillsbury, 2010[g]	Iowa, Missouri	Restored native grassland	Multiple	--	44.6[c]	21.7	24.8	2.3	--	32.1	--
Powell and Busby, 2013	Kansas	Tallgrass prairie	Unburned idle	93[b]	--	--	--	--	--	--	12.5
Powell and Busby, 2013	Kansas	Tallgrass prairie	Burned idle	52[a]	--	--	--	--	--	--	0.3
Powell and Busby, 2013	Kansas	Tallgrass prairie	Hayed	50.1[a]	--	--	--	--	--	--	6.5
Powell and Busby, 2013	Kansas	Tallgrass prairie	Grazed	74[b]	--	--	--	--	--	--	9.4
Renfrew and Ribic, 2002	Wisconsin	Tame lowland grassland	Grazed	--	8.4[c]	--	--	--	34.9	--	1
Renfrew and Ribic, 2002	Wisconsin	Tame upland grassland	Grazed	--	9.9[c]	--	--	--	26.1	--	1.1
Renfrew and Ribic, 2008	Wisconsin	Tame grassland	Grazed	--	9[c]	--	31.8	--	37.6	--	--
Robles, 2010	Iowa	Tame grassland	--	--	16.3[c]	--	--	--	--	--	--
Roseberry and Klimstra, 1970 (nests)	Illinois	Multiple	Multiple	38	--	--	--	--	--	--	--
Roth and others, 2005	Wisconsin	Tame grassland (CRP)	Idle warm-season	--	58[c]	--	38.2	--	--	--	3.2
Roth and others, 2005	Wisconsin	Tame grassland (CRP)	Harvested warm-season	--	12.4[c]	--	33.2	--	--	--	1.4
Sample, 1989	Wisconsin	Multiple	--	66	19.8[c]	--	73.7[j]	4.1	5.4	14.4	--

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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)
Skinner, 1975	Missouri	Multiple	Multiple	10.2–30.4	--	--	30	--	3	--	--
Skinner and others, 1984	Missouri	Tallgrass prairie	Multiple	--	--	--	20–50	--	--	--	--
Wiens, 1969[e] (nests)	Wisconsin	Tame grassland	Multiple	--	--	98	11	--	0	--	--
Wiens, 1969[e] (territories)	Wisconsin	Tame grassland	Multiple	--	--	96	30	--	3	--	--
Wood and others, 2013[g]	Missouri	Restored native grassland	0–1 Year post-burned	186.7	--	41.3	33.9	--	--	49.9	2
Wood and others, 2013[g]	Missouri	Restored native grassland	2–4 Year post-burned	177.2	--	34.1	34.5	--	--	71	3
Wood and others, 2013[g]	Missouri	Restored native grassland	≥5 Year post-burned	183.6	--	43.9	23.1	--	--	65.5	3.7

[a]Live vegetation height.

[b]Standing dead vegetation height

[c]Visual obstruction reading (Robel and others, 1970).

[d]Values averaged among three topographic positions.

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

[f]The sum of the percentages is >100%, based on the methods of Hays and others (1981).

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

[h]Ranges encompass the average heights of live grass, dead grass, live forb, and woody plants.

[i]Range of values includes data from successful and failed initial nests and data from successful and failed subsequent nests.

[j]Herbaceous vegetation cover.

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