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The Effects of Management Practices on Grassland Birds—Clay-Colored Sparrow (*Spizella pallida*)

Chapter Z of

The Effects of Management Practices on Grassland Birds

Professional Paper 1842–Z

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

Cover. Clay-colored Sparrow. Photograph by Mark Osborne Herbert, used with permission. Background photograph: Northern mixed-grass prairie in North Dakota, by Rick Bohn, used with permission.

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

Chapter Z of

The Effects of Management Practices on Grassland Birds

Edited by Douglas H. Johnson,[1] Lawrence D. Igl,[1] Jill A. Shaffer,[1] and John P. DeLong[1,4]

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Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
millimeter (mm)	0.03937	inch (in.)
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)

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

CV coefficient of variation

DNC dense nesting cover

n.d. no date

PCP Permanent Cover Program

SD standard deviation

spp. species (applies to two or more species within the genus)

Acknowledgments

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The Effects of Management Practices on Grassland Birds—Clay-Colored Sparrow (*Spizella pallida*)

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

Capsule Statement

Keys to Clay-colored Sparrow (*Spizella pallida*) management include providing grasslands with a shrub or forb component or shrub-dominated edge habitat, which includes dense grass and moderately high litter cover, and avoiding disturbances that completely eliminate woody vegetation. Clay-colored Sparrows have been reported to use habitats with 20–186 centimeters (cm) average vegetation height, 3–50 cm visual obstruction reading, 15–74 percent grass cover, 5–23 percent forb cover, less than (<) 30 percent shrub cover, 1–20 percent bare ground, 10–63 percent litter cover, and less than or equal to (≤) 5 cm litter depth. The descriptions of key vegetation characteristics are provided in table Z1 (after the "References" section). Vernacular and scientific names of plants and animals follow the Integrated Taxonomic Information System (https://www.itis.gov).

Clay-colored Sparrow. Illustration by Christopher M. Goldade, U.S. Geological Survey.

Breeding Range

Clay-colored Sparrows breed from the southern Northwest Territories, south through eastern British Columbia and southwestern Ontario to western Wyoming and northern Nebraska, and east to southeastern Ontario (National Geographic Society, 2011). The relative densities of Clay-colored Sparrows in the United States and southern Canada, based on North American Breeding Bird Survey (BBS) data (Sauer and others, 2014), are shown in figure Z1 (not all geographic places mentioned in report are shown on figure).

Suitable Habitat

The Clay-colored Sparrow is a habitat generalist of grasslands containing or adjoining scattered, low-statured trees and shrubs (Grant and Knapton, 2020). The species breeds in shortgrass, mixed-grass, and tallgrass prairies that are idle, burned, hayed, or grazed (Peabody, 1899; Walkinshaw, 1939; Smith and Smith, 1966; Knapton, 1978; Dale, 1983; Madden, 1996; Prescott and Murphy, 1996; Bakker and others, 2002; Grant and others, 2004; Winter and others, 2004; Bleho, 2009; Pietz and others, 2009; White, 2009; Igl and others, 2018b). Clay-colored Sparrows inhabit ecological transition areas between grasslands and forested areas, including oak (*Quercus* species [spp.]) savannas and oak barrens (Pietz and others, 2009; Vos and Ribic, 2011, 2013; Wood and others, 2011; Bar-Massada and others, 2012), pine (*Pinus* spp.) barrens (Mossman and others, 1991; Ryba, 2002), prairie parkland (Thompson and others, 2016), and aspen (*Populus* spp.) parkland (Prescott and Murphy, 1999; Grant and others, 2004; Raitt and Artuso, 2018). The species frequents other wooded and brushy habitats, including forest openings, wooded slopes

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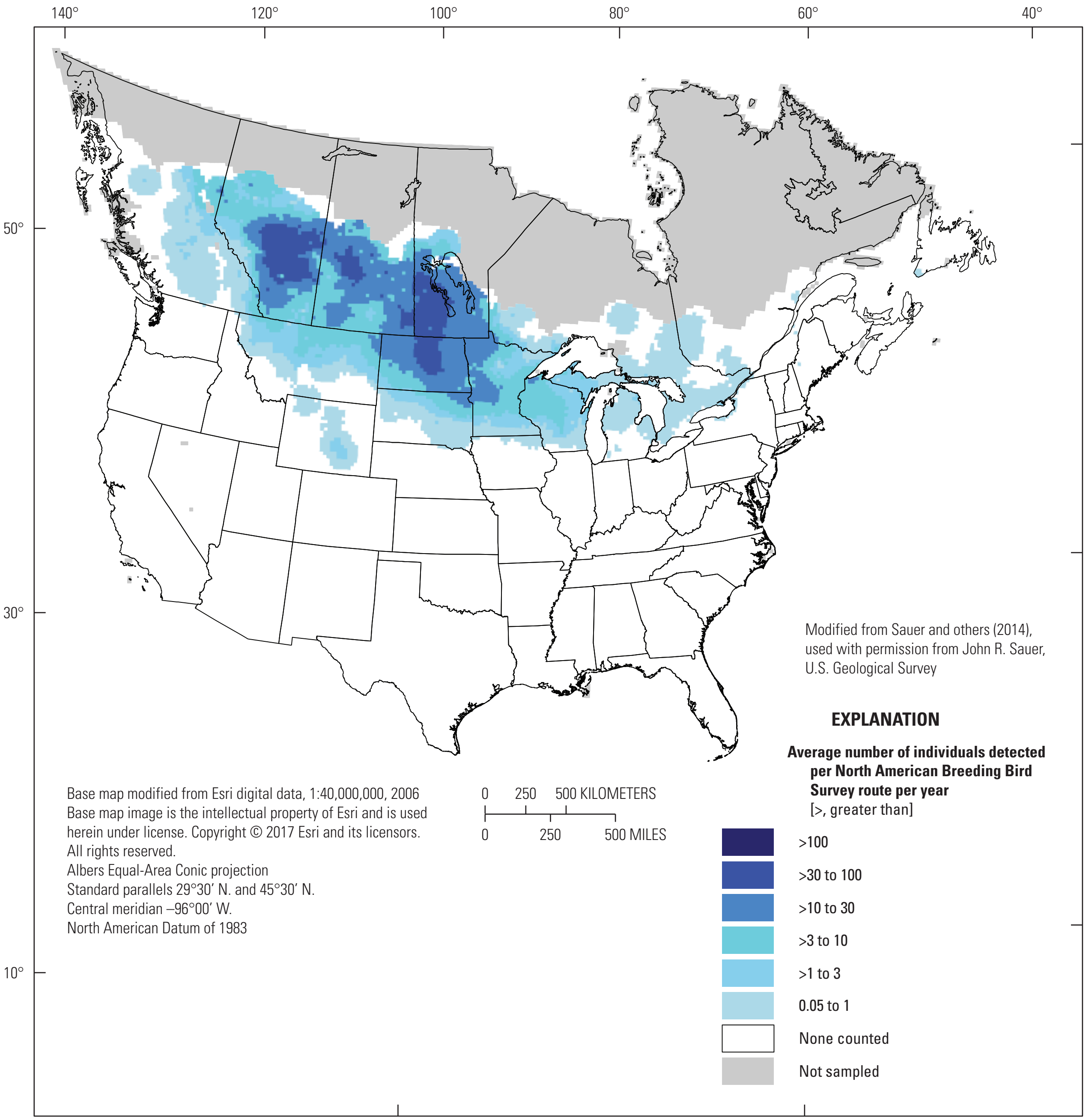

Figure Z1. Breeding distribution of the Clay-colored Sparrow (*Spizella pallida*) in the United States and southern Canada, based on North American Breeding Bird Survey (BBS) data, 2008–12. The BBS abundance map provides only an approximation of breeding range edges.

and edges, shrub thickets, shelterbelts, wooded riparian valleys, field edges, tree and shrub plantings, and brushy urban areas (Rand, 1948; Root, 1968; Maher, 1974; Stewart, 1975; Salt and Salt, 1976; Faanes, 1983; Arnold and Higgins, 1986; Murphy and Sondreal, 2003; Wood and others, 2011; Igl and others, 2018a). Other suitable habitats include tame pastures, idle cropland, and road rights-of-way (Salt, 1966; Stewart, 1975; Safratowich and others, 2008; Bakker and Higgins, 2009; Davis and others, 2016). The species inhabits planted cover (for example, Conservation Reserve Program [CRP] fields, dense nesting cover [DNC], and Permanent Cover Program [PCP] fields) (Salt, 1966; Root, 1968; Renken, 1983; Johnson and Schwartz, 1993a, 1993b; Jones, 1994; Prescott and Murphy, 1996; Prescott and Murphy, 1999; Shutler and others, 2000; McMaster and Davis, 2001; Murphy and Sondreal, 2003; Bakker and Higgins, 2009; Durán, 2009; Igl, 2009; Mozel, 2010; Ranellucci and others, 2012). The species also nests in swamps, peatland, river coulees, and wetland margins (Root, 1968; Maher, 1974; Niemi, 1985; Shutler and others, 2000). In a study throughout the Prairie Pothole Region of North Dakota and South Dakota, the Clay-colored Sparrow was among the 25 most common species encountered at 1,190 wetlands ranging from fresh to saline (Igl and others, 2017). The species was observed at 177 of the 1,190 wetlands, including 32 percent of the alkali wetlands, 49 percent of the permanent wetlands, 13 percent of the semipermanent wetlands, 11 percent of the seasonal wetlands, and 17 percent of the temporary wetlands (wetland classification followed Stewart and Kantrud, 1971). Wetlands inhabited by Clay-colored Sparrows were characterized as consisting of an average of 43 percent open water, 19 percent emergent vegetation, 33 percent wet meadow, and 4 percent shore/mudflat. Clay-colored Sparrows prefer to forage in open areas with sparse, short vegetation, such as cropland and pastures (Knapton, 1978; Dale, 1983; Grant and Knapton, 2020).

Woody Vegetation

Grant and Knapton (2020) described the Clay-colored Sparrow as the most numerous passerine species of low shrub communities of the northern prairies. The species often nests and perches in small-statured woody vegetation (Grant and others, 2004), such as western snowberry (*Symphoricarpos occidentalis*) and silverberry (*Elaeagnus commutata*) (Dale, 1992; Schneider, 1998). In mixed-grass prairies in Manitoba, Clay-colored Sparrow density increased by about 32 individuals with every percent increase in woody vegetation per square meter (Ranellucci, 2010). In tallgrass prairies of Minnesota and North Dakota, Clay-colored Sparrow density increased by 2.2 pairs per 100 hectares (ha) for each percentage increase in woody vegetation (Winter and others, 2005). The effect of vegetation structure and composition on Clay-colored Sparrows is organized below by geographical location.

Vegetation Structure and Composition

In Alberta, Manitoba, and Saskatchewan, Clay-colored Sparrow presence was positively associated with the number of forb contacts 10–20 cm above the ground, the number of narrow-leaved grass contacts 20–30 cm above the ground, and vegetation height (McMaster and Davis, 2001). Geographic variables also were important determinants for Clay-colored Sparrow occurrence, as occurrence prediction models included ecoregion, longitude, and the interaction between ecoregion and the number of clumped-grass contacts 10–20 cm above the ground, as well as land use. In southern Alberta, Clay-colored Sparrow densities were higher closer to nonprairie habitats, such as cropland and forage habitats (a description of forage habitat was not provided), than in purely grassland habitats; densities also were positively related to litter depth (Koper and Schmiegelow, 2006). In Alberta aspen parkland, Clay-colored Sparrows were most abundant in habitats with greater than (>) 50 percent shrub cover (Prescott and others, 1995). In Manitoba mixed-grass prairies, abundance of Clay-colored Sparrows was positively associated with percent coverage of shrubs and standing grass (Durán, 2009). In Manitoba tallgrass prairies, Clay-colored Sparrow density was positively associated with vegetation height (Mozel, 2010).

Several studies have been conducted in southern Saskatchewan, on grasslands ranging from grazed and ungrazed mixed-grass prairies to planted grasslands, and all studies found that the presence of a shrub component and tall, dense grass was important to Clay-colored Sparrows (Dale, 1983, 1984; Anstey and others, 1995; Saskatchewan Wetland Conservation Corporation, 1997; Davis and Duncan, 1999; Davis, 2003a, 2004; Bleho, 2009; Molloy, 2014; Davis and others, 2016). In native parkland and grassland habitats, Clay-colored Sparrow abundance was positively associated with shrubs 20–100 cm tall and broad-leaved grasses <10 cm tall (Anstey and others, 1995). In planted pastures and native mixed-grass prairie grasslands, Clay-colored Sparrow occurrence was positively associated with percentage cover of western snowberry, fringed sagewort (*Artemisia frigida*), and standing dead vegetation (Davis and Duncan, 1999). In grazed and ungrazed planted grasslands and native mixed-grass prairies, the most important vegetation variable for areas occupied by Clay-colored Sparrows was increasing coverage of shrubs; increasing litter depth, grass cover, and forb height also served as proximate cues for habitat use (Dale, 1983, 1984). In a 2-year study in native mixed-grass prairies, Davis (2003a, 2004) found that Clay-colored Sparrow occurrence was negatively related to distance to the nearest shrub in both years of the study and positively related to the density of live grasses 10–20 cm above the ground in 1 of the 2 years. In another study in mixed-grass prairies, Clay-colored Sparrow occurrence was negatively related to distance to the nearest shrub and was positively related to narrow-leaved (<5 millimeters [mm] wide) grasses 10–30 cm tall (Saskatchewan Wetland Conservation Corporation, 1997). In another 2-year study, Clay-colored Sparrow abundance was highest in sites with decreasing distance to shrubs (Davis and others, 2014). In mixed-grass prairies, Davis and others (2016) reported that Clay-colored Sparrow abundance was associated with native grasslands characterized by increased coverage of shrubs, narrow-leaved rhizomatous grasses, and standing dead vegetation. In southwestern Saskatchewan, Clay-colored Sparrow abundance increased with increasing vegetation height-density, plant species richness, heterogeneity of vegetation structure, and shrub cover (Henderson and Davis, 2014). Within moderately grazed mixed-grass prairies in southern Saskatchewan, Bleho (2009) evaluated the relationship between Clay-colored Sparrow abundance and vegetation structure at both the plot and pasture level, whereby plots were areas of 100-meter (m) radii within pastures grazed season-long (June to October). Bleho (2009) measured vegetation patchiness (that is, vegetation heterogeneity) by reporting standard deviation (SD) and coefficient of variation (CV). At the plot level, Clay-colored Sparrow abundance was positively associated with percentage cover of shrubs, the SD-derived measure for patchiness of shrub and bare ground cover, and the CV-derived measure for patchiness of grass coverage and vegetation height-density. Abundance was negatively associated with percentage cover of exposed small clubmoss (*Selaginella densa*) and lichen (no species provided), with the two statistical measures for patchiness of exposed small clubmoss and lichen coverage, and with the CV-derived measure for patchiness of bare ground coverage. At the pasture level, Clay-colored Sparrow abundance was positively associated with vegetation height-density. In both upland and lowland mixed-grass prairies in Saskatchewan, Clay-colored Sparrow abundance was positively related to increased shrub cover and negatively related to increased bare ground cover (Molloy, 2014). In the lowland habitat, Clay-colored Sparrow abundance was positively correlated with cover of blue grama (*Bouteloua gracilis*), needle and thread (*Hesperostipa comata*), and thickspike wheatgrass (*Elymus lanceolatus*). In native and tame pastures in southeastern Saskatchewan, Clay-colored Sparrow abundance increased nearer to shrubs and as visual obstruction reading and litter depth increased (Unruh, 2015).

In mixed-grass and tallgrass prairies managed by the U.S. Fish and Wildlife Service in Montana, North Dakota, South Dakota, and Minnesota, Clay-colored Sparrow densities increased with increasing visual obstruction reading and increasing litter depth (Igl and others, 2018b). In mixed-grass prairies in northwestern North Dakota, Grant and others (2004) reported that Clay-colored Sparrows were present in grasslands with a high percentage cover of shrubs, high maximum vegetation height, high percentage cover of Kentucky bluegrass (*Poa pratensis*) and sweetclover (*Melilotus* spp.), and a low percentage cover of native grasses and forbs; occurrence was not related to coverage of smooth brome (*Bromus inermis*) and quackgrass (*Elymus repens*), litter cover, percentage live vegetation cover, or year. In mixed-grass prairies and tame grasslands in northwestern North Dakota, shrub cover best predicted occurrence of the species; Clay-colored Sparrows used areas with high visual obstruction, high vegetation density (number of vegetation contacts), and low grass cover (Madden, 1996; Madden and others, 2000). The probability of occurrence for Clay-colored Sparrows was 69 percent at 3 percent shrub cover and 95 percent occurrence at 20 percent shrub cover (Madden and others, 2000). In native mixed-grass prairies and DNC grasslands in south-central North Dakota, Clay-colored Sparrows used areas of slightly more shrub cover, greater litter cover, and deeper litter than unused areas (Renken, 1983; Renken and Dinsmore, 1987). The species used areas with tall, dense forbs, such as absinth wormwood (*Artemisia absinthium*), in the absence of areas with shrubs. In mixed-grass prairies in south-central and northwestern North Dakota, Clay-colored Sparrow abundance was positively associated with density of low-growing shrubs, plant communities dominated by shrubs (western snowberry and silverberry) and introduced grasses (smooth brome, Kentucky bluegrass, and quackgrass), percentage cover of forbs, visual obstruction (vegetation height-density), litter depth, and vegetation density (Schneider, 1998). The strongest vegetative predictor of Clay-colored Sparrow presence was increasing cover of low-growing shrubs. Abundance was negatively associated with plant communities dominated solely by shrubs, native grasses (which included green needlegrass [*Nassella viridula*], needle and thread, junegrass [*Koeleria macrantha*], little bluestem [*Schizachyrium scoparium*], and *Bouteloua* spp.), or wet-meadow vegetation, and by percentage cover of small clubmoss. In mixed-grass prairies in south-central North Dakota, Clay-colored Sparrows occurred along both shrubby and shrubless transects but were most abundant on the shrubby transects (Arnold and Higgins, 1986). In tame grasslands in northeastern North Dakota, Clay-colored Sparrow abundance was positively related to live vegetation height, visual obstruction reading, and number of woody plants (Cole, 2016). At three study locations in North Dakota and Minnesota tallgrass prairies, density of Clay-colored Sparrows increased with increasing woody cover and tended to increase with greater litter depth (Winter and others, 2005, 2006). In addition, density tended to be highest at intermediate vegetation heights and tended to vary among study location and years. In fragmented native or tame grasslands in Minnesota, Clay-colored Sparrow density was predicted to marginally increase with increasing litter depth, grass height, and grass extent (Thompson and others, 2014).

In tallgrass prairies in eastern South Dakota, Clay-colored Sparrow occurrence and density were positively related to mean tallest forb, and occurrence was negatively related to mean tallest grass (Bakker and others, 2002). In mixed-grass prairies in eastern South Dakota, Clay-colored Sparrow occurrence was positively related to mean tallest forb and mean litter depth, and Clay-colored Sparrow density was negatively related to mean effective leaf height (Bakker and others, 2002). In western Minnesota and northwestern Iowa, Clay-colored Sparrow density was positively related to the percentage cover of grass and shrubs (Quamen, 2007). In central Wisconsin, Clay-colored Sparrows selected territories with dense stands of woody vegetation and avoided open grasslands; occupied territories were characterized by vegetative features with high nest cover value compared to areas generally available outside of their territories (Munson, 1992). These vegetative features included stem density of sandbar willow (*Salix interior*) and white meadowsweet (*Spiraea alba*); percentage cover of reed canary grass (*Phalaris arundinacea*); frequency of occurrence of sandbar willow, reed canary grass, white meadowsweet, and sedges (*Carex* spp.); woody species richness; vegetation height; plant species richness; and vertical density.

Native and Tame Vegetation

Clay-colored Sparrows use both native and tame grasslands, with no apparent preference (Peabody, 1899; Walkinshaw, 1939; Rand, 1948; Fox, 1961; Salt, 1966; Root, 1968; Stewart, 1975; Renken, 1983; Arnold and Higgins, 1986; Munson, 1992; Prescott and Murphy, 1996; Davis and Duncan, 1999; Bakker and Higgins, 2009; Durán, 2009; Mozel, 2010). In Alberta, Clay-colored Sparrow occurrence was similar among native and tame pastures (Prescott and Murphy, 1996), but the species was more abundant in DNC grasslands planted to tame grass species than in DNC grasslands planted to native grass species (Prescott and others, 1995). In native prairie pastures, Clay-colored Sparrows used areas characterized by a high diversity of vegetation cover and short grasses that were moderately uniform in height; in tame pastures, the species used areas characterized by moderate-to-high herbaceous biomass, moderate-to-high height variability, and high forb-to-grass ratio (Prescott and Murphy, 1996). In southern Saskatchewan, Davis and others (2016) reported that Clay-colored Sparrows were 5.3–6.6 times more abundant in native pastures than in hayland and planted pastures. Mean clutch initiation dates varied among habitat types; Clay-colored Sparrows initiated more nests in native pastures later in the breeding season compared to hayland and planted pastures. Clutch size and number of fledged young did not differ among habitat types, although Clay-colored Sparrows laid larger clutches in hayland. The number of fledged Clay-colored Sparrow young did not significantly differ among grassland types (Davis and others, 2016). In Saskatchewan, Clay-colored Sparrows were more abundant in native grasslands invaded by tame grasses than in pure stands of native grassland (Dale, 1992). In two other Saskatchewan studies, Clay-colored Sparrows preferred native pastures to tame pastures of crested wheatgrass (*Agropyron cristatum*) or smooth brome, possibly because native pastures had more shrubs (primarily western snowberry) >10 cm high and greater coverage of standing dead vegetation and fringed sagewort (Anstey and others, 1995; Davis and Duncan, 1999).

In southwestern Manitoba, Wilson and Belcher (1989) reported that Clay-colored Sparrow abundance was positively correlated with tame vegetation (brome, Kentucky bluegrass, and leafy spurge [*Euphorbia esula*]) and negatively correlated with native vegetation. In southern Manitoba, however, Mozel (2010) reported that Clay-colored Sparrow densities were significantly lower in planted grasslands that included both native and tame grass species than in tallgrass prairies; Clay-colored Sparrow densities were lowest in agricultural fields. In another Manitoba study, Clay-colored Sparrows were more productive, based on a behavioral index, in native grasslands than in tame grasslands and more common in native grasslands than in tame DNC or tame hayland (Jones, 1994). Several studies have evaluated the use of reproductive indices, such as the one used by Jones (1994), as an alternative to nest searching and monitoring of grassland birds and found that reproductive indices often lack the ability to predict nest fate or provide reliable estimates of reproductive performance at the territory or plot level (Rivers and others, 2003; Althoff and others, 2009; Morgan and others, 2010). The results of Jones (1994) related to productivity should be evaluated within the context and caveats of the growing body of literature on this topic.

In North Dakota, South Dakota, Minnesota, and Montana, densities of Clay-colored Sparrows in CRP grasslands did not differ between native and introduced seeding mixtures; Clay-colored Sparrow density was positively associated with cover of legumes, primarily alfalfa (*Medicago sativa*) and sweetclover, which may serve as a structural substitute for shrubs (Johnson and Schwartz, 1993a). In mixed-grass prairies in northwestern North Dakota, Grant and others (2004) reported that Clay-colored Sparrows were present in grasslands with a high percentage cover of Kentucky bluegrass and yellow sweetclover (*Melilotus officinalis*) and a low percentage cover of native grasses and forbs; occurrence was not related to coverage of smooth brome and quackgrass. In mixed-grass prairies in western North Dakota, Clay-colored Sparrow density increased with the floristic quality of native plant species; each native plant species was assigned a floristic quality rating that reflected the fundamental conservatism that the plant species exhibits for natural habitats (Chepulis, 2016). In eastern South Dakota and western Minnesota, Clay-colored Sparrow densities were 75–91 percent higher in native tallgrass prairies than in fields planted to monocultures of intermediate wheatgrass (*Thinopyrum intermedium*) or switchgrass (*Panicum virgatum*) or fields planted to mixtures of tame cool-season grass or native warm-season grass species; native unbroken tallgrass prairies contained shrubby vegetation that was not found in the other planted cover types (Bakker and Higgins, 2009). In western Minnesota and northwestern Iowa, Clay-colored Sparrows had higher densities and occupancy rates in grasslands than in hayland or cropland; grassland included native tallgrass prairie pastures, tame pastures, and CRP, whereas hayland included alfalfa or alfalfa intermixed with tame grass species (Quamen, 2007). In southern Wisconsin, Blank and others (2014) evaluated Clay-colored Sparrow use of cropland and bioenergy (or biomass) plantings, including grassland monocultures of warm-season grass species, grass-dominated grasslands (that is, >50 percent live vegetation cover consisting of grass species), and forb-dominated grasslands (that is, <50 percent live vegetation cover consisting of grass species). Clay-colored Sparrows were not present in cropland or in grass monocultures and occurred at lowest densities in grass-dominated grasslands and highest densities in forb-dominated grasslands.

Nests and Nest Sites

Clay-colored Sparrows build their nests above the ground (usually <50 cm above ground) in small trees and shrubs, tall forbs, or in residual vegetation (Peabody, 1899; Walkinshaw, 1939; Smith and Smith, 1966; Root, 1968; Stewart, 1975; Knapton, 1978; Ryba, 2002; Winter and others, 2004; Bakker and Higgins, 2009). In idle and mixed-grass prairies in Manitoba and Saskatchewan, Clay-colored Sparrows preferred to nest in western snowberry, which provided better nest concealment and less light penetration than other shrub species (Fox, 1961; Knapton, 1978). In mixed-grass prairies in northwestern North Dakota, nest survival rates were positively associated with increasing vegetation height-density (Kerns and others, 2010). In a second study in mixed-grass prairies in northwestern North Dakota, daily survival rates increased as coverage of Kentucky bluegrass and overall vegetation concealment around nests increased (Grant and others, 2006). In a third study in mixed-grass prairies in northwestern North Dakota, daily nest survival rates were lower for Clay-colored Sparrow nests with high shrub coverage; for example, nests with 10-percent shrub cover that had not been parasitized by a Brown-headed Cowbird (*Molothrus ater*) had an estimated daily survival rate of 0.955, whereas unparasitized nests with 90-percent shrub coverage had a survival rate of 0.939 (Grant and others, 2017). In mixed-grass prairies in north-central North Dakota, vegetation height-density and grass height were greater and vegetation was more heterogeneous at nest sites than expected based on availability (Nenneman, 2003). Vegetation height-density was highest within 1 m of the nest. Nests were closer to shrubs and nest sites had more shrub cover and less grass cover than expected. In the first year post-burn, Clay-colored Sparrows selected nest sites that had higher litter depth and residual vegetation than was expected based on availability. Although litter depth and residual vegetation were generally higher 2 and 3 years postburn, Clay-colored Sparrows seemed to be less selective for these characteristics during those years (Nenneman, 2003). In tallgrass prairies in North Dakota and Minnesota, nest success tended to increase with increasing nest cover and with density of Clay-colored Sparrows, and the probability of nesting success increased with date in the nesting season (Winter and others, 2005, 2006). In pine barrens in Wisconsin, Clay-colored Sparrows nested in shrubs, especially coniferous shrubs such as *Pinus* spp., and in areas with high amounts of vegetation and coarse woody debris (Ryba, 2002).

Climate

The future distribution of Clay-colored Sparrows and their breeding habitat may be affected by climate-induced changes to temperature and precipitation (Langham and others, 2015). Under projected greenhouse gas emission scenarios described by the Intergovernmental Panel on Climate Change (2000), Langham and others (2015) categorized the Clay-colored Sparrow as a climate-threatened species, indicating that the species would lose >50 percent of its current distribution by 2080 across all Intergovernmental Panel on Climate Change scenarios, with possible net gain from potential range expansion. Using a combination of BBS, eBird (https://www.ebird.org; Sullivan and others, 2009), and point-count data, Nixon and others (2016) modeled the effect of future climate change scenarios on Clay-colored Sparrow breeding distribution along the boreal forest–prairie ecotone in Alberta. Nixon and others (2016) predicted that the Clay-colored Sparrow's breeding range would expand by 19 percent and that expansion largely would occur northward, originating in the Parkland Region of Alberta, with little southward expansion. Stralberg and others (2015) modeled BBS and point-count data representing over 356,000 avian surveys from nearly 126,000 locations from 128 research projects to estimate the impact of future climate change scenarios on Clay-colored Sparrow density and abundance in the boreal and southern arctic ecological regions of North America. They estimated that Clay-colored Sparrow density and abundance would gradually become higher in the boreal region over three time periods collectively representing 90 years. Wilsey and others (2019) compiled avian occurrence data from 40 datasets to project climate vulnerability scores under scenarios in which global mean temperature increases 1.5, 2, or 3 degrees Celsius (ºC). Clay-colored Sparrows ranked moderate in vulnerability during the breeding season at 1.5 ºC and 2 ºC increases and ranked high at a 3 ºC increase. Peterson (2003) modeled the impact of two scenarios—0.5 and 1 percent per year increases in carbon dioxide—on bird species whose geographical distributions were exclusively within the Great Plains, which included the Clay-colored Sparrow; Peterson (2003) estimated that Clay-colored Sparrows would experience breeding-range contraction and dramatic distributional movements under the two climate scenarios. Using BBS data for four States that constitute the Badlands and Prairies Bird Conservation Regions, Gorzo and others (2016) reported that Clay-colored Sparrow abundance was not related to either a standardized temperature index or a standardized precipitation index. Wu and others (2022) estimated that under a scenario with a global mean temperature increase of 2 ºC, the number of National Wildlife Refuges in the United States that host the Clay-colored Sparrow would fall from 100 to 0 during summer and increase from 5 to 25 during winter. Travers and others (2015) compared historical bird data on species' spring-arrival dates in eastern North Dakota in the early to mid-20th century to dates in the early 21st century and concluded that Clay-colored Sparrows were arriving later in the recent period than in the historical period.

Moisture levels may affect the distribution and abundance of Clay-colored Sparrows. In the dry mixed-grass prairie and northern fescue (*Festuca* spp.) grassland ecoregions of south-eastern Alberta, Clay-colored Sparrows selected areas that were more mesic; species occurrence was negatively associated with a compound topographic index, which reflected the state of soil moisture across the landscape (Clements, 2014). The compound topographic index considers topographic features, including slope, flow accumulation and direction, and contributing area, to form a representation of levels of soil moisture across the landscape. In an assessment of 13 BBS routes in North Dakota, Niemuth and others (2008) examined associations between two indices of regional moisture (that is, the number of prairie potholes containing water during annual May waterfowl surveys and the Palmer Drought Severity Index) and populations of Clay-colored Sparrows and other grassland birds. The authors found that Clay-colored Sparrow abundance was positively associated with the number of prairie potholes in May of the same year and in May of the previous year. In northwestern North Dakota, Grant and others (2010) reported that the number of combined indicated pairs for 22 species, including the Clay-colored Sparrow, was correlated with precipitation received during the previous breeding season; Clay-colored Sparrow abundance was the highest in the year with the highest annual precipitation. In a 3-year study in western North Dakota that partially coincided with a severe drought, Clay-colored Sparrow densities declined 78 percent from the breeding season before the drought (year 1) to the breeding season after the drought (year 3) (George and others, 1992). In North Dakota and Minnesota tallgrass prairies, climate (Palmer Drought Severity Index, Conserved Soil Moisture Index) had no effect on densities of Clay-colored Sparrows (Winter and others, 2005, 2006).

Area Requirements and Landscape Associations

Breeding territories of male Clay-colored Sparrows are relatively small (about 0.04–0.5 ha) (Fox, 1961; Salt, 1966; Root, 1968; Knapton, 1979). Territory size and arrangement in relation to other male territories may depend upon shrub cover; male Clay-colored Sparrows nesting in areas with low shrub cover may require large territories (Knapton, 1979). Adult Clay-colored Sparrows typically forage outside of the male's territory (Knapton, 1979); Munson (1992) observed birds traveling several hundred meters to foraging areas disconnected from their territories, and the species commonly establishes breeding territories near or adjacent to suitable foraging areas (Knapton, 1979).

The Clay-colored Sparrow has shown a variable response to grassland patch size. In mixed-grass prairies in southern Saskatchewan, Davis (2003a, 2004) reported that the Clay-colored Sparrow was area insensitive, such that the species' abundance and occurrence declined with an increase in pasture size. Clay-colored Sparrows were more abundant in irregular-shaped patches with greater shrub density (Davis, 2004). In another study in Saskatchewan mixed-grass prairies, time-specific factors such as nest age, date, and year were better predictors of nest survival than patch size and shape (Davis and others, 2006). In Manitoba tallgrass prairies, Clay-colored Sparrow abundance was negatively associated with patch size, and the species preferred smaller patches with higher edge-to-area ratios (Bruinsma, 2012). In another Manitoba study in tallgrass prairies, Mozel (2010) found higher densities of Clay-colored Sparrows in small prairie patches that contained high proportions of trees and low proportions of grassland surrounding the patch. In Manitoba mixed-grass prairies, Ranellucci (2010) reported that the abundance of Clay-colored Sparrows decreased as the proportion of open area (that is, grass- and forb-dominated areas with few shrubs and no forest patches) increased. For CRP grasslands in nine counties in North Dakota, South Dakota, Minnesota, and Montana, Johnson and Igl (2001) developed logistic and linear regression models relating Clay-colored Sparrow presence, frequency, and density to area of contiguous grassland. The authors concluded that Clay-colored Sparrows favored larger grasslands; grassland patch size was positively associated with Clay-colored Sparrow presence, frequency, and density in one county and was positively associated with Clay-colored Sparrow density in two other counties. Using BBS data, Bohannon and Blinnikov (2019) examined the relationship between Clay-colored Sparrow abundance on BBS routes and habitat fragmentation in western North Dakota and eastern Montana caused by oil-extraction activities. The local population did not significantly decline with increasing edge density (that is, the amount of linear edge per total landscape area). In mixed-grass and tallgrass prairies of eastern South Dakota, Clay-colored Sparrows used both large and small patches of suitable grassland where the patches were embedded within a landscape with a high proportion of grassland habitat; occupancy rates were higher in small prairie patches within landscapes with high grassland abundance than in large prairie patches within low grassland landscapes (Bakker and others, 2002). In tallgrass prairie fragments in Minnesota, Johnson and Temple (1986) reported that the Clay-colored Sparrow was more common in smaller prairie fragments, which may reflect that smaller patches contain a greater proportion of shrubby vegetation and thus more suitable habitat for Clay-colored Sparrows (Johnson and Igl, 2001). In Wisconsin oak barrens and dry sand prairies, Clay-colored Sparrow abundance was not related to patch size (Vos and Ribic, 2011).

Landscape composition and proximity to edges may affect Clay-colored Sparrow abundance and occurrence. Throughout the Great Plains, Pavlacky and others (2022) evaluated the effect that restoration of the CRP had on site occupancy of grassland bird species; the site occupancy of Clay-colored Sparrows increased with increasing shrubland in the surrounding landscape. Within the Prairie Pothole Region of Canada, Fedy and others (2018) examined the effect of grassland, cropland, shrubland, woodland, and wetland habitats at four scales (within 400; 800; 1,600; and 3,200 m of BBS stops) on the relative probability of occurrence of Clay-colored Sparrows. The best model indicated that the species preferred landscapes consisting of shrubland, tame grasslands, and other perennial cropland grown for hay, pasture, or seed, and an abundance of wetland basins within 3,200 m; the species selected against landscapes with annually seeded cropland within 800 m, native grasslands within 3,200 m, and a high wetland area count within 3,200 m (Fedy and others, 2018). Veech (2006) used BBS data from throughout the Great Plains to characterize the landscape within a 30-kilometer (km) radius of populations of Clay-colored Sparrows that were increasing or decreasing; rangeland constituted a greater proportion of the landscape for increasing populations than for decreasing populations, and urban land composed a greater proportion for decreasing populations. The proportion of CRP lands did not differ between increasing and decreasing populations. In hayfields in southern Saskatchewan, the number of Clay-colored Sparrow pairs was not related to amount of cropland or wetlands within 1.6 km of study areas (McMaster and others, 1999). In another southern Saskatchewan study, the composition of the surrounding landscape (that is, the proportion of native pastures, tame hayland, and cropland within 400, 800, or 1,600 m of each study plot) did not affect Clay-colored Sparrow abundance (Davis and others, 2016). In a study evaluating organic, minimum-tillage, and conventional-tillage agriculture and tame and native grasslands in Saskatchewan, Clay-colored Sparrow presence was negatively related to the number of wetlands within 2.6 square kilometers (km^2) of point counts (Shutler and others, 2000). In Alberta mixed-grass prairies, Clay-colored Sparrow abundance increased as distance to wetland edges decreased; abundance increased by 25 percent or more within 1.15 km (as measured out to 1.8 km) from wetland edge (Sliwinski and Koper, 2012). Abundance also increased as distance to cropland edges decreased; abundance increased by 25 percent or more within 2.79 km (as measured out to 4.1 km) of cropland edges. In Manitoba, Clay-colored Sparrow occupancy in powerline rights-of-way (that is, strips of grassland at least 30-m wide planted under power transmission lines) decreased as the amount of wooded lands (trees or shrubs) and urban land within 100 m of rights-of-way increased (Leston and Koper, 2017). In mixed-grass prairies in Manitoba, abundance of Clay-colored Sparrows was positively associated with edge density (that is, the perimeter-area ratio of grassland patches) from 1,200 to 4,800 m; abundance was negatively associated with distance to the nearest forest from 2,400 to 4,800 m and with percent coverage of forest habitat at the 2,400-m scale (Durán, 2009). In mixed-grass prairies in southwestern Manitoba, Clay-colored Sparrow abundance increased with a higher proportion of trees in the landscape, and abundance decreased with a higher proportion of grassland in the landscape (Ranellucci, 2010). In southwestern Manitoba, Clay-colored Sparrow abundance was unaffected by grassland amount relative to grassland configuration; the relative abundance of grassland facultative species, including the Clay-colored Sparrow, showed no response to a landscape shape index, which quantified the amount of edge for a given land-cover class relative to that of a maximally compact and simple shape (that is, a circle) of the same area (Lockhart and Koper, 2018).

In the Prairie Pothole Region of North Dakota, Browder and others (2002) reported that Clay-colored Sparrows had a negative association with cropland and wetlands within 200 and 400 m of survey points; the species had a positive association with grassland and woody habitats (areas >2 ha with woody plants >6 m tall and aerial coverage of >30 percent) within 200 and 400 m of survey points and a positive association with barren land (road surfaces, parking lots, and buildings) within 200 m of survey points. In North Dakota and South Dakota, Clay-colored Sparrows were associated with 177 wetlands that averaged 10 ha in size (Igl and others, 2017). Landscape composition within 800 m of these wetlands was 59 percent grassland, 22 percent agricultural, and 14 percent wetland; the average number of wetlands within 800 m of occupied wetlands was 25 (Igl and others, 2017). In mixed-grass prairies in northwestern North Dakota, Grant and others (2004) reported that grasslands occupied by Clay-colored Sparrows had higher coverage of quaking aspen (*Populus tremuloides*) woodland within both 100 and 500 m of survey points than unoccupied areas. In mixed-grass prairies in western North Dakota, Clay-colored Sparrow densities decreased with an increasing percentage of grassland within 1.6 km of study plot boundaries (Chepulis, 2016). Cunningham and Johnson (2006) reported that Clay-colored Sparrow occurrence in North Dakota tallgrass prairies was negatively associated with grassland cover and woodland cover at the 100-m scale and positively associated with tree cover at the 1,200-m scale. In tallgrass prairies in Minnesota and North Dakota, landscape composition affected Clay-colored Sparrow densities more clearly than did grassland patch size or local vegetation structure; Clay-colored Sparrow densities increased with percentage of shrubs and trees surrounding and including the study areas up to 200 m (Winter and others, 2006). In tallgrass prairies of eastern South Dakota, Clay-colored Sparrow occurrence was positively related to the proportion of managed and idle grassland habitat within 1,600 m, and in mixed-grass prairies, occurrence was positively related to the proportion of idle grasslands within 1,600 m (Bakker and others, 2002). In Wildlife Management Areas and CRP grasslands in western Minnesota that were harvested for biofuel production, Clay-colored Sparrow abundance declined as the percentage of grassland that was harvested increased within 250 m of the study plots (Dunlap, 2014). In fragmented native or tame grasslands in Minnesota, Clay-colored Sparrow density was positively related to most grass- and tree-related covariates (that is, the proportion of grass or tree cover within 100, 500, and 1,000 m of point counts) (Thompson and others, 2014). Clay-colored Sparrows were predicted to increase from 0.52 to 0.65 bird per ha as all woody vegetation covariates increased from the 10th to 90th percentile, and to increase from 0.44 to 0.73 bird per ha as grass-related covariates increased. In western Minnesota and northwestern Iowa, Clay-colored Sparrow density was positively related to the percentage of grasslands within 400 m of avian point-count surveys (Quamen, 2007).

Grassland patch size, proximity to edges, and landscape composition also may affect Clay-colored Sparrow nest-site selection and productivity. In mixed-grass prairies in Saskatchewan, the mean number of Clay-colored Sparrow young fledged per successful nest increased with grassland patch size; cowbird parasitism of Clay-colored Sparrow nests was not related to patch size (Davis, 2003a). In another Saskatchewan study, Davis and others (2006) reported that grassland patch size had little effect on Clay-colored Sparrow nest survival. In southern Saskatchewan, the best predictor of Clay-colored Sparrow nest survival was the amount of cropland within 400 m of the study plot in the surrounding landscape, but this relationship was highly variable; in general, daily nest survival declined as the amount of cropland within the landscape increased (Davis and others, 2016). In North Dakota mixed-grass prairies, Grant and others (2006) found that Clay-colored Sparrow nest survival was higher for nests near woodland edges, where abundance of an important nest predator, the thirteen-lined ground squirrel (*Ictidomys tridecemlineatus*), is typically lower. In North Dakota tallgrass prairies, cowbird parasitism of Clay-colored Sparrow nests decreased with an increase in tree cover; for every 1 percent decrease in percent tree cover within 2 km of a Clay-colored Sparrow nest, the odds that the nest had been parasitized by a cowbird increased by 15 percent (Pietz and others, 2009). In tallgrass prairies in North Dakota and Minnesota, Clay-colored Sparrow nest success was not affected by grassland patch size, the distance of nests to the nearest shrubs or trees, or the percentage of shrubs and trees within 200 or 1,000 m of study areas (Winter and others, 2006). In Minnesota tallgrass prairies, nest depredation and Brown-headed Cowbird brood parasitism decreased and Clay-colored Sparrow productivity increased farther from woody edges; nest depredation rates were lower on large (130–486 ha) than on small (16–32 ha) prairie fragments (Johnson and Temple, 1986, 1990).

Brood Parasitism by Cowbirds and Other Species

Clay-colored Sparrows are common hosts of the brood-parasitic Brown-headed Cowbird (Friedmann and Kiff, 1985). Published rates of cowbird brood parasitism (Shaffer and others, 2019) varied from 5 percent of 781 Clay-colored Sparrow nests (Winter and others, 2004) to 39 percent of 33 nests (Stewart, 1975). Clay-colored Sparrow nests may be multiply parasitized (Peabody, 1899; Knapton, 1978; Davis, 2003b; Igl and Johnson, 2007). In CRP grasslands in North Dakota, South Dakota, Minnesota, and Montana, the average number of cowbird eggs in 23 parasitized nests was 1.5, and the maximum number of cowbird eggs in a single Clay-colored Sparrow nest was four (Igl and Johnson, 2007). The species may abandon nests that have been parasitized by cowbirds (Fox, 1961; Hill and Sealy, 1994).

Cowbird parasitism often results in lower Clay-colored Sparrow productivity (Fox, 1961; Salt, 1966; Root, 1968; Knapton, 1978; Buech, 1982; Romig and Crawford, 1995; Kerns and others, 2010). In mixed-grass prairies in Saskatchewan, Clay-colored Sparrow clutch size, the number of host eggs that hatched, the number of host eggs incubated to full term that hatched, and the number of host young that fledged per successful nest were lower in nests parasitized by cowbirds than in unparasitized nests (Davis, 2003b). In Saskatchewan, distance to cowbird perch sites and nest concealment cover were not different between parasitized and unparasitized nests (S.K. Davis, Canadian Wildlife Service, Regina, Saskatchewan, written commun. [n.d.]). In tallgrass prairie in eastern North Dakota, parasitized Clay-colored Sparrow nests had significantly lower mean clutch size and mean fledging rate; parasitized nests were significantly closer to the nearest cowbird perch site than unparasitized nests (Romig and Crawford, 1995). Nests that were >52 m from a perch were not parasitized. In mixed-grass prairies in northwestern North Dakota, Kerns and others (2010) found higher nest survival rates in parasitized nests than unparasitized nests. In another study in mixed-grass prairies in northwestern North Dakota, Murphy and others (2017) found no evidence for an influence of cowbird brood parasitism on Clay-colored Sparrow nest survival. The authors did not find relationships between the probability of a nest being parasitized and the distance of a nest to the nearest patch of tall (>1.5 m) woody cover, the amount of tall woody vegetation within 100 m, or the frequency of occurrence of low (≤1.5 m) shrubs within 5 m of nests.

Breeding-Season Phenology and Site Fidelity

Clay-colored Sparrows breed from about late April to mid-August and depart for the wintering grounds between August and October (Salt, 1966; Root, 1968; Stewart, 1975; Knapton, 1978; Janssen, 1987). In tallgrass prairies in North Dakota and Minnesota, peak breeding occurred from mid-May through late June (Winter and others, 2004). Second broods may be attempted, especially when breeding begins earlier in spring. During one breeding season in Manitoba, pairs that successfully raised young in the first attempt did not renest (Knapton, 1978). However, in the following year, more nests were initiated before May 23, and 11 pairs attempted a second brood.

In Manitoba, site fidelity was exhibited by both male and female Clay-colored Sparrows (Knapton, 1978). Return rates for males ranged from a low of 62 percent of 28 birds to a high of 85 percent of 33 birds over 3 years and two study sites. Return rates for females ranged from a low of 14 percent of five birds to a high of 29 percent of five birds. Of the banded males that returned, 76 percent returned to the same territory in successive years (and often to the same song perches), but none of the banded females returned to the same territory in successive years. Mate fidelity was fairly low for returning birds; breeding pairs rarely reformed in subsequent years. Natal philopatry also was fairly low; only four of 305 Clay-colored Sparrows that were banded as immature birds (that is, postfledging, hatch-year birds), and zero of 146 birds that were banded as nestlings returned in subsequent years (Knapton, 1978). Klimkiewicz and Futcher (1987) reported that a Clay-colored Sparrow banded in North Dakota was recaptured 5 years later in the same location where it was originally banded. In a meta-analysis to compare site fidelity of migratory shrubland and forest passerines in eastern North America, Schlossberg (2009) reported that 43 percent of 163 adult Clay-colored Sparrows returned to former breeding sites and <1 percent of 146 yearlings returned to natal sites.

Species' Response to Management

Complete or nearly complete removal of woody vegetation from an area via management (for example, burning, mowing, or herbicide treatments) may make that area unattractive to Clay-colored Sparrows or have negative short-term effects on the species' occurrence or abundance (Halvorsen and Anderson, 1983; Huber and Steuter, 1984; Madden, 1996; Johnson, 1997). In Minnesota grasslands, Thompson and others (2016) evaluated the impact of tree and shrub removal (through a combination of cutting, shearing, burning, and herbicide applications) on Clay-colored Sparrow abundance. On untreated control sites, Clay-colored Sparrow abundance generally declined over the course of 7 years. On treated sites, Clay-colored Sparrows declined from the year before tree and shrub removal began to the third year after the removal of woody vegetation began, but then the species responded positively with the abatement of prescribed fire, recovery of litter depth, and the regeneration of shrubs. Clay-colored Sparrow abundance was significantly higher in the sixth year after treatment (Thompson and others, 2016). In eastern North Dakota and South Dakota, Quamen (2007) evaluated grassland bird avoidance of woody edges and bird response to removal of treebelts. The abundance of Clay-colored Sparrows was unrelated to distance from treebelts or to the presence of trees. Abundance 1 year before and 1 year after tree removal remained at or above levels observed in treeless grasslands.

Fire

Burning is effective at curtailing vegetation succession of grasslands and savannas, which include small-statured woody vegetation, into habitats that contain tall-statured woody vegetation (for example, woodlands) that is undesirable to Clay-colored Sparrows (Ryba, 2002; Grant and others, 2006; Grant and Knapton, 2020). However, frequent burning that eliminates all woody vegetation, litter, and tall, dense grass is detrimental to the species (Johnson, 1997; Madden and others, 1999). Burns that result in complete removal of woody vegetation may result in the absence or decreased abundance of Clay-colored Sparrows until woody vegetation recovers (Halvorsen and Anderson, 1983; Grant and others, 2010; Davis and others, 2017), whereas cooler or patchy burns that maintain some amount of woody vegetation may retain Clay-colored Sparrows even immediately after burning (Nenneman, 2003). The effects of burning on Clay-colored Sparrow population and nest demographics are organized by geographical location. In Saskatchewan, densities of Clay-colored Sparrow in grasslands that were burned in fall (October) 3 years earlier were one-third of the densities found in unburned grasslands (Pylypec, 1991). In Saskatchewan mixed-grass prairies, White (2009) and Richardson (2012) evaluated the interaction of burning and grazing on Clay-colored Sparrow abundance over a 2–5-year period. Burned conditions were created by a July wildfire, whereas grazing conditions were derived from season-long (late May to mid-September) cattle grazing at low-to-moderate (0.43 animal unit month [AUM] per ha with 50 percent removal of biomass) grazing intensity (Richardson and others, 2014). White (2009) reported that Clay-colored Sparrow occurrence was similar in the second year of a 2-year study among the four management treatments of burned-grazed, burned-ungrazed, unburned-grazed, and unburned-ungrazed; occurrence was too low for analysis in the first year. Within these same Saskatchewan pastures over a 5-year period, Clay-colored Sparrow abundance was negatively associated with grazing, unaffected by burning (possibly because not all shrubs burned), and increased over time in unburned-grazed pastures but decreased over time in unburned-ungrazed pastures (Richardson, 2012; Richardson and others, 2014). The authors attributed the interactive effect to changes in environmental conditions from dry to abnormally wet that resulted in increased vegetation growth (helpful to Clay-colored Sparrows in concealing nests) and increased woody vegetation (helpful to Clay-colored Sparrows as a nesting substrate), despite the pastures being grazed (Richardson, 2012; Richardson and others, 2014). In Manitoba and Saskatchewan, Davis and others (2017) compared Clay-colored Sparrow densities in grasslands planted to tame or native grass and forb species and managed with haying or burning, whereby haying occurred after July 15, spring burns were conducted from April to late May, fall burns were conducted from September to late October, and burning and haying were conducted only once on each field. Clay-colored Sparrow density was greater in tame hayed sites than in native burned sites up to 5–6 years after management, at which time densities in burned sites reached similar densities as in hayed sites. Clay-colored Sparrow densities increased threefold between 1 and 8 years after native vegetation sites were burned, whereas densities changed little over time in tame sites that had been hayed. Davis and others (2017) suggested that Clay-colored Sparrows used alfalfa as perches and nesting substrates at hayed sites, and that burned sites became more attractive to Clay-colored Sparrows over time as bare ground cover decreased.

In mixed-grass and tallgrass prairies managed by the U.S. Fish and Wildlife Service in Montana, North Dakota, South Dakota, and Minnesota, Clay-colored Sparrow densities were lowest in the first growing season after burning and increased in subsequent growing seasons (Igl and others, 2018b). Densities were higher in tallgrass prairie units than in mixed-grass units in the second growing season after burning and were lower in mixed-grass prairie units that were burned-only, grazed-only, or burned-grazed than in units that were rested for more than five growing seasons. In mixed-grass prairies at Lostwood National Wildlife Refuge in northwestern North Dakota, Clay-colored Sparrow abundance increased with the number of years since the most recent burn, and the species was most abundant in areas that had not been burned for more than 80 years compared to areas burned 0.5–8 years earlier (Madden, 1996; Madden and others, 1999). Most prescribed burns occurred in summer (mid-July through August), although some occurred in late spring (late April through early May); burns were conducted to remove 80–95 percent of above-ground vegetation (Madden and others, 1999). In brush-invaded, mixed-grass prairies at Lostwood National Wildlife Refuge, Murphy and Smith (2008) evaluated grassland bird response to the combined use of fire, rest, and grazing; each grassland was subjected to four spring or summer prescribed fires separated by 2–4 years of rest (nondisturbance), and rotational grazing (3 cells, each cell grazed for 14 days, then 2 cells grazed for a second 14-day period after a 28-day rest; grazing from lay May through mid-August at 1.2 AUM per ha) was initiated 2 years after the final fire. Clay-colored Sparrow abundance declined by the end of the burning sequence as shrub cover decreased and grass cover increased. In mixed-grass prairies at Des Lacs National Wildlife Refuge in north-western North Dakota, Murphy and others (2017) reported that Clay-colored Sparrow nest survival was not related to number of postburn breeding seasons (2, 3, and 4–5 years), but nest survival declined with increasing prevalence of tall woody cover within 100 m of nests. Nest survival was not related to proximity of nests to the nearest patch of tall (>1.5 m), woody cover or to low (≤1.5 m) shrub cover within 5 m of nests. In another study at Des Lacs National Wildlife Refuge, Ludwick and Murphy (2006) reported that Clay-colored Sparrow abundance showed a negative but weak association to fire history, which was based on the number of fires and the number of years since the last fire; burns were conducted in spring (April or May) or late summer through mid-fall (August through October). In mixed-grass prairies at J. Clark Salyer National Wildlife Refuge in north-central North Dakota, the number of Clay-colored Sparrow breeding pairs, nest density, and nest survival were lowest during the first postburn growing season and then increased between the second and fourth postburn growing seasons (Grant and others, 2010, 2011). Typical fire management involved fall (August to September) burning of 100–200-ha blocks every 2–6 years except during years of drought. Postburn densities of Clay-colored Sparrow were positively associated with standing dead vegetation and litter depth, indicating that Clay-colored Sparrows responded to changes in vegetation structure after the fire (Grant and others, 2010, 2011). In mixed-grass prairies in south-central North Dakota, Clay-colored Sparrow density increased monotonically with the number of years since the most recent burn; no information was provided on burn regimes except that burns on individual study plots were conducted in spring or fall, averaging 3–5 years between burns (Johnson, 1997). In mixed-grass prairies in South Dakota, unburned pastures were lightly grazed (0.2 AUM per ha) in the dormant season by American bison (*Bison bison*) and burned pastures were rested from grazing during the year before a spring (May) burn; Clay-colored Sparrows avoided burned areas, preferring denser vegetation in a lightly grazed, unburned area (Huber and Steuter, 1984). In Wisconsin, Halvorsen and Anderson (1983) reported that Clay-colored Sparrow density declined by 93 percent immediately following a spring (mid-March to late April) burn, which the authors attributed to the reduction in cover; no differences in shrub density were noted between burned and unburned areas. In western Minnesota and northwestern Iowa, Ahlering and others (2019) examined the effect of management history (time since fire or grazing), grassland type (remnant prairie or restored grassland), and land ownership (public or private ownership) on Clay-colored Sparrow abundance after habitat and landscape variables had been considered. Fire and grazing history best explained additional variation in the abundance of Clay-colored Sparrows. Compared to sites with no grazing, Clay-colored Sparrows were more abundant on sites burned 2 or more years before the study occurred, on sites grazed during the study year but not during the previous 2 years, and on sites grazed the year before the study; Clay-colored Sparrows also were more abundant on private lands than on public lands (Ahlering and others, 2019).

Haying

As with burning, frequent haying or mowing operations that eliminate sturdy forb species (for example, alfalfa) that can be used as nest substrates are detrimental to Clay-colored Sparrows (Leston and Koper, 2017). Clay-colored Sparrows may disappear or decrease in abundance in fields the year of haying but will likely recover if fields are not annually mowed (Messmer, 1990; Igl and Johnson, 2016). Clay-colored Sparrows tolerate some disturbance, as the species nests in hayland and other grasslands that are periodically hayed or mowed (Kantrud, 1981; Dale, 1992; Jones, 1994; Anstey and others, 1995; Prescott and others, 1995; Dale and others, 1997; McMaster and others, 2005; Igl, 2009). In Alberta, Manitoba, and Saskatchewan, Clay-colored Sparrows occurred more frequently on PCP grasslands that were hayed than those that were grazed; descriptions of hayland and grazing regime or intensity were not provided (McMaster and Davis, 2001). In Alberta, Clay-colored Sparrows preferred hayland in which haying was deferred (that is, mowed after July 15) to hayland that was mowed earlier in the growing season, although use of idle habitats was higher than use of either hayland type (Prescott and others, 1995). In Saskatchewan, Clay-colored Sparrows preferred idle mixed-grass prairies to hayfields that were mowed either annually or periodically (every 3–8 years) (Dale and others, 1997). Also in Saskatchewan, Dale (1993) reported that Clay-colored Sparrows used alfalfa as a nesting substrate in place of shrubs; Johnson and Schwartz (1993a) made similar observations in CRP grasslands in North Dakota, South Dakota, Minnesota, and Montana. In Manitoba, Clay-colored Sparrows tended to respond negvatively to increases in mowing frequency in powerline transmission rights-of-way, possibly because frequently mowed areas had a lower volume of herbaceous vegetation that would be necessary for nesting (Leston and Koper, 2017). Management of rights-of-way varied from being mowed 1–2 times a year (with vegetation left to decompose on-site) and sprayed with herbicides frequently, being mowed once a year and sprayed infrequently, being hayed (that is, the vegetation was baled and removed), to being unmowed. In North Dakota, Clay-colored Sparrows were marginally more abundant in idle portions of CRP grasslands than in portions of CRP grasslands that had been hayed the previous year (Horn and Koford, 2000). Igl and Johnson (2016) assessed the effects of haying on grassland breeding birds in 483 CRP fields in nine counties in four States in the northern Great Plains over a 16-year period. Compared to densities in CRP fields that had been idled for 5 or more years, Clay-colored Sparrow densities were lower in the first year after haying but generally increased above densities in idled fields the second through fourth years after haying. In western Minnesota, Dunlap (2014) evaluated bird use of planted grasslands characterized by diverse mixes of native tallgrass vegetation; grasslands were assigned one of six biofuel harvest treatments: control (no harvest), 50 percent block harvest, 50 percent strip harvest, 75 percent block harvest, 75 percent strip harvest, and 100 percent harvest. Clay-colored Sparrow abundance declined with an increase in the percentage of a grassland that was harvested (via haying or mowing) in October or November of each year.

Grazing

Grazed grasslands often are used by Clay-colored Sparrows, but shrub cover may be a more important factor in determining habitat suitability for this species than grazing regime or grazing intensity (Owens and Myres, 1973; Kantrud, 1981; Kantrud and Kologiski, 1982; Dale, 1984; Bock and others, 1993; Anstey and others, 1995; Saab and others, 1995). Heavy grazing may be detrimental to Clay-colored Sparrows, especially if litter and shrub cover are reduced (Kantrud, 1981; Kantrud and Kologiski, 1982; Dale, 1983). However, in a meta-analysis of six grazing studies conducted in Canada, Bleho and others (2014) found that the rate of cattle-induced destruction (that is, direct destruction or abandonment) of Clay-colored Sparrow nests decreased with increasing livestock grazing intensity and stocking rate. Apparent nest destruction by cattle or cattle-induced abandonment was highest in lightly grazed pastures (<33 percent of available forage used), followed by moderately grazed pastures (33–65 percent of available forage used), with no nest destruction reported in heavily grazed pastures (>65 percent of available forage used). Nest survival rate and probability of nests not being depredated were similar in grazed and ungrazed pastures. Bleho and others (2014) surmised that cattle may avoid large patches of shrubs, thus offering protection for Clay-colored Sparrow nests.

Grazing systems may affect Clay-colored Sparrow abundance, density, and nest success. In Alberta, Clay-colored Sparrows were most abundant on season-long grazed parkland pastures (a habitat that contained patches of shrub cover); the species was more abundant in deferred (grazed after July 15) tame pastures than in season-long or deferred mixed-grass pastures, and they were uncommon in season-long tame pastures (Prescott and others, 1995). In south-central Saskatchewan, neither a rotational grazing system (rotating livestock through pastures such that each pasture was grazed once during the season at an average 1.0 AUM per ha) or a season-long grazing (continuous grazing from mid-May until temperatures fell below 0 ºC in the fall at an average 0.9 AUM per ha) affected Clay-colored Sparrow abundance (Davis and others, 2014). In lightly to moderately grazed pastures (32–43 percent utilization of forage by livestock) in Saskatchewan, Bleho (2009) found that Clay-colored Sparrow abundance was not affected by grazing and that the species was more abundant in lowland habitat where shrub cover was more abundant. In Manitoba mixed-grass prairies, Ranellucci and others (2012) and Carnochan and others (2018) examined the effects of twice-over rotational grazing (grazing twice from June to mid-October at an average 1.87 AUMs per ha with about a 2-month rest in between grazing and cattle rotated between 3–6 pastures), and season-long grazing (continuous grazing from May through October at an average 2.17 AUMs per ha). In a 2-year study, Clay-colored Sparrow abundance was higher on twice-over rotational grazed pastures than on season-long grazed pastures in 1 of 2 years (Ranellucci, 2010; Ranellucci and others, 2012). In another 2-year study conducted 2 years later on the same pastures, Carnochan and others (2018) reported more nests but lower nest success in twice-over pastures than in season-long pastures, but neither finding was statistically significant.

In mixed-grass prairies in south-central North Dakota, Clay-colored Sparrows were common in short-duration grazed pastures, twice-over grazed pastures, and season-long grazed pastures, as well as in idle grasslands (Messmer, 1990). Short-duration pastures were rotated through a grazing schedule of about 1 week grazed and 1 month ungrazed, repeated throughout the season at 0.34–0.61 AUM per ha; twice-over grazed pastures were grazed twice per season, with about a 2-month rest in between grazing at 0.38–0.77 AUM per ha; and season-long grazed pastures had a livestock herd on the same pasture throughout the growing season at 0.53–0.92 AUM per ha. Regardless of grazing treatment, the species was consistently most abundant in areas with western snowberry (Messmer, 1990). In another study in the same study area, Clay-colored Sparrow densities decreased with increasing grazing intensity; densities were highest in lightly grazed pastures (2.0 AUMs per ha), and the species was absent from extreme grazed pastures (4.8 AUMs per ha) (Salo and others, 2004). In south-central and northwestern North Dakota, the percent frequency of Clay-colored Sparrows was similar between rotationally grazed pastures and season-long pastures (Buskness and others, 2001). Rotationally grazed pastures consisted of 4–8 cells, grazed from May 26 to November 10 at 0.6–2.5 AUMs per ha; season-long pastures were grazed from May 15 to November 1 at 0.9–2.7 AUMs per ha. In mixed-grass prairies in northwestern North Dakota, frequency of occurrence of singing male Clay-colored Sparrows was similar in plots that were burned only, whereby prescribed burns were scheduled on plots varying from 3 to 6 burns that occurred 1–8 years since last burn (Danley and others, 2004). Burns were conducted either in late spring or in summer (Madden and others, 1999). Plots were burned and rotationally grazed (each of three cells per plot were grazed for 14 days from late May through mid-August; two of three cells were grazed for a second 14-day period after a 28-day rest; grazing occurred 1–4 years after the last of the prescribed burns) (Danley and others, 2004).

Planted Cover

Idle grasslands often support high densities of Clay-colored Sparrows (Renken, 1983; Messmer, 1990; Hartley, 1994; Prescott and others, 1995; Madden, 1996; Koford, 1999; Durán, 2009; Ranellucci, 2010; Igl and Johnson, 2016). In Alberta, Clay-colored Sparrows were absent from tame DNC grasslands that were <2 years old; abundance gradually increased during the third, fourth, and fifth (the final year of study) years (Prescott and Murphy, 1999). In east-central Saskatchewan, the species occurred at nearly equal frequency in idle, native grasslands as in idle, DNC grasslands (Hartley, 1994). Within the same general geographical area (and with two overlapping study sites) as Hartley's (1994) study, Clay-colored Sparrows were more common in DNC grasslands and grasslands planted to creeping red fescue (*Festuca rubra*) and Kentucky bluegrass than in fallow cropland fields (Dale, 1993). In another Saskatchewan study, Clay-colored Sparrows preferred idle native grasslands invaded by tame grasses to native grasslands and hayland (Dale, 1992). In Manitoba, no difference in productivity or abundance of Clay-colored Sparrows was detected between DNC grasslands planted to native grass species, DNC grasslands planted to tame grass species, and idle mixed-grass prairies (Dhol and others, 1994). In mixed-grass prairies in southwestern Manitoba, Clay-colored Sparrows were nearly twice as abundant on mostly idle Wildlife Management Areas than on Federal and private lands that were actively managed by grazing or haying (Durán, 2009). In another study in southwestern Manitoba, Clay-colored Sparrows were significantly more abundant in idle grasslands than on twice-over rotational grazed pastures (that is, 3–6 paddocks per pasture, and each paddock was grazed twice during the grazing season) in 1 of 2 years (Ranellucci, 2010; Ranellucci and others, 2012). In south-central North Dakota, Clay-colored Sparrow use of idle areas declined after mowing and as western snowberry cover decreased (Messmer, 1990). Also in North Dakota, Clay-colored Sparrow densities were significantly higher in idle mixed-grass prairies than in grazed mixed-grass prairies or DNC grasslands planted to alfalfa, intermediate wheatgrass, and tall wheatgrass (*Thinopyrum elongatum*) (Renken, 1983; Renken and Dinsmore, 1987). In south-central North Dakota, areas left unburned longer than 11 years had higher Clay-colored Sparrow densities than recently burned areas (Johnson, 1997). Koford (1999) reported that Clay-colored Sparrows were more abundant in idle Waterfowl Production Areas than in CRP fields in North Dakota and Minnesota; compared to CRP grasslands, Waterfowl Production Areas contained more western snowberry and yellow sweetclover, which were used by Clay-colored Sparrows as nesting substrate and song perches.

Cropland

Clay-colored Sparrows rarely use cropland for nesting during the breeding season (Salt, 1966; Johnson and Schwartz, 1993b; Anstey and others, 1995; Johnson and Igl, 1995; Grant and Knapton, 2020), but cultivated areas near nesting sites may provide sparse, shorter vegetation suitable for foraging (Dale, 1983; Mozel, 2010). In addition, shrubs retained along field borders often are used by Clay-colored Sparrows for nesting (Owens and Myres, 1973; Dale, 1983). In Alberta, Manitoba, and Saskatchewan, Clay-colored Sparrows were more common in grasslands enrolled in the PCP than in cropland (McMaster and Davis, 2001). In Alberta, Salt (1966) often observed Clay-colored Sparrows in cultivated fields after their young fledged, and Owens and Myres (1973) detected Clay-colored Sparrows more frequently along a roadside survey route through cultivated land than along a survey route with more native grassland. In another Alberta study, Clay-colored Sparrows were absent from cropland embedded within an aspen parkland landscape (Prescott and Murphy, 1999). In Saskatchewan, Clay-colored Sparrows were more abundant in DNC grasslands than in cropland on organic, conventional-tilled, or minimum-tillage farmland (Shutler and others, 2000). In another Saskatchewan study, Clay-colored Sparrows were least abundant in willow (*Salix* spp.)-ringed wetlands surrounded by cropland and most abundant in willow-ringed wetlands surrounded by grassland vegetation (Mushanski, 2015). In east-central Saskatchewan, Clay-colored Sparrow abundance was higher in DNC grasslands and native grasslands than in wheat (*Triticum* spp.) fields (Hartley, 1994), and in Manitoba, Clay-colored Sparrows were more common in native grasslands than in cropland (Mozel, 2010). In North Dakota, Clay-colored Sparrows were absent from cropland fields but were common in CRP grasslands (Johnson and Igl, 1995). Johnson and Igl (1995) estimated that the North Dakota population of Clay-colored Sparrows would decline by over 9 percent if CRP grasslands in the State reverted back to cropland; similarly, Drum and others (2015) reported that Clay-colored Sparrow populations would decline by 14.8 percent if all CRP grasslands were converted to cropland in the Prairie Pothole Region of the United States.

Pesticides

Few studies have examined the direct or indirect effects of pesticide applications on Clay-colored Sparrows. During the breeding season, the Clay-colored Sparrow relies on invertebrates for food and may ingest insecticides indirectly through contaminated prey. Forsyth and others (1994) examined the potential hazards of carbofuran-contaminated migratory grasshoppers (*Melanoplus sanguinipes*) on adult and nestling Clay-colored Sparrows. The authors reported that there were no mortalities or taste aversion related to eating contaminated grasshoppers during laboratory experiments, although adult hopping behavior increased nonsignificantly by 80 percent for birds that consumed poisoned grasshoppers compared to control birds. In a Texas study examining the response of birds to brush suppression and gamebird habitat management (disking, spraying of the herbicide 2,4,5–T [2,4,5–trichlorophenoxy acetic acid] about 14 years earlier, and construction of brush shelters), Gruver and Guthery (1986) reported that brush suppression and management had no effects on grassland sparrows as a group. Clay-colored Sparrows were included with other grassland sparrows, but the effects on individual species were not examined.

Energy Development

Clay-colored Sparrows show some tolerance to anthropogenic activities, such as oil and gas development. In boreal forests in Alberta, Clay-colored Sparrows were recorded on reclaimed well sites (that is, gas and oil wells that are no longer in production and are in various stages of vegetation recovery) but not recorded on adjacent mature (>80 years old) boreal forest sites (Wilson and Bayne, 2019). Farther north and in the Athabasca Oil Sands Region, Clay-colored Sparrows were more abundant on young (0–20 years old) reclaimed oil-sands mining sites than on older reclaimed plots (26–35 years old; still immature from a vegetation succession perspective) (Hawkes and others, 2021). Using data from captured birds at mist-netting stations in reclaimed and natural habitats in Alberta's oil sands region, Foster and others (2017) determined that Clay-colored Sparrow captures were negatively associated with open-to-forested habitat gradients; capture data indicated that the species preferred more open or early successional habitats than forested habitats. Captures also were negatively associated with time since reclamation, although not significantly so, indicating the species' preference for habitats with open canopies. In mixed-grass prairies in southeastern Alberta, Clay-colored Sparrow relative abundance was not affected by conventional natural gas infrastructure (that is, density of and proximity to shallow gas wells); however, the species was highly sensitive to changes in vegetation structure associated with energy development (Rodgers, 2013; Rodgers and Koper, 2017). In mixed-grass prairies in southern Alberta, Clay-colored Sparrow abundance declined with increasing distance from shallow gas wells and roads, but abundance was not significantly affected by density of shallow gas wells or by distance to oil wells (Daniel, 2015). In native and tame pastures in southeastern Saskatchewan, Clay-colored Sparrow abundance was not affected by the presence of oil wells, oil-well density, or oil-well activity (Unruh, 2015). Clay-colored Sparrow abundance was lowest when cumulative oil-well disturbance was 3 percent of the landscape, described as a "moderate" level of disturbance on a range of 0–8 percent; cumulative disturbance was calculated by summing the area encompassed by all well pads, battery and building pads, oil roads and trails, and pipelines for each sample site. In northwestern North Dakota, Clay-colored Sparrow densities were not reduced within 150 m of roads associated with unconventional oil extraction sites (that is, hydraulic fracturing and horizontal drilling); the authors also found no evidence of avoidance to single-bore oil-well sites (Thompson and others, 2015). In mixed-grass prairies in western North Dakota, Clay-colored Sparrow densities increased with increasing density of unconventional oil wells within 1.6 km of study plot boundaries; sparrow densities were unrelated to road densities (Chepulis, 2016).

Wind-energy development may negatively impact Clay-colored Sparrow distribution and abundance. 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 Clay-colored Sparrow scored a 2.07 out of nine, where nine indicated high risk, and Beston and others (2016) estimated that 6.01 percent of the Clay-colored Sparrow breeding population in the United States may be exposed to wind facilities. Clay-colored Sparrows may avoid wind-energy facilities during the breeding season (Shaffer and Buhl, 2016). At two wind facilities in mixed-grass prairies in North Dakota, Clay-colored Sparrows exhibited displacement from wind turbines during two time periods: 1 year after construction (immediate displacement) and 2–5 years after construction (delayed displacement); the species exhibited displacement within 200 m of wind facilities and >300 m from wind facilities, depending on location.

Roads

In Alberta, average Clay-colored Sparrow abundance did not differ significantly between roadside point counts and off-road point counts (that is, 800 m from the nearest roadside count) (Wellicome and others, 2014). In southern Alberta, distance to roads negatively affected Clay-colored Sparrow densities (Koper and Schmiegelow, 2006). In Alberta mixed-grass prairies, Clay-colored Sparrows did not display a clear pattern of avoidance or attraction to roads (Sliwinski and Koper, 2012). In lightly to moderately grazed mixed-grass prairies in Saskatchewan, abundance of Clay-colored Sparrows was not significantly different along trails (single pair of wheel ruts visually indistinct from surrounding habitat in terms of plant structure and composition) than along roads (traveling surfaces with adjacent drainage ditches planted to smooth brome and ending with a fence 11–18 m from the traveling surface) (Sutter and others, 2000). In Manitoba, Clay-colored Sparrow occupancy in urban and rural rights-of-way were not related to traffic or noise levels (Leston and Koper, 2017). At Arrowwood National Wildlife Refuge in south-central North Dakota, Dieni and Scherr (2004) found no evidence that Clay-colored Sparrow abundance was related to distances (0–400 m) from a road.

Management Recommendations from the Literature

Grassland Protection and Restoration

Grant and Knapton (2020) summarized conservation actions that benefit the Clay-colored Sparrow, including the protection of grasslands from conversion to agricultural production, fragmentation, invasion by nonnative plants, suppression of fire, and overgrazing. Grant and Knapton (2020) also recommended the continuation and expansion of cropland set-aside programs, such as the CRP, and the management of grasslands with patchy low-statured shrubs so that these areas do not undergo vegetation succession to taller-statured shrubland and woodland. In areas where fragmentation is high because of urbanization or agriculture, or where unchecked vegetation succession eventually degrades Clay-colored Sparrow habitats (for example, savannas, barrens, parkland), public lands protect imperiled habitats upon which Clay-colored Sparrows rely. Examples include the Fort McCoy Military Installation for oak savanna (Vos and Ribic, 2013), Moquah Barrens Wildlife Area for pine barrens (Ryba, 2002), and J. Clark Salyer National Wildlife Refuge for mixed-grass prairies and aspen parkland (Grant and others, 2006). Federal policies that protect grassland types on public land, such as the oak savannas found on military installations in Wisconsin, may be key to preserving rare habitats and grasslands inhabited by Clay-colored Sparrows in the eastern portion of their range (Vos and Ribic, 2011, 2013). Federal policies that protect grasslands on private land, such as CRP grasslands or conservation easements, provide avian habitat, but Quamen (2007) cautioned that protected areas in western Minnesota and northwestern Iowa did not overlap with areas of projected highest avian richness. Quamen (2007) advocated for the application of conservation planning maps to guide placement of grassland restoration—such as CRP—or grassland protection in the form of easements, and where placement optimizes benefits to grassland birds. Privately owned lands (especially pastureland generally referred to as “working lands”) can provide habitat and protect native ecosystems, as over 70 percent of the United States is held in private ownership (Ciuzio and others, 2013). Veech (2006) found that rangeland constituted a greater proportion of the landscape for increasing Clay-colored Sparrow populations than for decreasing populations. Ahlering and others (2019) found that the fire and grazing management strategies yielded higher densities of Clay-colored Sparrow on private lands than on public lands. Conservation partnerships between Federal, State, and Tribal agencies; nongovernmental organizations; and private landowners result in programs like grassbanks. Gripne (2005) described a grassbank as a conservation tool that exchanges the value of a given amount of forage that is not produced for conservation benefits. Clay-colored Sparrows benefit from grassbanks for the grassland habitat protected, the high nest-success rates on rangeland (Bleho and others, 2014), and the higher densities on private grasslands than public lands (Ahlering and others, 2019). In addition, the ability to manipulate factors, such as stocking rate (Salo and others, 2004), that affect Clay-colored Sparrow demographics require good relationships and agreements with private individuals.

Planted Cover

Public/private partnerships also provide habitat for Clay-colored Sparrows by converting cropland to perennial grassland cover, with common examples being the PCP in Canada and the CRP in the United States (McMaster and Davis, 2001; Igl, 2009; Igl and Johnson, 2016). Grassland restoration and the maintenance of idle areas, such as brushy edges around cropland and infrequently mowed transmission rights-of-way, will benefit Clay-colored Sparrows as long as these habitats contain tall, dense grass; an abundant litter layer; and sturdy forbs like alfalfa and yellow sweetclover (Owens and Myres, 1973; Dale, 1983; Leston and Koper, 2017). Igl and Johnson (2016) suggested that land managers maintain a mosaic of CRP grasslands, including some that have been idled long-term and others that have been hayed or disturbed periodically at 3–5-year intervals. Retaining some idle CRP grasslands guarantees that some undisturbed nesting cover remains for Clay-colored Sparrows. Davis and others (2017) suggested that the type of management (for example, burning or haying) on planted grasslands may be less important than tailoring the frequency, timing, and type of management to local environmental conditions in a given region and year, with less frequent management in arid environments and more frequent management in mesic conditions. Davis and others (2017) further recommended that managers establish a mosaic of grasslands that vary from 1 to 6 years since the last management treatment and that treatments occur outside of the breeding season to reduce avian mortality or nest destruction from haying or burning. Blank and others (2014) reported that newer programs to establish grasslands as sources for bioenergy create more preferred habitat for Clay-colored Sparrows than corn fields. Blank and others (2014) suggested that establishing bioenergy grasslands in a landscape of other grassland parcels maximizes the benefit to Clay-colored Sparrows but cautioned that the timing of biomass harvests to minimize nest loss will be an important consideration.

Woody Vegetation

Management practices that maintain existing grasslands with scattered low-statured woody vegetation provide the nesting and foraging needs of the Clay-colored Sparrow (Grant and Knapton, 2020). Shrubby vegetation that is favorable to Clay-colored Sparrows can be encouraged by allowing grasslands to remain idle between periods of grazing, burning, or haying (Dale, 1983; Halvorsen and Anderson, 1983; Arnold and Higgins, 1986; Madden, 1996; Johnson, 1997). Madden and others (2000) suggested that even low (3 percent) amounts of shrub cover maintained the presence of Clay-colored Sparrows in mixed-grass prairies, indicating that co-management for this species and other grassland bird species less dependent on shrub coverage is feasible (Grant and Knapton, 2020). Grant and others (2006) cautioned that, when management includes objectives for prairie restoration or maintaining grassland bird populations, tall woody plants should be reduced to levels within the range of natural variation defined by major ecological processes (for example, drought, grazing, fire) characteristic of the region. Once taller trees and shrubs become well-established in grasslands, successful long-term tree removal can be expensive and challenging and may require continued management treatments that are not immediately beneficial to Clay-colored Sparrows (Thompson and others, 2016). In pine barrens, prescribed fire or timber harvest maintain the vegetation characteristics preferred by Clay-colored Sparrows (Root, 1968; Ryba, 2002). Applying management treatments such as burning, mowing, or grazing to portions of large areas on a rotational schedule may provide a mosaic of vegetative successional stages (Renken, 1983; Renken and Dinsmore, 1987; Madden, 1996; Johnson, 1997; Igl and others, 2018b).

Fire

Prescribed fire is an effective management tool for restoring native grasslands invaded by woody vegetation and nonnative plant species (Johnson, 1997; Madden and others, 2000, Grant and others, 2010, 2011; Murphy and others, 2017). Grant and others (2010) warned that burning as a management tool may be applied too infrequently in the northern Great Plains, and that the extent and frequency of prescribed burns need to increase above current levels to maintain and restore the ecological integrity of native prairie. Burning large grassland areas on a rotational basis, burning portions of the total grassland area each year, or burning small grassland areas periodically are all useful approaches to create a variety of successional stages (Renken, 1983; Renken and Dinsmore, 1987; Madden, 1996; Johnson, 1997). Recommended fire-return intervals vary from 3–12 years (Grant and others, 2011; Grant and Knapton, 2020) to 5–10 years (Madden and others, 1999) for mixed-grass prairies threatened with invasion by aspen and nonnative grass species and 4–6 years in created grasslands within the aspen parkland ecoregion of Canada (Davis and others, 2017). Shorter fire-return intervals in northern mixed-grass prairies reduce woody vegetation and litter, resulting in decreased Clay-colored Sparrow abundance or avoidance of burned habitats altogether (Huber and Steuter, 1984; Pylypec, 1991; Berkey and others, 1993; Grant and others, 2010). Shorter fire-return intervals might be merited in savanna or pine barren habitats to curtail vegetation succession to woodland (Ryba, 2002). When applying management treatments, Arnold and Higgins (1986) recommended leaving patches of shrubs when burning or using herbicides; Nenneman (2003) found Clay-colored Sparrow nests in unburned or lightly burned patches where litter cover and western snowberry escaped burning.

Haying

Conventional management of hayland is generally detrimental to grassland bird species as traditional mowing dates occur within the avian breeding season when nests, eggs, and juvenile and adult birds can be destroyed or killed (Frawley and Best, 1991). For Canadian hayfields, Dale and others (1997) suggested delaying the mowing of hayfields until July 15 or later, estimating that 70 percent of grassland bird nests produce fledglings by that date in years with normal breeding phenology; mowing should be delayed further if nesting is hampered by inclement spring weather or drought. Davis and others (2016) also suggested that mowing after July 15 in Canadian hayfields might be appropriate, although more research on the survival and recruitment rates of young that fledge after haying would be merited. Dale and others (1997) recommended that, when mowing cannot be delayed, large fields should be divided in half and each half should be mowed in alternate years, which will ensure some productivity in individual fields as well as provide protective cover for fledglings in the unmowed half of the field.

Grazing

As Clay-colored Sparrows respond more strongly to the amount of shrub coverage than to grazing regime or grazing intensity (Messmer, 1990; Bock and others, 1993; Ranellucci, 2010; Bleho and others, 2014), maintaining a shrubby component within grazed pastures helps ensure nesting habitat for Clay-colored Sparrows (Grant and Knapton, 2020). Grazing at intensities that eliminate ground or shrub cover will be detrimental to the species (Owens and Myres, 1973; Kantrud, 1981; Kantrud and Kologiski, 1982; Dale, 1983; Salo and others, 2004). Even heavily grazed pastures may provide nesting habitat; Bleho and others (2014) reported that the lowest rates of cattle-induced nest destruction occurred in heavily grazed pastures rather than in lightly grazed pastures and surmised that this finding reflected that cattle avoided large patches of shrubs. Within the northern mixed-grass prairies of the United States and Canada, rotational grazing systems did not confer greater advantages in bird productivity or vegetation structure than continuous grazing systems (Buskness and others, 2001; Bleho and others, 2014). Carnochan and others (2018) advised caution in applying a twice-over grazing system for the management of grassland birds. For the suite of grassland birds that included Clay-colored Sparrow, a season-long grazing system conferred greater reproductive success, including lower rates of nest destruction owing to cattle trampling.

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Table Z1. Measured values of vegetation structure and composition in Clay-colored Sparrow (*Spizella pallida*) 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; DNC, dense nesting cover]

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)
Bakker and Higgins, 2009	Minnesota, South Dakota	Tallgrass prairie	Native	96[a]	20[b]	--	--	--	--	--	2.6
Bakker and Higgins, 2009	Minnesota, South Dakota	Tame grassland	Seeded to intermediate wheatgrass (*Thinopyrum intermedium*)	135[a]	36[b]	--	--	--	--	--	3.1
Bakker and Higgins, 2009	Minnesota, South Dakota	Tame grassland	Cool-season seeding mixture	124[a]	36[b]	--	--	--	--	--	3.4
Bakker and Higgins, 2009	Minnesota, South Dakota	Tame grassland	Warm-season seeding mixture	166[a]	27[b]	--	--	--	--	--	4.1
Bleho, 2009	Saskatchewan	Mixed-grass prairie	Ungrazed	--	7.4[b]	15.6	4.5	6.2	4.7	60.9	--
Bleho, 2009	Saskatchewan	Mixed-grass prairie	Grazed	--	4[b]	17.9	6.9	3.6	8.4	45.2	--
Grant and others, 2004	North Dakota	Mixed-grass prairie	--	56	--	--	--	17.5	--	--	3.2
Madden, 1996	North Dakota	Mixed-grass prairie	Burned	--	20.8[b]	33.6	22.8	30.1	--	--	4.2
Munson, 1992[c] (territories)	Wisconsin	Tame grassland	Drained swamp	186.3	--	60.1	67	--	--	--	--
Nenneman, 2003 (fields)	North Dakota	Mixed-grass prairie	Burned	46.1[a]	34.3[b]	--	--	--	--	--	2.4
Nenneman, 2003 (nests)	North Dakota	Mixed-grass prairie	Burned	54.6[a]	47[b]	--	--	--	--	--	3.1
Niemi, 1985 (territories)	Minnesota	Peatland	--	120	--	--	--	--	--	--	--
Renken, 1983[d]	North Dakota	Tame grassland (DNC)	Idle, grazed	--	16[b]	63.5	28.7	10.6	0.1	99.6	3
Rodgers, 2013[d]	Alberta	Mixed-grass prairie	--	22.8[a]	--	35.8	11.1	--	2.9	--	0.2
Salo and others, 2004	North Dakota	Mixed-grass prairie	Light grazing intensity	52.9[a]	50.3[b]	--	--	--	--	--	5.3
Salo and others, 2004	North Dakota	Mixed-grass prairie	Moderate grazing intensity	48.3[a]	45.8[b]	--	--	--	--	--	4.6
Salo and others, 2004	North Dakota	Mixed-grass prairie	Heavy grazing intensity	27.1[a]	22.9[b]	--	--	--	--	--	2
Schneider, 1998	North Dakota	Mixed-grass prairie	Grazed	--	10.2[b]	40.7	15.3	--	3.4	--	2.3
Unruh, 2015	Saskatchewan	Mixed-grass prairie	Grazed	20	9[b]	73.9	9.6	--	15.7	--	0.8

Table Z1. Measured values of vegetation structure and composition in Clay-colored Sparrow (*Spizella pallida*) breeding habitat by study. The parenthetical descriptors following authorship and year in the "Study" column indicate that the vegetation measurements were taken in locations or under conditions specified in the descriptor; no descriptor implies that measurements were taken within the general study area.—Continued

[cm, centimeter; %, percent; --, no data; DNC, dense nesting cover]

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)
Unruh, 2015	Saskatchewan	Tame grassland	Grazed	23	10.9[b]	63.8	13.3	--	22.2	--	0.8
White, 2009	Saskatchewan	Mixed-grass prairie	Burned and grazed	37.2	3.5[b]	30.7	6.1	0.7	19.5	14.9	1.6
White, 2009	Saskatchewan	Mixed-grass prairie	Burned and ungrazed	39.4	4[b]	31.4	6.8	0.5	15.4	10.4	1.1
White, 2009	Saskatchewan	Mixed-grass prairie	Unburned and grazed	41.4	3.4[b]	17.3	7.8	0.4	3.2	47.3	2.1
White, 2009	Saskatchewan	Mixed-grass prairie	Unburned and ungrazed	41.7	7.2[b]	14.8	5.1	2.1	1.6	62.8	5.1
Winter and others, 2004 (nests)	Minnesota, North Dakota	Tallgrass prairie	Multiple	48.7	38[b]	27.3	21.1	21.4	0.9	29.2	4.9
Winter and others, WissenLeben e.V., Raisting, Germany, written commun. [n.d.] (plots)	Minnesota, North Dakota	Tallgrass prairie	Multiple	43	25.9[b]	37	20.6	2.8	3.9	34.8	4.6

[a]Mean grass height.

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

[c]The sum of the percentages is greater than 100% because plant leaf overlap was allowed in calculations of percent coverage.

[d]The cover percentages are based on the modified point quadrat technique of Wiens (1969).

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