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The Effects of Management Practices on Grassland Birds—Loggerhead Shrike (*Lanius ludovicianus*)

Chapter T of

The Effects of Management Practices on Grassland Birds

Professional Paper 1842–T

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

Cover. Loggerhead Shrike. Photograph by Mike Budd, U.S. Fish and Wildlife Service.
Background photograph: Northern mixed-grass prairie in North Dakota, by Rick Bohn, used with permission.

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By Lawrence D. Igl,[1] Jill A. Shaffer,[1] Douglas H. Johnson,[1] Marriah L. Sondreal,[1] Christopher M. Goldade,[1,2] Melvin P. Nenneman,[1,3] Amy L. Zimmerman,[1] Jason P. Thiele,[1,4] and Betty R. Euliss[1]

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The Effects of Management Practices on Grassland Birds

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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	
hectare (ha)	2.471	acre
square kilometer (km^2)	247.1	acre
hectare (ha)	0.003861	square mile (mi^2)
square kilometer (km^2)	0.3861	square mile (mi^2)
	Mass	
microgram (µg)	0.00000003527	ounce (oz)
milligram (mg)	0.00003527	ounce (oz)
gram (g)	0.03527	ounce (oz)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8 \times °C) + 32$$

Abbreviations

AUM	animal unit month
BBS	Breeding Bird Survey
CRP	Conservation Reserve Program
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
n.d.	no date
ppm	parts per million
sp.	species (an unspecified species within the genus)
spp.	species (applies to two or more species within the genus)
ssp.	subspecies

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The Effects of Management Practices on Grassland Birds—Loggerhead Shrike (*Lanius ludovicianus*)

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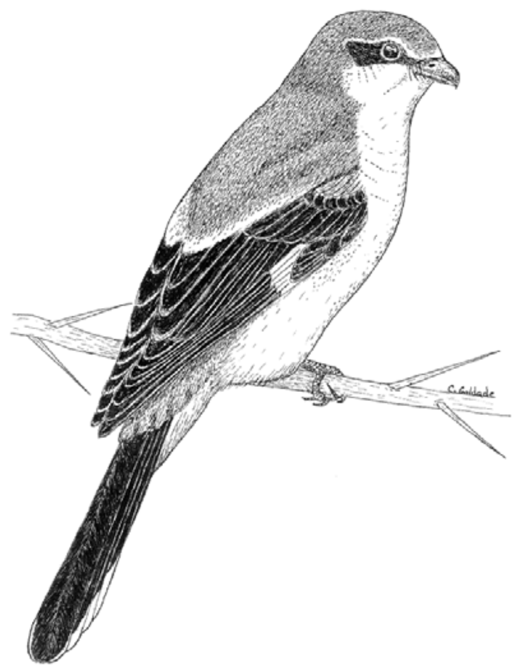
Capsule Statement

The key to Loggerhead Shrike (*Lanius ludovicianus*) management is providing open grasslands with scattered trees and shrubs for foraging, nesting, and perching. Loggerhead Shrikes have been reported to use habitats with 20–266 centimeters (cm) vegetation height, greater than or equal to (≥) 10 percent grass cover, 3–48 percent forb cover, 2–25 percent shrub cover, 3–40 percent bare ground, and 11–67 percent litter cover. The descriptions of key vegetation characteristics from the literature are provided in table T1 (after the “References” section). Vernacular and scientific names of plants and animals follow the Integrated Taxonomic Information System (https://www.itis.gov).



Loggerhead Shrike. Illustration by Christopher M. Goldade, U.S. Geological Survey.

Breeding Range

Loggerhead Shrikes breed from Washington, southeastern Alberta, central Saskatchewan, southwestern Manitoba, southern Ontario, and southern Quebec; south to California, Texas, and Florida; and south through the Pacific Slope and interior of Mexico (National Geographic Society, 2011; Yosef, 2020). The relative densities of Loggerhead Shrikes in the United States and southern Canada, based on North American Breeding Bird Survey (BBS) data (Sauer and others, 2014), are shown in figure T1 (not all geographic places mentioned in this report are shown on figure). Breeding populations of Loggerhead Shrikes have been reported in areas north and east of the illustrated range (C. Haas, Virginia Polytechnic Institute, Blacksburg, Virginia, written commun. [n.d.]).

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Suitable Habitat

Loggerhead Shrikes prefer open habitats characterized by grasses and forbs of low stature interspersed with bare ground and shrubs or low trees (Stewart, 1975; Rotenberry and Wiens, 1980; Brooks and Temple, 1990b; De Geus, 1990; Poole, 1992; Telfer, 1992; Prescott and Collister, 1993; Hellman, 1994; Cuddy, 1995; Pruitt, 2000; Shen and others, 2013; Yosef, 2020). During the breeding season, Loggerhead Shrikes use shortgrass, mixed-grass, and tallgrass prairies (Strong, 1971; Prescott and Collister, 1993; Cuddy, 1995; Bjorge and Prescott, 1996; Michaels and Cully, 1998); sagebrush (*Artemisia* species [spp.]) and shrubsteppe (Miller, 1931; Woods, 1995a; Poole, 1992; Woods and Cade, 1996; Miller and others, 2017); desert-scrub vegetation (Medin, 1986; Fiehler and others, 2017; Cypher and others, 2021); ungrazed and grazed pastures (Kridelbaugh, 1982; Luukkonen, 1987; Novak, 1989;

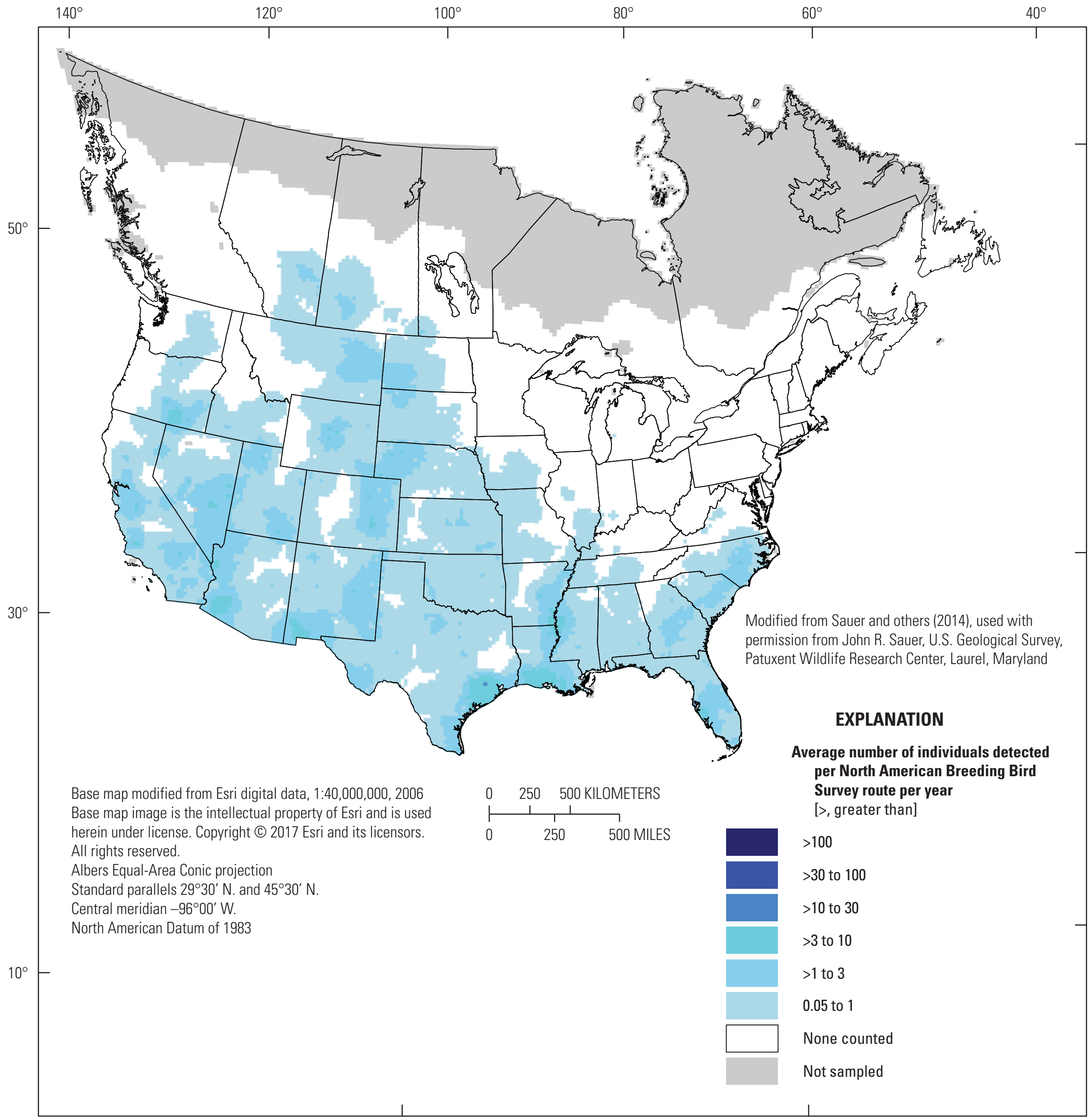

Figure T1. Breeding distribution of the Loggerhead Shrike (*Lanius ludovicianus*) in the United States and southern Canada, based on North American Breeding Bird Survey (BBS) data, 2008–12. The BBS abundance map provides only an approximation of breeding range edges.

Smith and Kruse, 1992; Telfer, 1992; Hellman, 1994); planted cover such as Conservation Reserve Program (CRP) fields and reclaimed strip mines (Hands and others, 1989; Pruitt, 2000; McCoy and others, 2001; Rummel and Brenner, 2003; Smythe, 2006; Igl, 2009; Pavlacky and others, 2021); and hayland (Brooks and Temple, 1990b; Walk and others, 2006). Shrikes often nest in strip cover or linear habitats, such as road and railroad rights-of-way, hedgerows, shelterbelts, and fencerows (Strong, 1971; Stewart, 1975; Kridelbaugh, 1983; De Geus, 1990; Smith and Kruse, 1992; Collister and Henry, 1995; De Geus and Best, 1995; Haas, 1995; Collister and De Smet, 1997). The species also breeds in savannas (LaRue, 1994; Michaels, 1997; Harris and others, 2022), aspen (*Populus* spp.) parkland (LaRue, 1994; Prescott and others, 1995; Michaels, 1997; Harris and others, 2022), and the transition zone between Great Plains grasslands and sagebrush steppe (Duchardt and others, 2016, 2018; Duchardt, 2019). Shrikes inhabit orchards (Yosef, 2020), riparian areas (Strong, 1971; Andrews and Righter, 1992; Poole, 1992), open woodlands (Andrews and Righter, 1992), farmsteads and residential areas

(Strong, 1971; Smith and Kruse, 1992; Cely and Corontzes, 1986), cemeteries (Stewart, 1975; Chavez-Ramirez, 1998; Pruitt, 2000), and golf courses (Pruitt, 2000). Grasslands and structurally similar crops (for example, oats [*Avena sativa*] and wheat [*Triticum aestivum*]) are preferred over rowcrops (for example, corn [*Zea mays*] or soybeans [*Glycine max*]) (De Geus, 1990; Smith, 1991; Smith and Kruse, 1992; Telfer, 1992).

Many studies have evaluated the effects of vegetation structure and composition on Loggerhead Shrike distribution and abundance. Throughout the Great Basin shrubsteppe and the Great Plains grasslands, abundance of Loggerhead Shrikes was positively correlated with percentage of shrub and bare ground cover and average height of emergent forb-shrub; abundance was negatively correlated with percentage of grass cover (Rotenberry and Wiens, 1980). In southeastern Washington, Loggerhead Shrike abundance was higher in areas of big sagebrush (*Artemisia tridentata*) with a native bunchgrass understory or a cheatgrass (also known as downy brome; *Bromus tectorum*) understory than in areas dominated by cheatgrass (Earnst and Holmes, 2012). In another Washington study, Loggerhead Shrike territories were in areas characterized by relatively large, thick shrubs interspersed with native bunchgrasses or sand dune openings with about 40 percent bare ground (Poole, 1992). Vegetation types supporting Loggerhead Shrike territories included big sagebrush (in lowland and upland areas), mixed shrubland, and antelope bitterbrush (*Purshia tridentata*). In addition to using open areas with scattered shrubs, Loggerhead Shrikes also used areas with minimal slope and high horizontal and vertical structural diversity. Plant community types that were not dominated by shrubs, such as grasslands and riparian areas, were not used. In Oregon and Nevada shrubsteppe, abundance of Loggerhead Shrikes was positively correlated with rockiness, shrub diversity, and percentage cover of spiny hopsage (*Grayia spinosa*), bud sagebrush (*Picrothamnus desertorum*), and shortspine horsebrush (*Tetradymia spinosa*) (Wiens and Rotenberry, 1981). In sagebrush steppe throughout southern and central Idaho, Loggerhead Shrike occupancy was positively associated with increased shrub height and increased variability in shrub height, was negatively associated with increased cover of perennial grasses and forbs, and peaked at intermediate values of shrub cover other than sagebrush (Miller and others, 2017). In northeastern Wyoming, Loggerhead Shrike abundance increased with increasing sagebrush cover (Barlow and others, 2020).

In the Great Plains and eastern portions of the Loggerhead Shrike's breeding range, the species commonly is associated with grasslands, often with some component of woody vegetation. In Alberta, habitat composition in 20 territories averaged about 52 percent native pastures, 33 percent rights-of-way, 8 percent tame pastures (forage crops), 5 percent fallow fields, and 2 percent cropland (Collister, 1994; Collister and Wilson, 2007b). In Alberta and Ontario, Loggerhead Shrikes nested in pastures with isolated trees and shrubs, thickets, or hedgerows; and in thorny bushes along railroad rights-of-way (Collister and Henry, 1995; Cuddy, 1995). Using remotely sensed data and shrike nest-location data from Grassland National Park in southwestern Saskatchewan, Guo and others (2009) and Shen and others (2013) found that Loggerhead Shrikes preferred to nest in open areas with scattered shrubs, especially thick or thorny shrub species of smaller size (less than [<] 3 meters [m]), to presumably discourage mammalian predators; active nest sites were far from roads (greater than [>] 2,000 m) at higher elevations. In southwestern Manitoba, scattered willow (*Salix* spp.) shrubs were favored by shrikes in grassland-dominated habitat, dense willow-bands were favored in cropland and lowland habitat, and deciduous trees and ornamental shrubs were favored in shelterbelts and hedgerows in cropland-dominated landscapes (De Smet and Conrad, 1990, 1991; De Smet, 1992; Collister and De Smet, 1997). Seventy-eight percent of 36 nests in the latter two habitats were surrounded by cropland, but only 21 percent of 28 nests were surrounded by cropland in the grassland-dominated habitat (De Smet, 1992; Collister and De Smet, 1997). In Minnesota, 45 percent of nests (sample size not given) were found in grasslands (prairies, eastern redcedar [*Juniperus virginiana*] glades, or lawns), 37 percent were adjacent to agricultural fields (rowcrops), and 18 percent were in pastures (Brooks and Temple, 1990b). In Illinois and Missouri, most territories were in pastures, but some were in oldfields, urban areas, hayfields, and wheat fields (Kridelbaugh, 1983; Smith and Kruse, 1992). In Iowa, Loggerhead Shrikes were found nesting in rights-of-way consisting of smooth brome (*Bromus inermis*) and small, scattered trees and shrubs (De Geus and Best, 1995). In Kansas, the species preferred savannas over grasslands or woodland edges (Michaels, 1997). In another Kansas study, the presence of nesting sites, usable foraging habitat, and low-to-moderate amounts of hedgerows were key factors for creating suitable habitat for Loggerhead Shrikes (Lauver and others, 2002). In shortgrass prairies in north-central Colorado, shrikes nested in trees in creek beds and homesteads (Porter and others, 1975). In Texas, Loggerhead Shrike territories contained about 100–200 trees and shrubs (Becker and others, 2009). In Ontario, most Loggerhead Shrikes established territories in actively grazed pastures; some established territories in idle pastures or oldfields (idle or neglected arable lands that have naturally reverted to perennial cover), but none had territories in or adjacent to rowcrops (Chabot and others, 2001a).

Several studies have reported associations between Loggerhead Shrike occurrence and measures of foliage height diversity, vegetative cover and height, and litter depth. In the Chihuahuan Desert in New Mexico, Loggerhead Shrike adult occurrence and nest occurrence were most strongly related to foliage height diversity and were most likely to occur at sites where foliage height diversity was low (St-Louis and others, 2010). Foliage height diversity was measured by counting the number of plant species that touched each 25-cm section of a vertical pole (3 m) placed at random distances (0–5 m) along each of the four cardinal directions. In Alberta, Loggerhead Shrikes occupied habitat that had more silver buffaloberry (*Shepherdia argentea*) shrubs, a higher percentage of cover of grass at least 20 cm tall (24.1 versus 2.5 percent), and greater average height of grass and forbs (20 versus 15.8 cm) than unoccupied habitats (Prescott and Collister, 1993). The species tended to avoid habitats that contained shorter vegetation, which resulted from heavy grazing by domestic cattle (*Bos taurus*). In Kansas, Loggerhead Shrikes used sites that were characterized by high structural heterogeneity, deep litter, high coverage of bare ground and standing dead vegetation, tall vegetation, and low total vegetative cover (Michaels, 1997; Michaels and Cully, 1998). In south-central Ontario, the width and percentage canopy cover of nest shrubs and trees were, respectively, 3.7 m and 77.7 percent for isolated hawthorn (*Crataegus* spp.) shrubs, 4.2 m and 84.9 percent for hedgerow hawthorn shrubs, 2.9 m and 88.8 percent for isolated eastern redcedar trees, 2.9 m and 80.5 percent for eastern white cedar (*Thuja occidentalis*) trees, 3.8 m and 96 percent for European buckthorn (*Rhamnus cathartica*), and 5.5 m and 91.8 percent for ash (*Fraxinus* spp.) (Chabot and others, 2001a). In Ontario and Quebec, Loggerhead Shrikes preferred to nest in pastures with low grass coverage (Cuddy, 1995). In several studies, nest trees ranged from 1.7 to 11 m in height (Brooks and Temple, 1990b; De Geus, 1990; Tyler, 1992; Prescott and Collister, 1993; Chabot and others, 2001a; Esely and Bollinger, 2001).

Several studies have reported differences in habitat between Loggerhead Shrike nest sites and unoccupied or random sites. In Washington, big sagebrush, antelope bitterbrush, and spiny hopsage were more common within 50 m of nest sites than around unoccupied sites, whereas rabbitbrush (*Chrysothamnus* spp.) and dead antelope bitterbrush were less common around nests sites than around unoccupied sites (Poole, 1992). Nest sites had greater shrub canopy coverage, taller shrubs, and less annual grass coverage than unoccupied sites. Nest shrubs were taller, were closer to a habitat edge, and contained denser cover and fewer main stems than unoccupied shrubs. Large, dense live shrubs were used for roosting, whereas tall, dead shrubs that provided good visibility were used for perching (Poole, 1992). In Idaho shrubsteppe, nests built later in the breeding season were built higher above the ground and nearer to the edge of nest shrubs than nests built earlier (Woods and Cade, 1996). In southwestern Manitoba, nest trees in pastures had wider canopies and were surrounded by fewer trees >2 m in height (within 10 m of the nest tree) than trees at random points, and nest trees in cropland were surrounded by fewer shrubs <2 m in height (within 10 m of the nest tree) compared to random points (Hellman, 1994). Hellman (1994) noted that the areas surrounding nest sites contained significantly more pastures, fewer trees, and longer fencerows than the areas surrounding randomly selected sites. In Ontario, nest sites within a 10-m radius from the canopy edge differed from random sites that were in similar, but unoccupied, suitable habitat; differences varied depending on nest substrate (Chabot and others, 2001a). No significant differences were found in vegetation height between nest sites and sites in suitable but unoccupied habitat. In areas with scattered, isolated hawthorn shrubs, nest sites had significantly greater grass coverage than similar suitable unoccupied areas. Nest sites in areas with hawthorn hedgerows had significantly greater bare ground coverage than similar unoccupied areas. In eastern redcedar habitats, nest sites had significantly greater tree or shrub coverage (Chabot and others, 2001a). Nest sites in isolated hawthorn habitats and eastern redcedar habitats had significantly greater moss or lichen coverage than nest areas in hawthorn hedgerows. The amount of potential habitat (that is, all habitats within a patch) around isolated hawthorn nest sites was significantly greater than that around eastern redcedar nest sites. Nest sites in isolated hawthorn shrubs and in eastern redcedar trees had significantly more potential habitat than nest sites in hawthorn shrubs within hedgerows (Chabot and others, 2001a). In southwestern Iowa, nest sites were in areas with greater coverage of trees and bare ground and lower coverage of shrubs than unoccupied sites (De Geus, 1990). In Illinois tallgrass prairies, the area within 25 hectares (ha) of nest sites contained more neighboring nest sites; more foraging areas; and more utility poles, trees, and fencelines used as hunting perches than did random sites (Fornes, 2004). In Missouri, nest tree heights were not significantly different from random tree heights (Esely and Bollinger, 2001).

Nest success of Loggerhead Shrikes may be related to nest substrate, concealment, or location. In south-central Washington, shrike nests with better concealment fledged more young (Poole, 1992). In Manitoba, nest sites with lower amounts of understory (ground cover and vegetation height) were more successful, and nests in pastures were more productive (2.5 young fledged per nest) than nests in cropland (1.44 young fledged per nest) or in mixed habitat types (1.86 young fledged per nest) (Hellman, 1994). Also in Manitoba, De Smet and Conrad (1991) found higher productivity in grassland-dominated habitats (3.7 young fledged per nest) than in cropland-dominated landscapes (1.6–1.8 young fledged per nest); the authors attributed the differences in productivity to higher predation rates in cropland-dominated landscapes because adults had to travel greater distances to obtain food for nestlings. In Minnesota, nest success was positively correlated with percentage cover of grasslands, and fledging success was positively correlated with percentage cover of herbaceous vegetation and of grasslands (Brooks and Temple, 1990b). In Illinois, highest nest success was in nests >3 m above the ground in conifers, in areas with ≥50 percent coverage of short grass, and in nests less than or equal to (≤) 100 m from impaling sites (that is, areas where prey are impaled to allow a shrike to tear the prey apart with its bill) (Lane and Hunt, 1987). In Missouri, nests that were placed closer to the center of nest trees and in taller trees tended to be more successful (Esely and Bollinger, 2001). In central Missouri, nest success was highest in deciduous trees and lowest in multiflora rose (*Rosa multiflora*) bushes, possibly because rose bushes are near the ground and not as structurally sound as deciduous trees used for nesting (Kridelbaugh, 1983).

Scattered shrubs or trees, particularly brushy or thorny species, serve as nesting substrates (Porter and others, 1975; Smith, 1991; Collister, 1994; Chabot and others, 1995, 2001a; Collister and Henry, 1995; Cuddy, 1995; Collister and Wilson, 2007b; Becker and others, 2009; Guo and others, 2009; Yosef, 2020; Smallwood and Smallwood, 2021). In Ontario, Loggerhead Shrikes nested in isolated trees (57 nests) more often than in hedgerows (9 nests) (Chabot and others, 1995, 2001a, 2001b). Loggerhead Shrikes nest in a wide variety of trees and shrub species of low-to-moderate heights. Selection of shrub and tree species for nesting varies by location and availability; examples of tree and shrub selection across the species' breeding range are provided below. In California, Smallwood and Smallwood (2021) found 94 shrike nests in 17 species of trees and shrubs; 34 percent of the nests were in red willow (*Salix laevigata*) and 17 percent were in bluegum eucalyptus (*Eucalyptus globulus*). In Idaho, 65 percent of 162 shrike nests were in big sagebrush, 20 percent were in antelope bitterbrush, and 12 percent were in greasewood (*Sarcobatus vermiculatus*) (Woods and Cade, 1996). In New Mexico, Harris and others (2022) found 84 percent of 51 shrike nests in fourwing saltbush (*Atriplex canescens*), 6 percent in Siberian elm (*Ulmus pumila*), 6 percent in tree cholla (*Cylindropuntia imbricata*), and 2 percent each in sand sagebrush (*Artemisia filifolia*) and oneseed juniper (*Juniperus monosperma*). In Alberta, 70 percent of 206 nests were in silver buffaloberry, 9 percent were in willow, 8 percent were in Siberian peashrub (*Caragana arborescens*), and 13 percent were in 12 other species of trees and shrubs (Collister, 1994). In Manitoba, 77 percent of 208 nests were in willow shrubs, 17 percent were in various trees, 3 percent were in other shrubs (primarily Siberian peashrub), and 3 percent were in bulldozed brush or rolled wire (De Smet and Conrad 1989, 1990). In Minnesota, shrikes nested in 13 tree species; 44 percent of 57 nests were in eastern redcedar, 21 percent were in deciduous trees bearing thorns or spines (American plum [*Prunus americana*], hawthorn, and Russian olive [*Elaeagnus angustifolia*]), 12 percent were in blue spruce (*Picea pungens*) and white spruce (*Picea glauca*), and 23 percent were in one of seven other tree species (Brooks and Temple, 1990b). In Illinois, Smith (1991) found 14 percent of 14 shrike nests in Colorado blue spruce; 14 percent in eastern redcedar; 14 percent in common crabapple (*Malus domestica*); and 7 percent each in eight other species of vines, trees, shrubs, or forbs. In Iowa, 58 percent of 159 nests were found in white mulberry (*Morus alba*), 20 percent in American plum, 16 percent in eastern redcedar, and the remaining nests were found in 15 other species of trees and shrubs (De Geus, 1990). In northwestern Missouri, 67 percent of 57 shrike nests were in osage orange (*Maclura pomifera*), 14 percent were in mulberry (*Morus* species [sp.]); 7 percent were in multiflora rose; and 12 percent were in honey locust (*Gleditsia triacanthos*), eastern redcedar, black cherry (*Prunus serotina*), and slippery elm (*Ulmus rubra*) (Esely and Bollinger, 2001). In southwestern Oklahoma, 31 percent of 133 nests were in osage orange, 13 percent were in netleaf hackberry (*Celtis reticulata*), 11 percent were in Siberian elm, 9 percent were in eastern redcedar, and the remaining nests were found in 17 other species of trees and shrubs (Tyler, 1992). In Ontario, 50 percent of 73 nests were in hawthorn; 40 percent were in eastern redcedar; and 10 percent were in eastern white cedar, European buckthorn, and ash (Chabot and others, 2001a). In Virginia, shrikes selected eastern redcedar and hawthorns for nest substrate more than expected and used black locusts (*Robinia pseudoacacia*) and other species less than expected based on availability (Luukkonen, 1987). In South Carolina, Froehly and others (2020) found 24 percent of 41 nests in loblolly pine (*Pinus taeda*), 22 percent in live oak (*Quercus virginiana*), 10 percent in water oak (*Quercus nigra*), 7 percent in laurel oak (*Quercus laurifolia*), 5 percent in longleaf pine (*Pinus palustris*), 5 percent in black cherry, 5 percent in sweetgum (*Liquidambar styraciflua*), and 2 percent in each of nine other tree, shrub, or vine species. In another South Carolina study, Gawlik and Bildstein (1990) found 63 percent of 49 nests were in eastern redcedar; 8 percent were in hackberry; 6 percent were in live oak; 4 percent were in black cherry; and 2 percent each were in nine other tree, shrub, or vine species. In south-central Florida, 60 percent of 152 nests were built in Pennsylvania blackberry bushes (*Rubus pensilvanicus*), but cabbage palm (*Sabal palmetto*), live oak, and wax myrtle (*Morella cerifera*) also were used frequently (22, 11, and 5 percent, respectively) (Yosef, 2001).

Trees and shrubs also are commonly used as foraging perches and impaling stations. In Minnesota, availability of open habitats, foraging areas, and elevated perch sites were considered the most important factors in habitat suitability (Brooks and Temple, 1990b). In Texas, trees and shrubs used as foraging perches were taller than randomly selected trees (Becker and others, 2009). During summer, honey mesquite (*Prosopis glandulosa*) trees that were partially dead were preferred foraging perches (46 percent of observations), perhaps because these trees provided shrikes with good visibility as well as some cover from predators. Other foraging perches included bare or dead mesquite (30 percent), all other species of trees (21 percent), and full canopy mesquite (3 percent) (Becker and others, 2009). Fences, utility wires, grasses, and forbs also are used as foraging perches (Hellman, 1994; Michaels, 1997; Michaels and Cully, 1998; Becker and others, 2009; Yosef, 2020). Thorny shrubs or trees and barbed-wire fences serve as impaling stations for prey (Yosef, 2020). In southwestern Idaho, impaling stations were 7–65 m from a nest, contained one to two sharp points, and were well protected within a shrub (Woods, 1995a).

In southwestern grasslands, one-seed juniper encroachment into grasslands may affect Loggerhead Shrike presence and nest-site selection (LaRue, 1994; Rosenstock and Van Riper, 2001; Andersen and Steidl, 2019; Harris and others, 2022). In upland grasslands of southeastern Arizona, Andersen and Steidl (2019) evaluated how breeding birds responded to woody plant encroachment into upland grasslands; Loggerhead Shrike distribution was not affected markedly by woody cover. In northeastern Arizona, shrikes were a common permanent resident in juniper savanna and greasewood (LaRue, 1994). In northern Arizona, shrikes were present in grasslands undergoing early invasion by one-seed juniper, in developing woodlands with abundant larger trees, and in grasslands without juniper invasion (Rosenstock and Van Riper, 2001).

In New Mexico, nest-site selection by Loggerhead Shrikes declined as the percentage of one-seed juniper cover increased (Harris and others, 2022). The rate of change in nest-site selection decreased the fastest at 13 percent juniper cover; shrike nests were more likely to occur in areas without junipers within a 170-m radius (Harris and others, 2022). One-seed juniper was seldomly used as a nesting substrate.

Loggerhead Shrikes may benefit from converting cropland to perennial grassland cover (McCoy and others, 2001; Riffell and others, 2008; Igl, 2009). In Missouri, Loggerhead Shrikes were present in CRP fields regardless of whether the fields were planted to cool-season or warm-season grasses (McCoy and others, 2001). Riffell and others (2008) used BBS data and National Resources Inventory data to assess the potential for the CRP to benefit Loggerhead Shrikes and other grassland birds in seven ecological regions in the eastern one-half of the United States. Sampling units were 1,962-square-kilometer (km^2) circular landscapes (25-kilometer [km] radius) centered around each BBS route. Shrike abundance between 1995 and 1999 was positively related to CRP in two (Central Hardwoods and Piedmont) of the seven ecoregions (Riffell and others, 2008).

In south-central Washington, Loggerhead Shrike territories were mostly on flat or gently rolling topography with deep, fertile soils (Poole, 1992). In northeastern Wyoming, Loggerhead Shrike abundance was not affected by topographic roughness (ranging from level terrain surface to extremely rugged surface topography) (Barlow and others, 2020). In another Wyoming study, Duchardt and others (2018) and Duchardt (2019) found that Loggerhead Shrike abundance was greater in areas with greater topographic roughness. The authors speculated that shrikes were not showing a preference for rugged topography but rather were using the isolated clusters of trees present along drainages.

Spatial and temporal variation in precipitation and temperature may affect reproduction, the timing of nesting, and abundance of Loggerhead Shrikes. In Alberta, 80 percent of 46 nests failed during a period of cool weather and above average precipitation (Collister, 1994). In southeastern Alberta, Collister and Wilson (2007a) examined the effect of weather on shrike breeding biology and nest survival; daily nest survival was higher during periods of warmer temperatures and lower precipitation. In another Alberta study, De Smet (1992) reported that nests monitored during summers with cool, wet weather had elevated mortality of young from exposure in open willows and grassland-dominated landscapes compared to nests in shelterbelts. In Missouri, Kridelbaugh (1983) reported lower reproductive rates and a higher incidence of brood reduction during a cold, wet spring than during a hot, dry spring in the previous year. Borgman and Wolf (2016) investigated the effects of increasing air temperature, highly variable winter and annual precipitation, and drought on the reproductive timing and output of Loggerhead Shrikes in central New Mexico. During the 6-year period, shrikes were exposed to variable but increasing temperatures. Shrikes advanced nest initiation, on average, by 20 days over the 6 years, and the advancement was significantly related to increases in average maximum air temperatures during March and April. The number of breeding pairs in the study area increased with higher temperatures. Winter precipitation and active-period precipitation (calculated for the period during which a nest was active) were important in driving shrike nest success, but in contrast with northern populations (Collister and Wilson, 2007a), nest success was not significantly related to breeding-season temperature.

The future distribution of Loggerhead Shrikes may be affected by climate-induced changes to temperature and precipitation. Under projected greenhouse gas emission scenarios described by the Intergovernmental Panel on Climate Change (2000), Langham and others (2015) categorized the Loggerhead Shrike as a climate-stable species, indicating that the species would retain >50 percent of its current distribution by 2050 across all Intergovernmental Panel on Climate Change scenarios, with potential for range expansion. Wilsey and others (2019) compiled avian occurrence data from 40 datasets to project climate vulnerability scores under scenarios in which global average temperature increases 1.5, 2, or 3 degrees Celsius (ºC). Loggerhead Shrikes ranked neutral in vulnerability during the breeding season at all three levels. Gardali and others (2012) did not classify the Loggerhead Shrike as vulnerable to the impacts of climate change in California; climate vulnerability was based on sensitivity (that is, intrinsic characteristics of an organism that make it vulnerable) and exposure (that is, the magnitude of climate change expected). Fleishman and others (2014) estimated the current location, quality, and connectivity of habitat for Loggerhead Shrikes 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. Loggerhead Shrikes were associated only with sagebrush shrubsteppe; shrikes were not found in pinyon-juniper woodlands (that is, woodlands dominated by singleleaf pinyon [*Pinus monophylla*], Utah juniper [*Juniperus osteosperma*], and western juniper [*Juniperus occidentalis*]) or in riparian woodlands dominated by deciduous trees (for example, quaking aspen [*Populus tremuloides*]) and shrubs (for example, willow). The area occupied by Loggerhead Shrikes was projected to not change markedly given the scenarios of expansion of pinyon-juniper woodlands or contraction of riparian woodlands by the year 2100 (Fleishman and others, 2014). Rodenhouse and others (2008) assessed potential effects of climate change on Loggerhead Shrikes in the northeastern United States. The authors projected that shrike presence would increase from ≤2 percent to ≥25 percent under four climate change scenarios described in Hayhoe and others (2007).

Prey Habitat

Loggerhead Shrikes are opportunistic predators, feeding on a wide variety of small prey, including insects and other arthropods, mammals, birds, reptiles, amphibians, and occasionally carrion and fruit (Judd, 1898; Sprunt, 1965; Kridelbaugh, 1982; Yosef, 2020). The largest part (66–88 percent) of their diet, numerically, consists of invertebrates (Beal and McAtee, 1912; Sprunt, 1965; Burton, 1990; Scott and Morrison, 1990). Small mammals and birds make up most of their vertebrate prey (Yosef, 2020). In Alberta, primary vertebrate prey were thirteen-lined ground squirrels (*Ictidomys tridecemlineatus*), meadow voles (*Microtus pennsylvanicus*), and sagebrush voles (*Lemmiscus curtatus*) (Collister, 1994).

Loggerhead Shrikes usually forage over areas of short grass (Kridelbaugh, 1982; Lane and Hunt, 1987), probably because prey is easier to detect in shorter vegetation. However, along a railway embankment in drier shortgrass prairies in southeastern Alberta, Loggerhead Shrikes preferred to forage in ungrazed areas, which provided taller (≥20 cm) grass (Prescott and Collister, 1993). In southeastern Alberta, Loggerhead Shrikes preferred hunting in native pastures and tame pastures of forage crops, avoided cereal crops and native and introduced vegetation within railroad rights-of-way, and used fallow fields in proportion to their availability (Collister, 1994; Collister and Wilson, 2007b). However, foraging success was found to be highest in railroad rights-of-way, where areas of tall, dense vegetation may be important reserve areas for vertebrate prey during times when arthropod prey is scarce (Collister, 1994; Collister and Wilson, 2007b). In South Carolina, shrikes selected nest-site characteristics that enhanced foraging ease and success while reducing predation risk; shrikes selected nest sites with low heterogeneity of vegetation density, high heterogeneity for vegetation height, and lower shrub and tree densities at the territory scale (Froehly and others, 2020). Shrikes also preferred nest trees with larger diameters at breast height.

Area Requirements and Landscape Associations

Loggerhead Shrike pairs maintain a multipurpose territory within which foraging, mating, nesting, and raising young occur; their territories are typically larger than other insectivorous passerines of similar size, which likely reflects their specialized foraging behavior and diet (Yosef, 2020). Territories are usually about 6–9 ha in size (Yosef, 2020), with territory size ranging from 2.7 ha (a single territory) in Alberta (Collister, 1994; Collister and Wilson, 2007b) to an average of 25 ha for 19 territories in Idaho (Woods, 1994). In Alberta, 20 territories along a railroad right-of-way averaged 8.5 ha in size (based on 95-percent minimum convex polygons) and were asymmetrical in shape (Collister, 1994; Collister and Wilson, 2007b). Average size of 23 shrike territories in Missouri was 4.6 ha (Kridelbaugh, 1982).

Aggregation of Loggerhead Shrike territories has been reported in California (T. Scott, pers. commun. *in* Etterson, 2000), Idaho (Woods, 1995b; Cade and Woods, 1997), Oklahoma (Etterson, 1990), and Indiana (Burton and Whitehead, 1990). Etterson (2000) evaluated the spatial distribution of shrike nests in Oklahoma based on a Monte Carlo simulation and found that territorial aggregation in shrikes in southwestern Oklahoma was largely a function of the availability of nest trees.

Habitat fragmentation has been suggested as a possible factor responsible for the widespread population decline of this species (Novak, 1995; Cade and Woods, 1997; Pruitt, 2000). Given the relatively large territories and habitat requirements of Loggerhead Shrikes, Smallwood and Smallwood (2021) indicated that the species is sensitive to habitat loss, degradation, and fragmentation. Froehly and others (2019), however, reported that fragmentation was not an important predictor of shrike occupancy during the breeding season but indicated that low occupancy probabilities and high fragmentation of pastures in their study area could imply that shrikes may have already been negatively affected by fragmentation.

Loggerhead Shrikes may be affected by the composition of the surrounding landscape. In sagebrush steppe throughout southern and central Idaho, the proportion of shrubs within 1 km had a negative influence on the probability of plot occupancy by Loggerhead Shrike (Miller and others, 2017). In the Chihuahuan Desert in New Mexico, Loggerhead Shrike occurrence was positively associated with the proportion of grassland in the landscape; shrikes were more likely to occur in areas where the proportion of grassland was high in a 1-km radius buffer centered at each nest (St-Louis and others, 2010). In southeastern Alberta, areas within 400 m of shrike observations contained a greater diversity of habitats and more frequently included road rights-of-way, farmyards, and shelterbelts than did random sites (Bjorge and Prescott, 1996). However, compared to random sites, no differences were detected in the proportion of annually cultivated fields, pastures, or hayland in areas around shrike observations. Densities of breeding pairs were significantly higher in high-density shrub blocks (6.6 pairs per 41.5 km^2) than in low-density shrub blocks (2.3 pairs per 41.5 km^2) (Bjorge and Prescott, 1996). High-density shrub blocks were defined as >100 clusters of shrubs and trees in a 41.5-km^2 block, and low-density shrub blocks were defined as <50 clusters of shrubs and trees in a 41.5-km^2 block (Bjorge and Prescott, 1996). In Minnesota, occupied nest sites (that is, a 50-ha circular plot centered on the nest location) had greater coverage of grasslands and pastures and longer hedgerows than did unoccupied random sites within shrike-occupied townships (Brooks and Temple, 1990b). In Missouri, areas within 200 m of the nest had more fencelines and more perch sites than random areas (Esely and Bollinger, 2001). Length of fenceline, area of forest, and number of perch sites were significant variables in a discriminant function analysis designed to separate nest sites from random sites. In Kansas, habitats within 300 m of survey stops for two BBS routes with stable shrike populations had more area in pastures; greater amounts of scattered trees and shrubs, more fencerows; fewer tree rows; and less area in wheat, rowcrop, and farmyards than habitats around two BBS routes with declining shrike populations (Bellar and Maccarone, 2002). Coppedge and others (2004) modeled the probability of occurrence of Loggerhead Shrikes as a function of landscape cover types within 1.8 km of survey stops for three BBS routes in northwestern Oklahoma, a region that has experienced extensive fragmentation and severe degradation from encroaching eastern redcedar. Wetland area (natural streams and rivers and man-made ponds) and shrubland area (areas dominated by >50 percent cover of low-statured perennial woody shrubs) were positively associated with shrike occurrence. In Missouri, the area within 200 m of nests had more area in pasture and less area in alfalfa (*Medicago sativa*) and corn than did random areas (Esely and Bollinger, 2001). There were no differences in percentage cover of rowcrop or forests within 300, 600, and 900 m of nest sites, but there was more grassland area within 300 m of nests than around random sites. In Illinois, Walk and others (2006) found that a greater percentage of hayland and pastures occurred within 100 m of Loggerhead Shrike nests than within 100 m of random points, even though the primary land use of the study area was rowcrop agriculture. In another Illinois study, nest sites had greater percentages of grass and rowcrop cover than did random sites (Fornes, 2004). In 12.57-ha circular plots in Virginia, sites occupied by shrikes had more area of active pastures and less area of rowcrops than vacant sites, had less area of idle pastures than random sites, and were closer to water than random sites (Luukkonen, 1987). In South Carolina, pastures, hay fields, residential lawns, and fallow fields constituted, on average, >80 percent of the habitat within 100 m of Loggerhead Shrike nests (Gawlik and Bildstein, 1990). In the coastal plains of South Carolina, occupancy by Loggerhead Shrikes was best predicted by the percentage of pasture within 1 km of the survey site; predicted occupancy increased from 2 percent when there was 0 percent pasture within a 1-km radius to 98 percent when there was 43 percent pasture within a 1-km radius (Froehly and others, 2019). The 1-km scale represented the maximum distance that a shrike would travel in the breeding season. Using eBird data (https://ebird.org; Sullivan and others, 2009) from 17 physiographic regions in the mid-Atlantic and southeastern United States, Johnson (2017) created an occupancy model for Loggerhead Shrikes during the breeding season for three habitat types (grassland, cropland/low human development, and high human development). The probability of shrike breeding occupancy in the three habitat types decreased with an increase in road density (kilometers of road per square kilometer), indicating a negative relationship with human development, and an increase in forest cover within 2.5 km of shrike observations.

Brood Parasitism by Cowbirds and Other Species

Loggerhead Shrikes exhibit high levels of egg rejection of Brown-headed Cowbird (*Molothrus ater*) eggs; this behavior probably reflects retention of a trait from the species' ancestors, which were parasitized by Old World cuckoos (Cuculinae) (Rothstein, 2001; Peer and others, 2011). Brown-headed Cowbirds also may have limited opportunities to parasitize shrike nests because of the Loggerhead Shrike's aggressive and predatory behaviors (Potter, 1939; Friedmann, 1963). Published rates of cowbird brood parasitism are very low; only two sources have reported cases of brood parasitism in Loggerhead Shrike nests (Shaffer and others, 2019). In southwestern Manitoba, 1,525 Loggerhead Shrike nests were found between 1987 and 2013 at the egg stage and monitored to near-fledging stage; two of the shrike nests were parasitized by cowbirds (K.D. De Smet, Manitoba Conservation, Melita, Manitoba, written commun., September 2018), including one nest that fledged five shrike young and one cowbird young (De Smet and Conrad, 1990). De Geus and Best (1991) reported that three of 261 shrike nests in southwestern Iowa were parasitized by cowbirds. Attempts to artificially parasitize Loggerhead Shrike nests have met with limited success (Potter, 1939; Rothstein, 1982). Loggerhead Shrikes rejected Red-winged Blackbird (*Agelaius phoeniceus*) and Tricolored Blackbird (*Agelaius tricolor*) eggs that were experimentally placed in shrike nests (Rothstein, 1982). In Oklahoma, Etterson (2004) examined six nuclear microsatellites to assess rates of intraspecific brood parasitism and extrapair paternity in 218 offspring from 44 Loggerhead Shrike broods; no offspring were the result of intraspecific brood parasitism, but 4 percent of all offspring were sired by extrapair fertilization.

Breeding-Season Phenology and Site Fidelity

Loggerhead Shrikes return to their breeding grounds from their wintering grounds from mid-February to early May (Porter and others, 1975; Stewart, 1975; Salt and Salt, 1976; Faanes, 1981; Kridelbaugh, 1983; Janssen, 1987; Luukkonen, 1987; De Smet, 1992; Poole, 1992; Tyler, 1992; Collister, 1994; Chabot and others, 1995; Woods, 1995a; Michaels, 1997). Shrikes at higher elevations or at northern latitudes tend to nest later and have shorter breeding seasons than shrikes at lower elevations or at southern latitudes (Luukkonen, 1987). Fall migration occurs between August and late October, with some stragglers leaving the breeding grounds in November (Stewart, 1975; Salt and Salt, 1976; Faanes, 1981; Janssen, 1987; Yosef, 2020). Banding and recovery records from 1923 to 1983 indicated that populations of Loggerhead Shrikes east of the Rocky Mountains migrate partly or wholly to the southeastern United States for the winter (Burnside, 1987).

Mate fidelity and between-year site fidelity have been reported for Loggerhead Shrikes. Mate fidelity between years is generally low, and some female Loggerhead Shrikes have been reported to desert their original mates for new mates within a breeding season (Haas and Sloane, 1989). Some studies indicate that males display higher adult site fidelity (that is, a bird returns to a previous breeding territory or to the study area) than females on the breeding grounds (Kridelbaugh, 1983; Haas and Sloane, 1989). In southwestern Manitoba, return rates differed significantly between adult males and females; 16 of 71 banded males and 6 of 69 banded females were resighted within 4 km of the study area in the year after banding (Collister and De Smet, 1997). However, in southeastern Alberta, there was no significant difference in the number of adult males and females that returned to within 4 km of their respective territories from the previous year; 18 of 48 banded males and 13 of 48 banded females were resighted within 4 km of the study area in the year after banding (Collister, 1994; Collister and De Smet, 1997). In the two study areas combined, 50 percent of 20 adult males and 27 percent of 11 adult females returned to the same nesting territory. In central Missouri, Kridelbaugh (1983) reported that 47 percent of 15 banded males returned to the area used the previous year, but none of the 15 banded females returned. In Idaho, two of seven adult males and one of four adult females banded the previous year returned to their respective breeding territories (Woods, 1995b). In North Dakota, 14 percent of 69 banded adults were resighted in the study area during a subsequent breeding season; the authors speculated that nest desertion and mate switching by females may have contributed to low site fidelity (Haas and Sloane, 1989).

In southwestern Iowa, reoccupancy of territories during a 3-year study ranged from 9 of 24 sites to 42 of 74 sites (De Geus, 1990). At Midewin National Tallgrass Prairie in Illinois, adult site fidelity was low (3 percent of 100 banded adults), but adult site reuse (that is, the presence of a breeding pair, regardless of previous breeding history) was high (62 percent of 100 banded adults) (Chabot and others, 2016). Average adult dispersal distance was 1.6 km; average adult female dispersal distance (2.1 km) was greater than average male dispersal distance (1.6 km) (Chabot and others, 2016). In Oklahoma, a shrike was recaptured 11 years after banding and about 17 km from where it had been banded (Klimkiewicz and others, 1983). In Ontario between 1999 and 2001, 6.8 percent of 73 color-banded adults returned to the study area; annual adult site fidelity ranged from 0 percent to 13.3 percent (Okines and McCracken, 2002).

Loggerhead Shrikes occasionally reuse their nests within a breeding season or from the previous breeding season (Miller, 1931; Sprunt, 1965; Woods and Cade, 1996; Yosef, 2001). Shrikes also have been observed using abandoned nests of Black-billed Magpies (*Pica hudsonia*) and Sage Thrashers (*Oreoscoptes montanus*) (Porter and others, 1975; Woods and Cade, 1996; Humple and Holmes, 2006; Sanders and others, 2018).

Site reuse and site fidelity may be related to reproductive success in the preceding year. In Manitoba, 7 percent of 129 adults that raised young to banding age (8–12 days old) returned to the same territory in the following year, but only 2.3 percent of 43 adults that failed to raise young to banding age returned to the same nesting territory in the following year (Collister and De Smet, 1997). In Illinois, 61 percent of 72 shrike territories in which at least one young fledged were reused in the following year, but only 48 percent of 31 territories were reused where reproduction was unsuccessful (Chabot and others, 2016).

Fidelity to natal sites is fairly low for Loggerhead Shrikes. In Idaho, four of 171 banded nestlings returned to the study area; three of these bred within 5 km of their respective natal areas (Woods, 1995b). Collister and De Smet (1997) studied natal fidelity of banded shrikes in Alberta and Manitoba. In Alberta, three of 249 banded nestlings returned within 4 km of their respective natal sites the following breeding season; overall, 16 of 582 banded nestlings returned over a 6-year span (Collister and De Smet, 1997). In southwestern Manitoba, 27 of 3,176 banded nestlings returned to the study area in the year after banding, and 74 were reencountered over the duration (1987–1994) of the study (Collister and De Smet, 1997). Thirty-six percent of the 74 returning birds banded as nestlings returned as 1-year-old birds, 38 percent as 2-year-old birds, 20 percent as 3-year-old birds, and 5 percent as ≥4-year-old birds. In North Dakota, natal site fidelity was 1 percent (2 of 243 banded nestlings or fledglings), and natal dispersal distances averaged 3.5 km (Haas, 1995). In Illinois, natal site fidelity was 6 percent of 40 banded juveniles, and the average natal dispersal distance was 0.97 km (Chabot and others, 2016). In Ontario between 1999 and 2001, 4.6 percent of 389 color-banded nestlings returned to natal sites; annual return rates of banded nestlings ranged from 1.5 to 12 percent (Okines and McCracken, 2002).

Loggerhead Shrikes have been known to raise two broods in one breeding season (Sprunt, 1965; Johnsgard, 1979; De Geus, 1990; Poole, 1992; Tyler, 1992; Chabot and others, 1995, 2001b, 2016; Humple and Holmes, 2006; Yosef, 2020) and to renest after failure of their first clutch (Porter and others, 1975; Kridelbaugh, 1983; Brooks and Temple, 1990a; De Geus, 1990; Poole, 1992; Hellman, 1994; Chabot and others, 1995; Woods, 1995a; Woods and Cade, 1996; Humple and Holmes, 2006; Yosef, 2020). In southeastern Alberta, Collister (1994) reported that Loggerhead Shrikes did not raise two broods, and all 12 renesting attempts after a nest failure were unsuccessful. During a long-term study (1987–2013) in southern Manitoba, 231 of 693 pairs renested after a failed initial nesting attempt, 13 renested twice, and at least 11 pairs produced a second nest after fledging young from initial nests (K.D. De Smet, Manitoba Conservation, Melita, Manitoba, written commun., September 2018). At southern latitudes, shrikes may be more likely to be multibrooded than at northern latitudes because of more favorable weather conditions and longer nesting seasons (Kridelbaugh, 1983; Luukkonen, 1987; Tyler, 1992). In southwestern Oklahoma, 24 of 122 shrike pairs attempted second broods during a 4-year study (Tyler, 1992).

Species' Response to Management

Burning as a management practice for improving breeding habitat for Loggerhead Shrikes has not been well studied. In south-central Washington, patchily burned late-seral big sagebrush and antelope bitterbrush communities provided the high levels of horizontal and vertical structural diversity preferred by breeding Loggerhead Shrikes in shrubsteppe communities (Poole, 1992). In northeastern Oregon, a wildfire burned about 1,700 ha of basin big sagebrush (*Artemisia tridentata* subspecies [ssp.] *tridentata*) and Wyoming big sage (*Artemisia tridentata* ssp. *wyomingensis*) and about 8,000 ha of adjacent grassland and shrubland; the number of shrike pairs decreased by about one-half after the fire, and nest survival decreased from 39 to 19 percent (Humple and Holmes, 2006). In communities of burned and unburned mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) in the northwestern Great Basin of Nevada, Loggerhead Shrikes were only observed on unburned sites (Holmes and Robinson, 2013). In the tallgrass prairies of the Flint Hills in northeastern Kansas, shrike use of breeding sites was not affected by the number of years since last burn, haying conducted in the previous year, or disturbance by military activities (Michaels, 1997; Michaels and Cully, 1998). In another Kansas study, Loggerhead Shrike abundance was not significantly different between burned and unburned tallgrass prairies (Zimmerman, 1993). In Texas, Long and others (2014) evaluated Loggerhead Shrike response to prescribed burning of ungrazed shortgrass prairie that was heavily encroached by honey mesquite and cholla (*Opuntia* spp.). Loggerhead Shrikes were observed in experimental plots (120–220 ha) treated with prescribed fire every 4 years and in unburned control plots, but they were not observed in plots treated with prescribed fire every 2 years (Long and others, 2014).

Loggerhead Shrike response to grazing varies among regions. In Idaho, grazing of big sagebrush by horses (*Equus caballus*) and cattle eliminated several Loggerhead Shrike territories (Woods, 1995b). During the breeding season in Utah's Great Basin low-shrub desert, shrikes regularly used ungrazed pastures and pastures that were heavily grazed in late winter (stocking rate was not provided); within those pastures, shrikes were largely restricted to dry washes that contained taller shrubs interspersed among shorter vegetation (Medin, 1986). In southeastern Alberta, Loggerhead Shrikes tended to avoid habitats that contained shorter vegetation, which resulted from heavy grazing by cattle (Prescott and Collister, 1993). In an east-central Alberta study, Loggerhead Shrikes were found on continuously grazed (that is, heavily grazed in spring and summer) mixed-grass pastures (Prescott and others, 1995). Regions in Alberta and Saskatchewan with severe Loggerhead Shrike population declines lost 39 percent of their unimproved pastures (that is, natural grazing lands, presumably mixed-grass prairies) to cropland over a 41-year period and up to 79 percent since Euro-American settlement (Telfer, 1992). Areas with moderate Loggerhead Shrike population declines showed lower losses of unimproved pastures than areas with severe declines. In Ontario, 86 percent of shrike breeding sites were in idle pastures and intensively grazed pastures characterized by short vegetation; the remaining 14 percent were in oldfields, hayland, or row crops (Chabot and others, 2001a). In tallgrass prairie regions, such as in Missouri (Kridelbaugh, 1982), Illinois (Smith and Kruse, 1992), and Kansas (Eddleman, 1974), Loggerhead Shrikes preferred vegetation that was kept short by grazing. On remnant tallgrass prairies and restored grasslands in the Grand River Grasslands in southern Iowa and northern Missouri, Pillsbury (2010), Pillsbury and others (2011), Duchardt (2014), and Duchardt and others (2016) evaluated breeding bird use of three management treatments: patch-burn graze (one distinct patch burned per year with free access by cattle from May 1 to October 1; stocked at 3.09 animal unit months [AUMs] per ha), graze-and-burn (one pasture-wide burn every 3 years and free access by cattle; stocked at 3.09 AUMs per ha), and burn-only (one pasture-wide burn every 3 years and no grazing). Shrikes were observed at low densities (≤0.079 individuals per ha) in all three management treatments. In Missouri, 88 percent of all foraging attempts by adult shrikes during the nestling stage occurred in pastures or lawns (Kridelbaugh, 1982). Throughout the occupied range of the Lesser Prairie-Chicken (*Tympanuchus pallidicinctus*) in Colorado, Kansas, New Mexico, Oklahoma, and Texas, Pavlacky and others (2021) evaluated the extent to which CRP grasslands and prescribed grazing practices designed to benefit Lesser Prairie-Chickens influence densities of the Loggerhead Shrike and other grassland birds. Loggerhead Shrike densities were not significantly different among native- and tame-seeded CRP lands, Lesser Prairie-Chicken-prescribed grazing lands, and reference grasslands (controls). In sand shinnery oak (*Quercus havardii*) communities in eastern New Mexico, Loggerhead Shrike density showed a neutral response to various combinations of herbicide (tebuthiuron) applications and short-term duration grazing (that is, taking a maximum of 50 percent of the available herbaceous cover per year, including 25 percent during the dormant season [January or February] and 25 percent during the growing season [July]) (Smythe, 2006).

Restoration of sagebrush habitats may improve habitat suitability for Loggerhead Shrikes. At the Camas National Wildlife Refuge in southeastern Idaho, Rockwell and others (2021) monitored avian abundance and community composition to measure the progress of sagebrush restoration among three sagebrush-steppe habitat types with varying degrees of invasion by nonnative crested wheatgrass (*Agropyron cristatum*). The three habitat types before restoration included sagebrush with a native-grass understory (that is, the reference condition), sagebrush with a nonnative-grass understory (that is, with little-to-no native grasses present), and crested wheatgrass-dominated sites (that is, mainly monotypic stands of crested wheatgrass with little-to-no shrub cover). Loggerhead Shrikes were detected exclusively in sagebrush with an understory of native grasses, but the species had insufficient frequency to be a significant management indicator species for other sagebrush-associated bird species (Rockwell and others, 2021).

Anthropogenic disturbances may affect Loggerhead Shrike reproductive success, survival, and nest-site selection. The species frequently forages along roadsides, which may increase their susceptibility to vehicle collisions (Committee on the Status of Endangered Wildlife in Canada, 2014; Environment Canada, 2015). In southeastern Arizona, shrike territories contained fewer residential and commercial developments and more open habitats with native low-growing desert-scrub vegetation (such as cactus [*Opuntia* spp.], brittlebush [*Encelia farinosa*], and triangle bursage [*Ambrosia deltoidea*]) than did random areas (Boal and others, 2003). However, shrikes also nested in playgrounds, residential yards, and parking lots, but only near open habitats. In southeastern Alberta, 52.2 percent of 113 Loggerhead Shrike locations of observed breeding pairs were within 200 m from roads, 6.2 percent were 201–400 m from roads, and 41.6 percent were >400 m from roads (Bjorge and Prescott, 1996). In Grassland National Park in Saskatchewan, however, Loggerhead Shrikes nested at sites significantly farther from roads (over 2,000 m) and at higher elevations than control sites (Shen and others, 2013). In Ontario, nest sites in scattered isolated hawthorn shrub habitats were significantly closer to roads than were randomly chosen shrubs in similar but unoccupied habitat (Chabot and others, 2001a). The average distance of 66 nest sites to roads ranged from 96 to 137.8 m, distances to houses ranged from 245.8 to 344.9 m, and distances to other sources of disturbance (gravel pits, quarries, and railroad tracks) ranged from 310 to >1,000 m. At the Minot Air Force Base in northwestern North Dakota, three of six shrike breeding pairs were successful in their first nesting attempts; nests of successful breeding pairs were in shrubs bordering horse paddocks, and nests of unsuccessful pairs were in shelterbelts near road rights-of-way (Igl, 1995). In Illinois, most successful nests were within 100 m of buildings or utility lines (Lane and Hunt, 1987). In Missouri, nests within 15 m of roads had smaller clutches, hatched fewer eggs, and fledged fewer young than nests farther than 15 m from roads (Esely and Bollinger, 2001). In Virginia, shrikes selected nest trees that were closer to roads (104 m) compared to random trees (121 m) (Luukkonen, 1987). In Ontario and Indiana, Hudecki and others (2021) examined the effect of plastic use by shrikes in grasslands. Twenty percent of 24 shrike nests during a 2-year study contained plastic debris, with three instances of nestlings becoming entangled.

Intensive agriculture may be detrimental to Loggerhead Shrikes. In Alberta, foraging success by Loggerhead Shrikes was low (20 percent) in crop fields, and foraging shrikes generally avoided crops and fallow fields in favor of native and improved pastures (Collister and Wilson, 2007b). Improved pastures were defined as forage crops >30 cm in height. Using BBS data over a 40-year period (1966–2007), Quinn and others (2017) modeled Loggerhead Shrike response to multiple measures of agricultural change along the 41st parallel through the central Great Plains and western Corn Belt of Colorado, Wyoming, Nebraska, and Iowa. During the focal period, the area of cropland planted, biomass yield, and chemical use in the region increased by 40, 100, and 500 percent, respectively. Loggerhead Shrike abundance declined as the area of land planted to cropland increased, but the relationships between shrike abundance and biomass yield or chemical use were not strongly supported (Quinn and others, 2017). In southeastern Illinois, reproductive success was very low (25.6 percent nest success for 34 nests) in a heavily agricultural landscape characterized by 85 percent rowcrops compared to other studies, and 88 percent of 24 nest failures were because of predation (Walk and others, 2006). Walk and others (2006) noted that populations of generalist predators such as raccoons (*Procyon lotor*) and Virginia opossums (*Didelphis virginiana*) had increased in Illinois during a period of increasing rowcrop agriculture.

Historically, some pesticides may have had deleterious effects on Loggerhead Shrikes, especially at higher application rates. Busbee (1977) reported that young, captive-raised Loggerhead Shrikes (collected in California) that were fed 1 microgram per gram of dieldrin (an organochloride insecticide) per day died within 16–78 days. Shrikes showed no effects on their ability to capture house crickets (*Acheta domesticus*) but showed a 5-day delay in their ability to capture house mice (*Mus musculus*); signs of impending death because of organochloride poisoning included convulsions and weight loss beginning a few days before death. In Illinois, dichlorodiphenyldichloroethylene (DDE) was detected in 61 of 69 shrikes (Anderson and Duzan, 1978). Average concentration of DDE was 21.9 parts per million (ppm). DDE also was detected in eggs; average DDE concentration in the contents of 104 eggs was 3.09 ppm. Shells of 57 eggs collected in 1971 and 1972 were 2.8 percent thinner than 83 museum specimens collected in 1875–95. Shell thickness was negatively correlated with DDE concentration in the egg contents (Anderson and Duzan, 1978). In another Illinois study, 17 of 21 eggs collected from 12 nests contained average DDE levels of 0.66 ppm (Pruitt, 2000; Herkert, 2004). Detectable levels of dichlorodiphenyltrichloroethane (DDT) were found in nine eggs. No other organochlorine compounds were detected. Herkert (2004) concluded that organochlorine pesticides are likely not driving recent Loggerhead Shrike population declines in Illinois. The effects of pesticides on Loggerhead Shrike populations have been studied elsewhere in the species' range. In California, Rudd and others (1981) found average DDT concentrations of up to 200 ppm in the skin, brain, and subcutaneous fat of shrikes; these levels were 200–400 times higher than the levels found in insect prey. In northwestern Virginia, oxychlordane and DDE residues were present in all shrike samples examined, including tissues of seven shrike carcasses and eight clutches of shrike eggs (Blumton and others, 1990). A study on the effects of sodium ammonium nitrate fertilizer application on bahiagrass (*Paspalum notatum*) pastures in central Florida indicated that Loggerhead Shrikes deserted the area, died, or expanded their territories after a fertilizer application during the shrike breeding season (Yosef and Deyrup, 1998). The fertilizer caused some vegetation to become chlorotic and stunted, reducing the amount of vegetation available to insects; populations of insects preyed upon by shrikes declined as a result (Yosef and Deyrup, 1998).

Wind-energy development may negatively impact Loggerhead Shrike survival, distribution, and abundance. Erickson and others (2014) compiled data from 116 studies from the United States and Canada to estimate songbird fatality rates at wind-energy facilities, after adjusting for detection bias and loss of shrike carcasses from scavenging. The authors estimated that about 340 to 591 shrike fatalities occur annually from collisions with wind turbines, accounting for 0.013 percent or less of the shrike's continental population. Beston and others (2016) developed a prioritization system to identify avian species (428 species evaluated) 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 Loggerhead Shrike scored a 3.73 out of nine, where nine indicated high risk, and Beston and others (2016) estimated that 3.46 percent of the Loggerhead Shrike breeding population in the United States may be exposed to wind facilities. 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 Loggerhead Shrike mortality was reported at one wind facility. At two wind-energy facilities in shortgrass prairies in Texas, Wulff and others (2016) examined diurnal flight heights of Loggerhead Shrikes and determined that the species' average flight height was 10.4 m, which is not within the rotor-swept zone (32–124 m) of wind-turbine blades; however, 13 percent of the shrikes that were observed had flight heights within the rotor-swept zone. At the Altamont Pass Wind Resource Area in California, which included both lattice and tubular wind towers, Loggerhead Shrikes avoided the rotor-swept zone of operating turbines but were more interactive with other birds while flying within the rotor-swept zone of nonoperating turbines; shrikes perched on operating turbines 1 percent of the total perching time observed (698 minutes) but perched on nonoperating turbines 26 percent of the time (Smallwood and others, 2009). In that same study area, estimates of Loggerhead Shrike fatalities associated with wind turbines averaged 93.4 fatalities per year with old-generation wind turbines compared to 10.6 fatalities per year after the old-generation turbines were removed and replaced with larger, modern wind turbines (Smallwood and Smallwood, 2021). Smallwood and Smallwood (2021) considered the Altamont Pass Wind Resource Area an ecological sink for shrikes because of wind-turbine collision mortality when old-generation wind turbines were in operation. In southern California, Loggerhead Shrikes were less common at wind facilities than at reference sites, which ranged from low to high anthropogenic disturbances that were unrelated to wind-energy development (Keehn, 2016).

Rapidly increasing development of solar energy, especially in western landscapes, may pose mortality risk to Loggerhead Shrikes. In south-central California, Loggerhead Shrikes were reported using two of seven solar photovoltaic energy generating facilities (photovoltaic cells that directly convert the sun's energy into electricity) in the San Joaquin Desert (Cypher and others, 2021). In another California study, Kagan and others (2014) summarized bird mortality data at three solar energy facilities. Loggerhead Shrike remains were found at a photovoltaic solar facility and at a solar power tower (thousands of mirrors that reflect solar energy to a tower, where water in boiler is converted to steam, generating electricity), but no shrike remains were among the 31 dead birds (15 species) reported at a trough system solar facility (parabolic mirrors that focus and reflect the sun to a tube that converts heat from the sun into electricity). Two of 61 birds (33 species) identified from their remains at a photovoltaic solar facility were Loggerhead Shrikes, and three of 141 birds (49 species) identified from their remains at a solar power tower were Loggerhead Shrikes. Causes of mortality for all species combined included blunt force impact trauma, predation trauma, emaciation, and electrocution (Kagan and others, 2014). Because of the diversity of birds dying at the different solar facilities, Kagan and others (2014) concluded that solar facilities were not attracting shrikes or any particular species. In Arizona, Colorado, and Ohio, shrikes were observed at two of four photovoltaic arrays; shrike densities in photovoltaic arrays were lower than densities in nearby grasslands at airports (DeVault and others, 2014).

Loggerhead Shrikes typically are tolerant of oil and gas development. In saltbush (*Atriplex* spp.)-scrub habitat in the San Joaquin Valley of California, shrikes were observed in areas with no active oil or gas wells, but the species also was commonly observed perching on overhead powerlines or other structures in areas with medium-density (11–15 well pads with active oil or gas wells per 36-ha plots) and high-density (102–393 well pads with active oil or gas wells per 36-ha plots) oilfields (Fiehler and others, 2017). The authors surmised that the abundance of structures and presence of prey (for example, large insects and small lizards) may have facilitated the species' presence in this highly disturbed oil-production landscape. In northeastern Wyoming, Barlow and others (2020) evaluated avian abundance in sagebrush habitats across a gradient of energy development and found that shrike abundance did not differ between active oil and gas areas and control areas (that is, undisturbed sagebrush steppe containing no energy development). Shrikes exhibited slightly higher abundance in a large-scale reclamation site following oil and gas development, although the shrike distribution estimates were highly overlapping. Between August 1992 and June 2005, remains of 172 bird 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 eight Loggerhead Shrikes were identified in oil pits in Kansas, Oklahoma, Texas, New Mexico, and California.

Management Recommendations from the Literature

Habitat loss and fragmentation on the Loggerhead Shrike's breeding grounds are considered important factors contributing to the population decline of the species (Cade and Woods, 1997; Humple and Holmes, 2006). Thus, maintaining and conserving grasslands are important for Loggerhead Shrike conservation. On privately owned lands, conservation incentive programs (for example, Farm Bill cost-share programs) can be used to maintain or create grasslands within 1 km of a breeding territory (Froehly and others, 2019, 2020). Several researchers have recommended protecting shrike habitat through incentive programs such as the Sodbuster Program and CRP; through easements, donations, land trusts, leases, or purchases; or through designation of habitat as natural areas (Hands and others, 1989; Collister, 1994; Hellman, 1994; Collister and Henry, 1995). Agricultural policies that promote conversion of prairies to cropland would be detrimental to this species (Hellman, 1994). Conserving areas that are large enough to support several average-sized shrike territories (about 2.7–25 ha per territory) of asymmetrical shape will benefit breeding Loggerhead Shrikes (Collister, 1994; Yosef, 2020), including females that sometimes mate with more than one male or switch mates (Haas and Sloane, 1989). Froehly and others (2020) recommended that management actions at large and small scales would help ensure that all habitat requirements are met, but the authors acknowledged that small-scale actions (for example, retaining large trees in open habitat to provide nesting substrate or increasing diversity in ground vegetation height to provide more high-quality foraging habitat) in highly fragmented landscapes might be the only option. Hands and others (1989) recommended preserving native prairies in breeding and wintering areas; where this is not possible, seeded pastures may be provided as substitutes (Hands and others, 1989; Telfer, 1992). In the western portions of the species' breeding range, conserving sagebrush-scrub habitats will benefit nesting Loggerhead Shrikes (Woods, 1995b; Woods and Cade, 1996).

Loggerhead Shrikes need open areas, but some coverage of woody vegetation is beneficial as perches for foraging, as sites to impale prey, and as nesting substrate (Becker and others, 2009; Yosef, 2020). Open areas may be enhanced for shrikes by maintaining low, thick shrubs and trees along fencelines; in abandoned farmyards; and throughout otherwise open pastures and fields (Kridelbaugh, 1982; Hands and others, 1989; Collister, 1994; Yosef, 2020). Linear habitats may be improved by manipulating herbaceous cover density; planting multiple rows of trees in shelterbelts; adding larger blocks of habitat adjacent to strips of woody vegetation to make nests less susceptible to depredation; or planting thorny, native vegetation in fencerows (Kridelbaugh, 1982; De Geus, 1990).

Shen and others (2013) emphasized the importance of preserving native grass and thorny shrub species (lower than 3 m) within the shrike's breeding range but managing or reducing dense woody vegetation. In Alberta and Saskatchewan, Telfer (1992) recommended planting at least one small patch of willow, buffaloberry, or Siberian peashrub per quarter-section (64.75 ha) in fence corners or in moist areas. In southwestern Manitoba, Hellman (1994) recommended maintaining and diversifying shelterbelts by incorporating thorny trees and bushes such as hawthorn and hedge rose and planting a 2–4-m strip of grass around shelterbelts to increase foraging areas near nest sites. Although Hellman (1994) did not observe shrikes using peashrub for nesting, earlier studies in the same study area noted occasional peashrub use particularly in shelterbelts (De Smet and Conrad, 1989, 1990). Prescott and Collister (1993) encouraged managers to evaluate the adequacy of available shrubs for nesting shrikes before planting more, but Bjorge and Prescott (1996) encouraged planting trees or shrubs in already diverse habitats to provide nesting and perching habitat. In Missouri, Kridelbaugh (1982) cautioned against planting nonnative multiflora rose bushes because of the poor nest support offered by this shrub species; instead, Kridelbaugh (1982) recommended providing thorny, native vegetation such as honey locust and hawthorn. Aging CRP grasslands may become more suitable for Loggerhead Shrikes, as natural vegetation succession produces more woody cover (Riffell and others, 2008). In the western United States, converting crested wheatgrass-dominated areas to sagebrush habitat with a native herbaceous understory will enhance vegetation structural and functional diversity and thus improve habitat for sagebrush-associated species, such as the Loggerhead Shrike (Rockwell and others, 2021). In New Mexico, Harris and others (2022) recommended maintaining one-seed juniper densities at 4–13 percent in juniper savannas to increase shrike nesting habitat without reducing nesting habitat for another species of conservation concern, the Gray Vireo (*Vireo vicinior*).

Hands and others (1989) recommended that herbaceous cover should be maintained, perhaps by burning at a frequency that prevents woody vegetation from dominating an area but that does not completely eliminate it. In south-central Washington, Poole (1992) noted that patchily burned areas provided the high structural diversity preferred by Loggerhead Shrikes using late-seral big sagebrush and antelope bitterbrush communities. In sagebrush steppe habitat, efforts to mitigate the deleterious effects of cheatgrass on the fire regime (for example, restoration of preinvasion conditions, limiting land-use activities that increase dominance of invasive plants) can be used to protect patches of sagebrush from wildfires (Humple and Holmes, 2006).

In areas with taller vegetation, grazing may provide suitable short vegetation for foraging Loggerhead Shrikes. Hellman (1994) indicated that moderate haying or grazing in Manitoba may increase Loggerhead Shrike productivity, although the author did not define moderate haying or grazing. Pastures often are preferred habitat in Missouri (Kridelbaugh, 1983), Illinois (Smith and Kruse, 1992), and Kansas (Eddleman, 1974). In the upper Midwest, Hands and others (1989) indicated that light grazing could be used to reduce vegetation.

Although Loggerhead Shrikes prefer to forage in short vegetation, foraging success may be higher in areas of tall grass (>20 cm) vegetation in which vertebrate prey abundance is higher (Collister, 1994). Collister (1994) recommended that a few areas of tall grass should be maintained within pastures as they serve as food reservoirs for small mammals, which are potential Loggerhead Shrike prey. Shen and others (2013) recommended grazing in areas with tall grass to provide short vegetation suitable for shrike foraging and to increase shrike productivity, but the authors also indicated that managers should maintain some patches of taller vegetation for small mammals that serve as a major prey item for shrikes. In areas with naturally short vegetation, several researchers recommended that grazing and mowing should be limited to allow grasses to grow taller (≥20 cm) in some areas (Prescott and Collister, 1993; Collister, 1994; Yosef, 2020). Collister and Wilson (2007b) recommended maintaining a heterogeneous landscape with sparsely vegetated patches adjacent to taller, denser vegetation. Fencing or other methods can be used to protect old shelterbelts and nesting bushes from cattle grazing and rubbing (Collister, 1994; Yosef, 2020).

In habitats with few or no natural perch substrates, artificial perches may be constructed to improve foraging habitat for Loggerhead Shrikes, but artificial perches also could increase the risk of competition or predation from raptors in some situations (Becker and others, 2009). Becker and others (2009) found that shrikes selected foraging perches with less foliage but with at least some cover; the authors recommended that the use of artificial perches to improve foraging habitat should consider the extent of cover surrounding the perch.

When possible, the use of biocides should be reduced to help protect insects and other prey species of the Loggerhead Shrike (Hands and others, 1989; Collister, 1994; Hellman, 1994). Yosef (2020) indicated that trimming or manual removal of shrubs and trees may be used instead of herbicides or frequent mowing to manage woody vegetation.

Avoiding disturbance of habitat near nest sites during the breeding season may prevent Loggerhead Shrikes from abandoning their territories; a 250-m buffer around occupied nests was recommended in Alberta (Collister and Wilson, 2007b). At the Altamont Pass Wind Resource Area in California, fatalities of shrikes were reduced by replacing smaller, old-generation wind turbines with larger, more efficient, and more widely spaced wind turbines that pose lower collision risk per megawatt produced (Smallwood and Karas, 2009; Smallwood and Smallwood, 2021). Given that shrikes rarely perched on operating wind turbines at the Altamont Pass Wind Resource Area, Smallwood and others (2009) recommended removing vacant wind towers, repairing broken towers, and synchronizing turbine operations within a row to reduce hazardous use of the rotor zone and bird collisions. The authors also recommended leaving large gaps between groups of turbines to allow birds to travel and forage without having to fly close to wind turbines. Smallwood and Smallwood (2021) recommended minimizing shrike mortality associated with wind turbines, conserving instead of eradicating California ground squirrels (*Otospermophilus beecheyi*) and their burrow complexes, and cultivating trees and shrubs (for example, oak gooseberry [*Ribes quercetorum*]) that offer nest substrates and protection against predators. DeVault and others (2014) contended that the relative lack of bird use at photovoltaic arrays would facilitate solar development at airports, especially given that airfield grasslands are managed to be largely free of wildlife. At some airports, conversion of airfield habitats to photovoltaic arrays could reduce bird-aircraft collision risk relative to current grass or other natural land covers used on airports (DeVault and others, 2014). To make oil-production waste fluids inaccessible to Loggerhead Shrikes 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 (Trail, 2006).

Captive-reared juvenile Loggerhead Shrikes have been successfully released into the wild in Ontario (Imlay and others, 2010, 2017; Nichols and others, 2010; Lagios and others, 2015; Parmley and others, 2015) and California (Kuehler and others 1993; Munkwitz and others, 2005; Sheldon, 2018). In Oklahoma, Etterson (2003) found that late-breeding shrikes that were inexperienced breeders nested closer to already established nests of experienced breeders than predicted by the distribution of suitable nest trees, indicating that these late-nesting shrikes use the distribution of breeding conspecifics when deciding where to nest. Etterson (2003) recommended that Loggerhead Shrike breeding ecology should be considered in shrike habitat conservation programs as well as captive breeding and reintroduction programs. Parmley and others (2015) concluded that long-term management decisions for a captive breeding program need to focus on increasing the number of shrike breeding pairs in the wild and sustaining a genetically diverse population of shrikes in captivity until shrike numbers are sufficient to sustain a wild population. In captivity, the number of fledglings in a brood and breeding female age were significant predictors of fledgling survival (Parmley and others, 2015). Survival among captive fledglings increased as the female aged up to 4 years and then slowly decreased over time. Fledgling survival was reduced for birds from second clutches; Parmley and others (2015) speculated that lower survival may reflect higher breeding stress and reduced fitness of the parents after having already fledged one brood. Postrelease survival and dispersal of captive-reared shrikes were higher than survival estimates reported in the literature for some wild juveniles of other passerines (Imlay and others, 2010). The average annual return rate for captive-reared Loggerhead Shrikes released during 2004–07 was 4.6 percent (range 2.0–6.6 percent; Nichols and others, 2010). Captive-reared juveniles that returned to the breeding grounds came from larger release groups and were released at a younger age than their nonreturning counterparts (Lagios and others, 2015). At a captive facility in Ontario, Bertelsen and others (2004) reported 100 percent mortality of five captive shrikes after exposure to West Nile virus. Thirty-seven uninfected birds were moved indoors and vaccinated with a commercial equine West Nile virus vaccine; after vaccination, 84 percent of the birds had West Nile neutralizing antibodies. In California, captive propagation plays a critical role in the viability of the San Clemente subspecies (*Lanius ludovicianus mearnsi*) of the Loggerhead Shrike (Kuehler and others 1993; Munkwitz and others, 2005; Sheldon, 2018).

Prairie and shrubland grouse often are considered umbrella species for co-occurring species, such as the Loggerhead Shrike, because grouse occupy large, contiguous landscapes and require a diversity of resources during their annual cycle (Rowland and others, 2006; Gary and others, 2022; Duchardt and others, 2023). Within the Lesser Prairie-Chicken's distribution in the central and southern Great Plains, Gary and others (2022) reported that management for the Lesser Prairie-Chicken can serve as a conservation umbrella of protection for the Loggerhead Shrike and other nontarget grassland birds, and shrikes were expected to receive a net conservation benefit from management for Lesser Prairie-Chickens. Duchardt and others (2023) reported that there was moderate support for greater than expected overlap for Greater Sage-Grouse (*Centrocercus urophasianus*) brood-rearing habitat and Loggerhead Shrike nesting habitat. The authors concluded that nesting substrate (small-to-moderate sized shrubs) was an important niche axis to consider when selecting umbrella species for grassland songbirds in the ecotone between the Great Plains and sagebrush steppe. Rowland and others (2006) reported a 25-percent overlap in the cover types used as habitat by Greater Sage-Grouse and Loggerhead Shrikes in the Great Basin Ecoregion.

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Table T1. Measured values of vegetation structure and composition in Loggerhead Shrike (*Lanius ludovicianus*) 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 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)
Chabot and others, 2001a (nests)	Ontario	Multiple	Multiple	30.3–36.7	--	--	--	--	--	--	--
Guo and others, 2009[a]	Saskatchewan	Mixed-grass prairie	--	30[b]	--	--	--	24.5	--	67.1	--
Lane and Hunt, 1987 (nests)	Illinois	Roadside	--	--	--	≥50	--	--	--	--	--
Miller and others (2017)	Idaho	Sagebrush steppe	--	55.5[c]	--	13.2	5.0	8.5	33.5	11.5	--
Pillsbury, 2010	Iowa, Missouri	Tallgrass prairie	Multiple	--	44.6[d]	35.4	24.8	2.3	--	32.1	--
Poole, 1992 (nests)	Washington	Sagebrush steppe	--	121.1[c], 60[e]		12.6	--	5.9	40	--	--
Prescott and Collister, 1993 (territories)	Alberta	Mixed-grass prairie	--	20[e]	--	58.2	3.5	3.6	3.5	--	--
Shen and others, 2013 (nests)	Saskatchewan	Mixed-grass prairie	Burning, grazing	31[b], 266[c]	--	--	--	--	--	--	--
St-Louis and others, 2010 (occurrence)	New Mexico	Multiple	--	--	--	10	48	--	--	--	--
St-Louis and others, 2010 (nests)	New Mexico	Multiple	--	--	--	15	16	--	--	--	--
Walcheck, 1970	Montana	Pine (*Pinus*)-juniper (*Juniperus*) woodland	--	--	--	45	9	18	28	--	--

[a]Values are from understory.

[b]Grass height.

[c]Live shrub height.

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

[e]Dead shrub height.

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