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The Effects of Management Practices on Grassland Birds—Baird's Sparrow (*Centronyx bairdii*)

Chapter HH of

The Effects of Management Practices on Grassland Birds

Professional Paper 1842–HH

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

Cover. Baird's Sparrow, by Rick Bohn, 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]
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The Effects of Management Practices on Grassland Birds

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

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DAVID BERNHARDT, Secretary

U.S. Geological Survey
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Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
decimeter (dm)	3.937	inch (in.)
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
hectare (ha)	2.471	acre
square kilometer (km^2)	247.1	acre
hectare (ha)	0.003861	square mile (mi^2)
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
cubic centimeter (cm^3)	0.06102	cubic inch (in^3)
	Mass	
gram (g)	0.03527	ounce (oz)
kilogram (kg)	2.202	pound (lb)

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

$$°F = (1.8 \times °C) + 32.$$

Abbreviations

AUM animal unit month

BBS Breeding Bird Survey

CRP Conservation Reserve Program

CV coefficient of variation

n.d. no date

PCP Permanent Cover Program

PDSI Palmer Drought Severity Index

SD standard deviation

VOR visual obstruction reading

Acknowledgments

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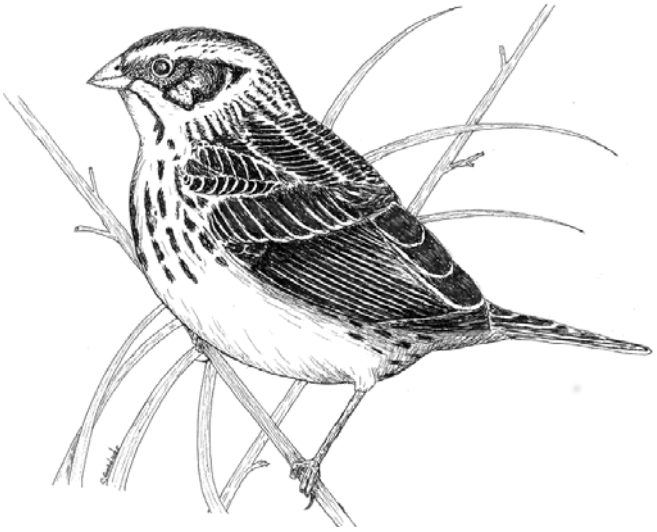
Capsule Statement

Keys to Baird's Sparrow (*Centronyx bairdii*) management are providing native or tame grasslands with moderately deep litter, controlling excessive grazing, and curtailing shrub encroachment. Baird's Sparrows have been reported to use habitats with less than or equal to (≤) 101 centimeters (cm) average vegetation height, 3–46 cm visual obstruction reading (VOR), 15–71 percent grass cover, 5–25 percent forb cover, ≤50 percent shrub cover, less than (<) 44 percent bare ground, 10–63 percent litter cover, and ≤21 cm litter depth. The descriptions of key vegetation characteristics are provided in table HH1 (after the "References" section). Vernacular and scientific names of plants and animals follow the Integrated Taxonomic Information System (https://www.itis.gov), except for the genus of the Baird's Sparrow, which follows the 59th Supplement to the American Ornithological Society's Checklist of North American Birds (Chesser and others, 2018).



Baird's Sparrow. Illustration by Christopher M. Goldade, used with permission.

Breeding Range

Baird's Sparrows are endemic to the northern Great Plains (Mengel, 1970), breeding from southern Alberta to southwestern Manitoba, and from northern and eastern Montana through western Minnesota and western South Dakota (National Geographic Society, 2011). The relative densities of Baird's 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 HH1 (not all geographic places mentioned in report are shown on figure). Youngberg and others (2020) indicated that the breeding range of Baird's Sparrow has expanded southward into eastern Wyoming, western Nebraska, and eastern Colorado.

Suitable Habitat

Baird's Sparrows prefer idle native mixed-grass prairies or planted (that is, "tame") grasslands and lightly to moderately grazed pastures (Lein, 1968; Owens and Myres, 1973; Stewart, 1975; Kantrud and Kologiski, 1982; De Smet and Conrad, 1991; Skeel and others, 1995; Sutter, 1996; Davis and Duncan, 1999; White, 2009; Pipher, 2011; Richardson, 2012; Davis and others, 2013; Lusk and Koper, 2013; Lipsey, 2015). The species sometimes uses planted cover (for example, Conservation Reserve Program [CRP] grasslands, Permanent Cover Program [PCP] grasslands, and dense nesting cover), dry wetland basins, wet meadows, and dense stands of grass within hayland and cropland (Lane, 1968; Stewart, 1975; Renken, 1983; Johnson and Schwartz, 1993; Davis and others, 1996; McMaster and Davis, 1998, 2001).

Native prairie often is regarded as optimal breeding habitat (Cartwright and others, 1937; Lane, 1968; Owens and Myres, 1973; Dale, 1992; Dale and others, 1997; Jones and

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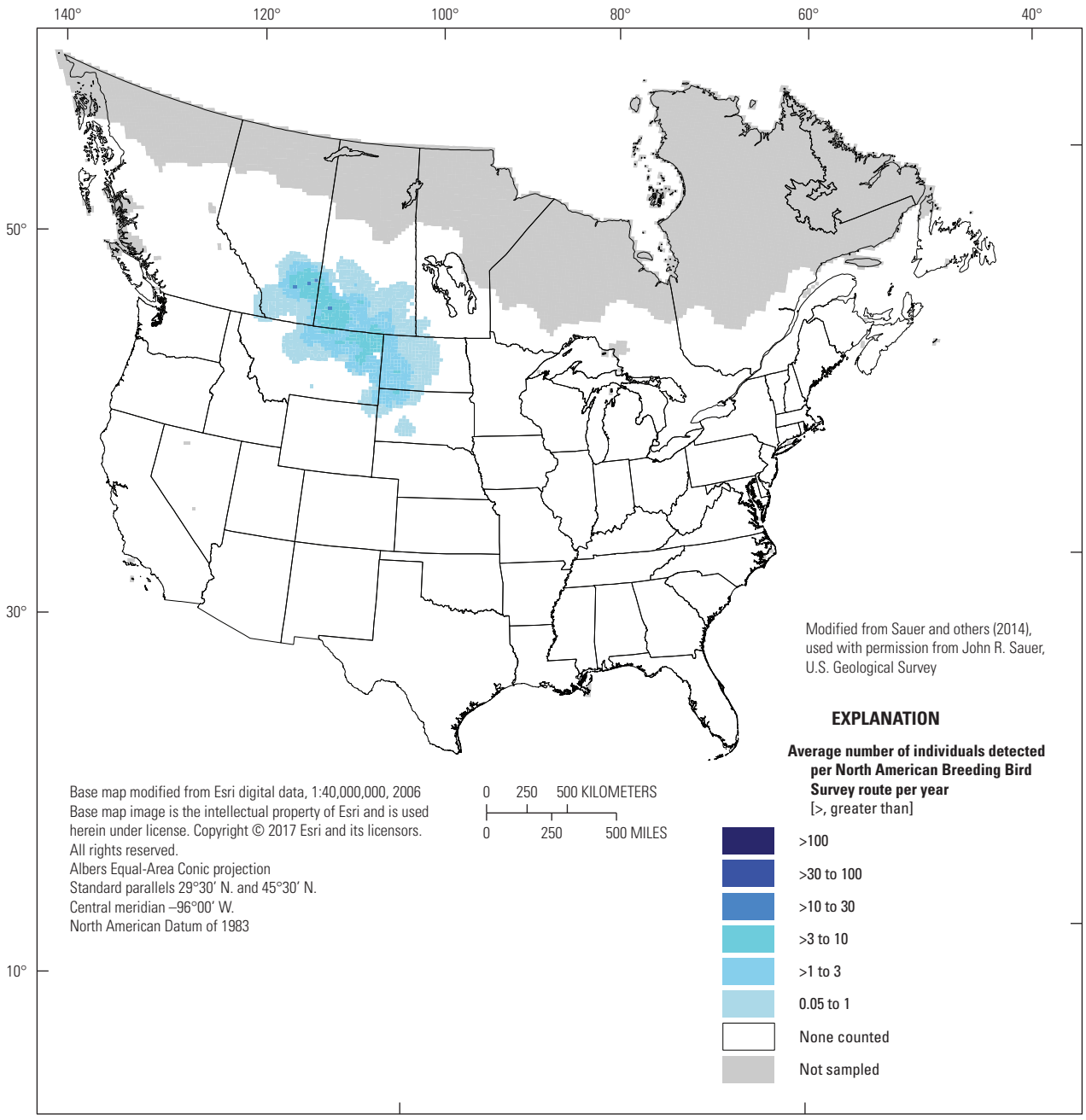

Figure HH1. The breeding distribution of the Baird's Sparrow (*Centronyx bairdii*) in the United States and southern Canada, based on North American Breeding Bird Survey (BBS) data, 2008–12. The BBS abundance map provides only an approximation of breeding range edges.

Green, 1998; Green and others, 2020), and some studies have shown that Baird's Sparrows exhibit a preference for native grasses (Winter, 1994; Sutter and others, 1995; Madden, 1996; Davis and others, 2013). In an Alberta and Saskatchewan study of native and planted grasslands, Davis and others (2013) reported that Baird's Sparrow occurrence was as much as five times higher in native grasslands that were grazed than in planted grasslands that were grazed, hayed, or both. In southern Saskatchewan, Davis and others (2016) determined that Baird's Sparrow abundance was twice as high in native grasslands that were grazed than in planted grasslands that were grazed or hayed. Daily nest survival was higher in native pastures than in planted grasslands, and Baird's Sparrows fledged 2.0–4.5 times more young per nest in native pastures than in planted grasslands. However, several other Saskatchewan studies found no preference between native and tame grasslands; Baird's Sparrows may respond more strongly to vegetative structure than to species composition (Anstey and others, 1995; Sutter and others, 1995; Davis and others, 1996, 1999). Davis and others (1999) reported that Baird's Sparrows

were as common in tame pastures and hayland as in native pastures but were least common in cropland.

General habitat requirements for Baird's Sparrow include patchy grass and litter cover; moderately high, but patchy, forb coverage; moderate vegetation height; moderately deep litter; and sparse woody vegetation. In southern Saskatchewan, the abundance of Baird's Sparrows is generally positively associated with grass cover (Anstey and others, 1995; Sutter, 1996; Sutter and Brigham, 1998; Davis and others, 1999; Davis, 2003a, 2004; Kalyn Bogard, 2011; Molloy, 2014). Sutter (1996) reported that abundance was positively correlated with grass and sedge (*Carex* species) cover in an arid site with tame vegetation but not in a moderately moist site or in an arid site with native vegetation. In grazed mixed-grass prairies, numbers of Baird's Sparrows were negatively related to grass and sedge cover, whereas in fields of crested wheatgrass (*Agropyron cristatum*), numbers of Baird's Sparrows were positively correlated to grass and sedge cover (Sutter and Brigham, 1998). In another study in mixed-grass prairies, Baird's Sparrow abundance was positively associated with percentage of grass cover, especially crested wheatgrass (Kalyn Bogard, 2011). In upland mixed-grass prairies, Baird's Sparrow abundance was positively related to increased cover of blue grama (*Bouteloua gracilis*) (Molloy, 2014). Stands of smooth brome (*Bromus inermis*) and other tame, broad-leaved (5–10 millimeters [mm]) grasses may be avoided, whereas stands of tame, narrow-leaved (2–4 mm) grasses (for example, crested wheatgrass) may be readily used (Dale, 1992; Anstey and others, 1995; Mahon, 1995; Sutter and others, 1995; Sutter and Brigham, 1998; Kalyn Bogard, 2011).

Elsewhere in the species' breeding range, grass and forb cover are important components of Baird's Sparrow habitat. In Alberta, standing grass provided cover for adults and nests, and tall forbs provided perches for singing males (Mahon, 1995). In a second Alberta study, Ludlow and others (2015) reported no relationship between density and percentage cover of crested wheatgrass. In the northern Great Plains of the United States, Baird's Sparrow abundance was positively associated with junegrass (*Koeleria macrantha*), needle and thread (*Hesperostipa comata*), fringed sagewort (*Artemisia frigida*), and small clubmoss (*Selaginella densa*) (Kantrud and Kologiski, 1982). In northeastern Montana, Baird's Sparrows preferred grasslands with higher-than-average herbaceous cover (Lipsey and Naugle, 2017). Baird's Sparrow abundance was positively related to coverage of grass and forbs and unrelated to coverage of small clubmoss and tame grass (Lipsey and Naugle, 2017). In northwestern North Dakota, the probability of Baird's Sparrow occurrence increased with grass cover, forb cover, and with native grasses specifically, reaching 50 percent occurrence at 42 percent grass cover, 35 percent forb cover, and 42 percent frequency of native grasses (Madden and others, 2000). Baird's Sparrows also occupied areas with significantly greater grass cover than unoccupied areas (Madden, 1996). In another study in northern mixed-grass prairies, Grant and others (2004) reported that Baird's Sparrows were present in grasslands with higher percentage cover of Kentucky bluegrass (*Poa pratensis*) than in unoccupied areas; occurrence was not related to coverage of native grass and forb species, tame legumes, and smooth brome and quackgrass (*Elymus repens*). In grazed mixed-grass prairies in northern and central North Dakota, abundance of Baird's Sparrows was negatively associated with percentage of grass cover, although abundance was positively associated with plant communities dominated solely by native grasses (green needlegrass [*Nasella viridula*], needle and thread, blue grama, junegrass, and little bluestem [*Schizachyrium scoparium*]) and percentage of small clubmoss cover (Schneider, 1998). Abundance was negatively associated with plant communities dominated by a mix of Kentucky bluegrass and native grass species and with plant communities dominated by wet-meadow vegetation. One of the strongest vegetational predictors of the presence of Baird's Sparrows was increasing small clubmoss cover (Schneider, 1998). In South Dakota mixed-grass prairies, Baird's Sparrow occurrence and male density were positively associated with grass height and percentage of forb cover (Greer, 2009).

Other components of vegetation structure, such as height and density, litter, standing dead vegetation, and bare ground, also have been found to be important predictors of Baird's Sparrow abundance. In Alberta, Saskatchewan, and Manitoba, Baird's Sparrow presence was positively associated with standing dead vegetation contacts in the third decimeter above the ground and with grass contacts in the second decimeter above the ground (McMaster and Davis, 2001). Geographic variables also were important determinants for Baird's Sparrow occurrence, as occurrence prediction models included longitude singly as well as the interaction between ecoregion and longitude and the interaction between ecoregion and latitude. In Alberta, density of Baird's Sparrows decreased as VOR increased (Ludlow and others, 2015). In southeastern Alberta, Baird's Sparrow abundance was positively associated with percentage of dead grass cover and declined as bare ground cover increased to 40 percent, at which point Baird's Sparrow abundance increased; the positive increase at higher levels of bare ground cover may have been affected by three outlier data points (Rodgers and Koper, 2017). In southern Saskatchewan, abundance was not strongly correlated to any habitat variables within a moderately moist site, but abundance was positively correlated with litter depth and negatively correlated with bare ground cover and vertical heterogeneity in a more arid site with tame vegetation (Sutter, 1996). In a more arid site with native vegetation, abundance was positively correlated with litter cover and litter depth. In grazed mixed-grass prairies, numbers of Baird's Sparrows were positively correlated with litter cover, litter depth, and vertical vegetation density (Sutter and Brigham, 1998). Numbers of Baird's Sparrows were lower in areas with high maximum vegetation height than in areas with high litter depth and high number of plant contacts greater than (>) 10 cm tall. In crested wheatgrass fields, numbers of Baird's Sparrows were positively correlated with litter cover, litter depth, maximum vegetation height, and vertical vegetation density (Sutter and Brigham, 1998).

Numbers of Baird's Sparrows were negatively related to bare ground and vertical heterogeneity (extent of variation in vegetation height). In areas with native vegetation and crested wheatgrass, numbers of Baird's Sparrows were higher in areas with high litter cover than in areas with high bare ground cover (Sutter and Brigham, 1998). In another study in southern Saskatchewan, abundance was positively associated with litter depth and standing dead vegetation ≤10 cm tall (Anstey and others, 1995). Also in southern Saskatchewan, Baird's Sparrow abundance was positively associated with native grasslands characterized by increased cover of narrow-leaved, rhizomatous grasses; standing dead vegetation; and shrubs (Davis and others, 2016). Occurrence of Baird's Sparrows was positively associated with density of narrow-leaved grasses >20 cm tall (Davis and others, 1999) and negatively associated with broad-leaved grasses ≤10 cm tall (Anstey and others, 1995). In mixed-grass prairies, Davis (2003a, 2004) reported that occurrence of Baird's Sparrows was negatively related to the density of live grass 0–10 cm above the ground in 1 of 2 years. In southwestern Saskatchewan mixed-grass pastures, abundance of Baird's Sparrow was positively related to litter cover, litter depth, standing dead vegetation cover, and vegetation height and negatively related to exposed bare ground cover (White, 2009). In another southwestern Saskatchewan study, the relationship between Baird's Sparrow abundance and litter depth varied by site; abundances increased with vegetation height and grass cover in both study sites, but abundance was highest in areas where litter depth was about 9 mm in the northernmost site and 3 mm in the southernmost site (Kalyn Bogard and Davis, 2014). In another study in southwestern Saskatchewan mixed-grass pastures, Baird's Sparrow probability of occurrence increased with litter mass (kilograms per hectare) and vegetation height-density; abundance increased with litter mass and vegetation height-density, and decreased with coverage of bare ground (Henderson and Davis, 2014). Baird's Sparrow abundance increased sharply at 0.05 to 0.15 cubic centimeter (cm^3) vegetation height-density and then rose slowly thereafter to 0.6 cm^3 vegetation height-density. In upland mixed-grass prairies in Saskatchewan, Baird's Sparrow abundance was negatively related to increased bare ground cover (Molloy, 2014). In Saskatchewan and North Dakota, Baird's Sparrow densities were negatively correlated to vegetation height and density (Ahlering and others, 2009).

In northeastern Montana, Baird's Sparrow abundance was positively related to maximum vegetation height, litter depth, and several parameters measuring vegetation density (total vegetation, live, dead, <10 cm, 10–20 cm, >20 cm, and grass); abundance was negatively related to coverage of bare ground (Lipsey and Naugle, 2017). In northwestern North Dakota, occurrence decreased with VOR, dropping below 50 percent and 25 percent at 1.5 decimeters (dm) and 2–2.5 dm, respectively (Madden and others, 2000), and Baird's Sparrows occupied areas with significantly lower VOR than unoccupied areas (Madden, 1996). In another study in northwestern North Dakota, Baird's Sparrows were present in grasslands with higher litter depth and lower percentage of live vegetation than in unoccupied areas (Grant and others, 2004). Occurrence was not related to maximum vegetation height or year. Within grazed mixed-grass areas in northern and central North Dakota, abundance was negatively associated with litter depth, vegetation height-density, and vegetation density (Schneider, 1998). Among the strongest vegetational predictors of Baird's Sparrow presence were decreasing bare ground cover and decreasing litter depth. In South Dakota mixed-grass prairies, Baird's Sparrow occurrence was negatively associated with litter depth (Greer, 2009).

Baird's Sparrows prefer grasslands with little or no shrub cover (Dale, 1983; Arnold and Higgins, 1986; Madden, 1996; Jones and Green, 1998; Lipsey and Naugle, 2017), and shrub cover >25 percent may negatively affect habitat suitability (Sousa and McDonal, 1983). In Saskatchewan, abundance was negatively associated with shrubs ≤1 meter (m) tall (Anstey and others, 1995), and occurrence was positively associated with sparse shrub cover (Davis and others, 1999). Occurrence was negatively related to the density of shrubs in 1 of 2 years (Davis, 2003a, 2004). Within moderately grazed mixed-grass prairies in southcentral Saskatchewan, Bleho (2009) evaluated the relationship between Baird's Sparrow abundance and vegetation structure at the plot and pasture levels, whereby plots were circular areas of 100-m radii within pastures grazed season-long (June to October). Two measures of vegetation patchiness (that is, heterogeneity)—standard deviation (SD) and coefficient of variation (CV)—were evaluated. At the plot level, Baird's Sparrow abundance was positively associated with the CV-derived measure for patchiness of exposed moss and lichen (no species provided) coverage. Abundance at the plot level was negatively associated with percentage of shrub and bare ground cover, the SD-derived measure for patchiness of bare ground and shrub coverage, and the CV-derived measure for patchiness of vegetation height-density. At the pasture level, Baird's Sparrow abundance was not significantly related to any vegetation variables. In upland and lowland areas of mixed-grass prairies in Saskatchewan, Baird's Sparrow abundance was negatively related to shrub cover (Molloy, 2014).

In Manitoba, Baird's Sparrow densities were high in pastures with extensive shrub cover, but the species avoided dense shrub patches (De Smet and Conrad, 1991). In northeastern Montana, Baird's Sparrows abundance was negatively related to coverage of shrubs (Lipsey and Naugle, 2017). In North Dakota mixed-grass prairies, Grant and others (2004) classified the Baird's Sparrow as a woodland-sensitive species. Baird's Sparrows were present in grasslands with lower shrub cover >1 m tall and lower shrub cover no more than 1 m tall than in unoccupied areas. Baird's Sparrows were present in grasslands with no quaking aspen (*Populus tremuloides*) woodland within 100 m of vegetation points and with a lower percentage cover of aspen woodland within 500 m than in unoccupied areas. The species' maximum probability of occurrence never exceeded 50 percent within the study area, and the probability of occurrence declined to 20 percent at about 10 percent woodland cover (Grant and others, 2004).

In northwestern North Dakota, Baird's Sparrow occurrence decreased with increasing shrub cover, dropping below 50 percent and 10 percent probability of occurrence at 18 percent and 54 percent shrub cover, respectively (Madden and others, 2000). In northern and central North Dakota, abundance was negatively associated with density of low-growing shrubs (western snowberry [*Symphoricarpos occidentalis*] and silverberry [*Elaeagnus commutata*]) (Schneider, 1998). In a comparison of bird densities between shrubless transects and transects that were 30–80 percent shrubs in mixed-grass prairies in North Dakota, Baird's sparrows occurred only in the shrubless transects (Arnold and Higgins, 1986). In South Dakota mixed-grass prairies, Baird's Sparrow occurrence and male densities were negatively associated with shrub height (Greer, 2009). In a statewide study in North Dakota, Igl and others (2008) reported that the Baird's Sparrows avoided using areas with woody vegetation (defined as all native and artificially stocked tree and shrub stands).

Vegetation structure may affect Baird's Sparrow nest-site selection. Baird's Sparrow nest-site locations in mixed-grass pastures in Saskatchewan were positively related to vegetation height, the density of standing dead vegetation 10–20 cm above the ground, litter depth, and low percentage of bare ground cover (Davis, 2003a, 2005). Nests were placed at the base of or within vegetation clumps, particularly smooth brome (23 percent of 76 nests) and fringed sagewort (16 percent of 76 nests) (Davis and Sealy, 1998). In other Saskatchewan studies, Lusk (2009) and Pipher (2011) reported similar results as Davis (2003a, 2005) with Baird's Sparrow nest sites characterized by higher vegetation density and litter depth than the average available vegetation. In Alberta, Ludlow and others (2015) detected no relationship between nest success and percentage cover of crested wheatgrass. In northeastern Montana and southwestern North Dakota, Bernath-Plaisted and others (2019) found little support that vegetation structure affected Baird's Sparrow nest success; however, juvenile survival increased with increasing vegetation height. In Montana, Baird's Sparrow nest sites were in areas characterized by deeper litter and taller vegetation than randomly selected areas, whereas nest patches (that is, areas with 5 m of nests) were characterized by high grass and litter cover, high vertical vegetation density, and low bare ground and small clubmoss coverage (Dieni and Jones, 2003).

Spatial and temporal variation in precipitation and temperature may affect the occurrence and distribution of Baird's Sparrows. Baird's Sparrows utilize drier areas in unusually wet years and moister areas in dry years, alternating between mesic areas, such as sloughs or wet meadows, and upland grasslands (Lane, 1968; Salt and Wilk, 1976; Kantrud and Faanes, 1979; Faanes, 1982; De Smet and Conrad, 1991). Within native grasslands of southeastern Alberta, Wiens and others (2008) reported that the best model of Baird's Sparrow occurrence during years of average climatic conditions, but not during drought years, included a positive relationship with conserved soil moisture, which is an estimate of soil moisture on May 1 using a weighted combination of precipitation data from the previous 2 years. In a second study in southeastern Alberta mixed-grass prairies, daily nest survival of Baird's Sparrows was highest at intermediate temperatures; precipitation did not affect nest survival (Ludlow and others, 2014). In another study in southeastern Alberta, Baird's Sparrow occurrence was negatively related to a compound topographic index, indicating that the species selected more xeric grassland areas within a 400-m radius of point-count centers (Clements, 2014). The compound topographic index accounts for topographic features, including slope, flow accumulation and direction, and contributing area, to form a representation of the amount of soil moisture across the landscape. Baird's Sparrow occurrence also was negatively related to a heat-load index, indicating that the species was more likely to occupy areas exposed to less solar radiation (Clements, 2014). In Saskatchewan and North Dakota, spring-arrival densities of Baird's Sparrows were higher when the previous summer was cool and the winter had low snowfall (Ahlering and others, 2009). Densities were negatively related to the previous May–September minimum temperature and to October–April snowfall. Densities were not related to total precipitation, average May–September temperature, average May–September maximum temperature, or average Palmer Drought Severity Index (PDSI) (Ahlering and others, 2009). In northeastern Montana, Lipsey and Naugle (2017) reported that Baird's Sparrow abundance was positively related to the amount of precipitation in the preceding 2 years and negatively related to mean growing-season (April–September) temperature. In northeastern Montana and southwestern North Dakota, Bernath-Plaisted and others (2019) found little support that temperature and precipitation variables affected Baird's Sparrow nest success or juvenile survival. In western North Dakota, density of Baird's Sparrows declined during one of the most severe droughts on record but returned to average levels 1 year postdrought (George and others, 1992). Using two indices of regional moisture, the PDSI and the number of wetland basins containing water during annual May waterfowl surveys, Niemuth and others (2008) concluded that Baird's Sparrow dispersion (that is, percentage of 13 BBS routes in northern North Dakota on which the species was detected) was closely related to current-year PDSI values, but that abundance was not related to moisture indices.

In an assessment of BBS data for the conterminous United States, O'Connor and others (1999) reported a negative relationship between Baird's Sparrow abundance and mean annual precipitation. Using BBS data for four States that constitute the Badlands and Prairies Bird Conservation Region, Gorzo and others (2016) reported that Baird's Sparrow abundance was negatively related to a within-year standardized temperature index and positively to a within-year standardized precipitation index. Using a combination of BBS, eBird (https://www.ebird.org; Sullivan and others, 2009), and point-count data, Nixon and others (2016) modeled the impact of future climate change scenarios on Baird's Sparrow breeding distribution along the boreal forest–prairie ecotone in Alberta and predicted that the species would shift dramatically northward within the next

80 years, with limited potential for expansion of suitable breeding habitat and only small core areas of stable climate remaining. 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). Baird's Sparrows ranked high in vulnerability during the breeding and wintering seasons under all three scenarios. 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 Baird's Sparrow; Peterson (2003) estimated that Baird's Sparrows would experience breeding-range contraction and dramatic distributional movements under the two climate scenarios. Peña-Peniche and others (2018) indicated that Baird's Sparrows use different climatic conditions within the ecological niches of the breeding, migratory, and wintering seasons, and that changes in precipitation because of a changing climate may differentially affect vegetation cover and thus potential suitable habitat within each of these seasons

Area Requirements and Landscape Associations

Male breeding territories typically are 0.4–0.8 hectare (ha) and often are near territories of other Baird's Sparrow males (Lane, 1968). In Saskatchewan, two Baird's Sparrow territories were 0.3 and 0.6 ha in size (Lein, 1968). In North Dakota, male territory sizes ranged from 0.8 to 2.25 ha (Winter, 1999). In northern Montana, male Baird's Sparrow territories ranged from 0.1 to 1.1 ha, with a mean of 0.42 ha (Jones, 2011).

Baird's Sparrows typically are considered area sensitive, preferring larger grasslands over smaller grasslands (Ribic and others, 2009). In Alberta, Saskatchewan, and Manitoba, Baird's Sparrow presence was positively associated with field size (McMaster and Davis, 2001). In Saskatchewan, occurrence was positively associated with grassland area, and minimum area requirements were about 25 ha (Davis, 2003a, 2004). Occurrence was negatively related to edge-to-area ratio. In Saskatchewan mixed-grass prairies, Baird's Sparrow nest survival decreased with increasing patch size, although nest survival was more strongly affected by nest age and date (Davis and others, 2006). In another Saskatchewan study, Baird's Sparrows were positively associated with larger patches of dry, native mixed-grass pastures in a patchy landscape that included shrubs, trees, and tame pastures, but not to patch-related variables such as patch diversity, number of patches, and total edge length (Skinner, 2004). In CRP fields in nine counties in North Dakota, South Dakota, Minnesota, and Montana, Baird's Sparrows exhibited area sensitivity, favoring larger contiguous patches of grassland (Johnson and Igl, 2001). In logistic and linear regression models relating Baird's Sparrow occurrence, frequency, and density to area of contiguous grassland, grassland patch size was positively associated with Baird's Sparrow presence in two counties and with Baird's Sparrow density in two counties (Johnson and Igl, 2001). In contrast to the above studies, Youngberg and others (2020) reported that pioneering populations of Baird's Sparrows successfully fledged young in remnant shortgrass and mixed-grass prairies in Colorado.

At a landscape scale, the amount of grassland surrounding a grassland patch may affect Baird's Sparrow distribution and abundance. 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 Baird's Sparrows. The best model for predicting Baird's Sparrow occurrence indicated that the species preferred landscapes consisting of native and tame grassland and an abundance of wetland basins within 3,200 m; the model indicated avoidance of wooded landscapes within 3,200 m (Fedy and others, 2018). In Alberta, Manitoba, and Saskatchewan, Baird's Sparrows occurred more frequently in grasslands enrolled in the PCP that were surrounded by other grasslands than in PCP grasslands surrounded by cropland, wetland, woodland, or human residences (McMaster and Davis, 1998). In the dry mixed-grass prairie and northern fescue (*Festuca* species) grassland regions in southeastern Alberta, Baird's Sparrow occurrence was positively related to increasing grassland cover within a 400-m radius of point-count centers (Clements, 2014). In a study conducted in native and planted grasslands in Alberta and Saskatchewan, Davis and others (2013) examined the extent to which the amount and type of grassland in the surrounding landscape within 400 m of study plots affected the abundance of Baird's Sparrows. Baird's Sparrow abundance in native and tame grasslands increased with the amount of native grassland in the landscape, and the increase was more pronounced, although variable, on tame grasslands. In a Saskatchewan study in native and planted pastures and hayfields, Davis and others (2016) reported that Baird's Sparrow abundance increased with the amount of native grassland within 400 m of the study plots. In southern Saskatchewan hayfields, the number of pairs was not affected by amount of cropland or wetland within 1.6 kilometers (km) of study areas (McMaster and others 1999). In mixed-grass prairies in northeastern Montana, Lipsey (2015) evaluated grassland bird distribution and abundance at four spatial extents (0.7; 2.6; 93; and 1,492 square kilometers [km^2]). Baird's Sparrow densities were lower in landscapes with a low percentage of grassland than in landscapes with a high percentage of large and intact grasslands. Lipsey (2015) estimated that a 40,469-ha grassland embedded in a landscape comprised of 40 percent grass would support 6,600 Baird's Sparrows, whereas the same area embedded in a landscape comprised of 15 percent grass would support 2,400 Baird's Sparrows. In South Dakota mixed-grass prairies, Baird's Sparrow occurrence and male densities were positively associated with the amount of grassland at the 400- and 800-m scales from the survey points in the surrounding landscape (Greer, 2009).

Using point-count surveys collected over 4 years throughout the northwestern portion of the U.S. Great Plains, Dreitz and others (2017) demonstrated that Baird's Sparrow occupancy was positively related to latitude, lands in public ownership, and the percentage of grassland habitat within 1 km^2 of survey plots, and negatively related to percentage of sagebrush habitat. Using data from 16,728 point-count surveys in the northern portion of the U.S. Great Plains, Correll and others (2019) quantified the relationship between grassland habitat specialism and population trends; the authors determined that species with high specialism rankings, such as the Baird's Sparrow, are more likely to experience declining population trends. In the Prairie Pothole Region of North Dakota, Baird's Sparrow presence was positively associated with the amount of grassland and negatively associated with the amount of cropland within 200 and 400 m of survey points (Browder and others, 2002).

Brood Parasitism by Cowbirds and Other Species

Brown-headed Cowbird (*Molothrus ater*) brood parasitism of Baird's Sparrow nests is generally low to moderate. Published rates of cowbird brood parasitism for Baird's Sparrow are summarized in Shaffer and others (2019); parasitism rates varied from 0 percent of 11 nests (Maher, 1973) to 36 percent of 76 nests (Davis and Sealy, 1998). Historical anecdotal observations indicated that Baird's Sparrows were rare hosts, apparently because nests placed in open grasslands were inconspicuous to female Brown-headed Cowbirds (Lane, 1968). Baird's Sparrows may be multiply parasitized (Friedmann, 1963; Friedmann and Kiff, 1985; De Smet 1992; Saskatchewan Wetland Conservation Corporation, 1997; Davis and Sealy, 2000; Davis, 2003b; Lusk, 2009). Klippenstine and Sealy (2008) evaluated Baird's Sparrow's response to foreign eggs within their nests using real cowbird eggs and nonmimetic blue eggs; Baird's Sparrows accepted all real cowbird eggs but rejected 19 percent of 21 blue eggs.

Nest productivity may be negatively affected by cowbird brood parasitism. In Saskatchewan, parasitized nests had lower productivity than unparasitized nests (Davis and Sealy, 1998), and clutch size, number of host eggs hatched, number of host eggs incubated to full term that hatched, and number of host young fledged per successful nest were smaller in parasitized than unparasitized nests (Davis, 2003b). In Manitoba, the mean number of host young fledged from successful, unparasitized nests was higher than from successful, parasitized nests; cowbird parasitism cost Baird's Sparrows 1.4 host young per successful nest (Davis and Sealy, 2000). In Saskatchewan, distances 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.]).

Breeding-Season Phenology and Site Fidelity

Baird's Sparrows may arrive on the breeding grounds as early as late April, with the peak arrival occurring from early to mid-May (Lane, 1968; Maher, 1973; De Smet, 1992; Davis and Sealy, 1998; Jones and Green, 1998; Ahlering, 2005). Nesting occurs from late May through mid-August (Maher, 1973; Stewart, 1975; De Smet and Conrad, 1991; Davis and Sealy, 1998; Jones and Green, 1998; Jones and others, 2010; Bernath-Plaisted and others, 2019). Baird's Sparrow populations may be irruptive on the breeding grounds, and nesting densities shift as local habitat conditions change (Kantrud and Faanes, 1979; De Smet and Conrad, 1991; Wershler and others, 1991; Green, 1992).

Little information is available concerning double broodedness in the Baird's Sparrow. Although Cartwright and others (1937) reported that three of five pairs raised two broods, Lane (1968) suggested that there was low probability of second broods. However, other studies have noted two peaks in clutch initiation dates (late May–early June and mid- to late July), indicating that the species may be double-brooded (Maher, 1973; De Smet and Conrad, 1991; Davis and Sealy, 1998; Jones and others, 2010). One banded female in Manitoba successfully raised two broods in one season (Davis and Sealy, 1998). In mixed-grass prairies in northern Montana, between-year return rates of banded Baird's Sparrow over a 7-year period were 5.1 percent of 117 adult males and 0 percent of 103 birds banded as nestlings (Jones and others, 2007). In mixed-grass prairies in North Dakota and Saskatchewan, 9.6 percent of 52 color-banded adult males returned in the year after banding (Ahlering, 2005). Baird's Sparrows depart for the wintering grounds from mid-September to October (Maher, 1973; Jones and Green, 1998).

Species' Response to Management

To provide suitable habitat for Baird's Sparrows, grasslands need periodic disturbance such as burning, mowing, grazing, or combinations thereof; optimal frequency of disturbance varies regionally and with vegetative composition (Renken, 1983; Dale and others, 1997). In drier portions of the species' range, idle grasslands with moderate litter and minimal shrub cover can support high densities of breeding Baird's Sparrows (Maher, 1973; Owens and Myres, 1973; Renken, 1983; De Smet and Conrad, 1991; Sutter and others, 1995; Dale and others, 1997).

Natural and prescribed burns can improve habitat by maintaining native grass communities, reducing litter, and decreasing shrub encroachment. Vegetative structure, litter accumulation, and encroachment of woody vegetation are determined by prairie type and moisture conditions; fire treatment intervals should approximate historic fire-return intervals (Madden, 1996). Baird's Sparrows typically experience

declines in abundance during the first growing season postburn (Pylypec, 1991; Madden, 1996; Johnson, 1997; White, 2009), with populations recovering to or exceeding prefire levels in 1–5 years (Pylypec, 1991; Winter, 1994; Madden, 1996; Johnson, 1997; Richardson, 2012). In Saskatchewan mixed-grass prairies, White (2009) and Richardson (2012) evaluated the interaction between burning and grazing on Baird's Sparrow abundance over a 2–5-year period. Highest abundances occurred in the undisturbed treatments and lowest abundances in sites with both burning and grazing (Richardson and others, 2014). Trends over time did not differ between unburned-grazed and unburned-ungrazed sites, indicating that effects of grazing did not change over time. However, trends over time in burned sites differed from trends over time in unburned sites, such that by the fourth and fifth year postburn, most differences in Baird's Sparrow abundance between burned and unburned treatments had declined. In North Dakota, abundance was highest in grasslands that had been burned four times in the previous 15 years, compared to abundance in unburned areas and areas burned one to two times in the previous 15 years (Madden and others, 1999). Also in North Dakota, Baird's Sparrow densities were highest on areas burned four times during the previous 24 years (four-burn), compared to areas left idle (zero-burn) or burned twice (two-burn) during the same period (Winter, 1999). The species was absent from zero-burn areas and had lower numbers and larger territories in two-burn areas than in four-burn areas. Within four-burn areas, Baird's Sparrows were absent from areas where there was no litter. Densities of Baird's Sparrows in two- and four-burn plots were positively related to maximum and mean vegetation height. Baird's Sparrows preferred areas in which litter depth was >0 but ≤2 cm (Winter, 1994).

Effects of mowing on Baird's Sparrows depend on timing, frequency, vegetation type (native or tame), and amount of cover removal (B.C. Dale, Canadian Wildlife Service, Edmonton, Alberta, Canada, written commun. [n.d.]). Native hayland seems to be preferred to tame hayland (Kantrud, 1981; De Smet and Conrad, 1991), although mixed-grass areas dominated by rough fescue (*Festuca campestris*) were avoided 1 year after mowing in Alberta (Owens and Myres, 1973). Native hayland may be preferable to tame hayland because native grasslands usually are cut later in the season, and often only the densest portions of the field are cut, leaving some areas uncut each year (B.C. Dale, written commun. [n.d.]). In Alberta, however, native hayfields that were mowed and winter-grazed were avoided, probably because of removal of vegetation and litter (Mahon, 1995). In tame hayfields of alfalfa (*Medicago sativa*), smooth brome, and Kentucky bluegrass in Saskatchewan, Baird's Sparrows were more abundant in annually cut hayfields than hayfields cut every 3–8 years, presumably because annual mowing was necessary in tame grasses to prevent excess litter accumulation (Dale and others, 1997). In southern Saskatchewan, daily nest survival rates were lower in hayfields than in planted or native pastures (Davis and others, 2016). Baird's Sparrows fledged 0.9 and 1.4 fewer young per nest in planted pastures and hayfields, respectively, than in native pastures. The lower nest survival in hayfields was attributed to predation rather than mowing. Igl and Johnson (2016) assessed the effects of emergency and managed haying on grassland breeding birds in 483 CRP grasslands in nine counties in four States in the northern Great Plains between 1993 and 2008. Baird's Sparrow densities generally declined in CRP grasslands that had been hayed 1, 2, 3, and 4 years earlier than in CRP grasslands that had been idled for more than 5 years. Baird's Sparrows used hayland at least as often as pastures in North Dakota, Manitoba, and Saskatchewan (Kantrud, 1981; Davis, 1994; Davis and others, 1996). Other studies in southwestern Manitoba, however, documented greater use of pastures than hayland, with 50–55 percent of annual occurrences occurring in pastures, about 30 percent in hayland, and the remainder in idle areas or cropland (De Smet, 1991, 1992; De Smet and Conrad, 1991).

Heavy or continuous grazing that reduces residual vegetation and litter is detrimental in both moist and dry parts of the species' breeding range (Owens and Myres, 1973; Kantrud, 1981; Dale, 1983; De Smet and Conrad, 1991; Davis, 1994; Anstey and others, 1995; Sutter and others, 1995). In denser, taller habitats (such as moist mixed-grass prairies), or during wet years, low-to-moderate grazing can improve habitat by providing shorter, sparser vegetation (Kantrud, 1981; Dale, 1983; Renken, 1983; Messmer, 1990; Wershler and others, 1991; Anstey and others, 1995). Baird's Sparrow abundance declined during two dry summers in Saskatchewan (Dale, 1984). Baird's Sparrows were more abundant in the following breeding season after a moist winter and spring; new growth on grazed pastures was twice the height of the previous season's growth. De Smet and Conrad (1991) reported that Baird's Sparrows expanded their range and abundance in southern Manitoba during dry years. In grazed mixed-grass prairies in southern Saskatchewan, Baird's Sparrows were least abundant in sites characterized by low litter cover, and abundance increased with greater coverage of residual vegetation (Davis and others, 2014). Range condition (that is, visual estimates of rangeland integrity, including grazing use, plant vigor, and residual cover or carryover) affected Baird's Sparrow abundance at the pasture level, indicating that Baird's Sparrows may reach their highest abundances in pastures with range conditions categorized as high-good to low-excellent (Davis and others, 2014). In mixed-grass prairies in northeastern Montana, Lipsey and Naugle (2017) reported that Baird's Sparrow abundance was negatively related to the amount of biomass removed by grazing livestock. Models indicated that a 10-percent increase in biomass removed by cattle grazing would result in a 14-percent decrease in Baird's Sparrow abundance (Lipsey, 2015; Lipsey and Naugle, 2017). Baird's Sparrow abundance was affected by the relationship of cattle use and soil productivity in rangelands: high levels of use by cattle on high-productivity rangeland decreased the abundance of Baird's Sparrows. Cattle avoided using low-productivity grasslands, which had little potential as suitable Baird's Sparrow habitat at any level of cattle use. Baird's Sparrow abundance was also affected by the relationship between cattle use of rangeland and precipitation: cattle reduced herbaceous cover only when

precipitation in preceding years was low (<50 mm; considered a "dry" scenario), which reduced Baird's Sparrow abundance. In wetter conditions (>800 mm), the measured range of cattle use had little effect on herbaceous cover, and heavier cattle use under wet conditions was predicted to have no effect on Baird's Sparrow abundance (Lipsey and Naugle, 2017).

Grazing intensity, livestock type, and grazing system may influence the nesting success and abundance of Baird's Sparrows. In a meta-analysis of grazing studies in the Prairie Provinces of Canada, Bleho and others (2014) concluded that Baird's Sparrow nest survival and probability of nests not being depredated were significantly higher in moderately grazed pastures (that is, 33–65 percent of available forage utilized) than currently ungrazed pastures. In a series of phased studies conducted in the mixed-grass prairies of the Grasslands National Park in southwestern Saskatchewan, the effects of cattle grazing on nest success and abundance were examined (Bleho, 2009; Lusk and Koper, 2013; Molloy, 2014; Sliwinski and Koper, 2015; Pipher and others, 2016; Fischer and others, 2020). Depending on the particular study question, at various times between 2006 and 2012 avian nest success, avian abundance, and vegetation were measured for 2 years prior to the reintroduction of cattle, for the 4 years after cattle were grazed at stocking rates varying from very low (0.25 animal unit month [AUM] per ha) to very high (0.83 AUM per ha), and for 3 years after cattle were removed from pastures. Pasture units contained upland and lowland portions in which upland areas were dominated by perennial graminoids and lowland areas were characterized by having more shrubs and taller forbs than upland areas. Molloy (2014), Sliwinski and Koper (2015), Pipher and others (2016), and Fischer and others (2020) further included ungrazed control pastures to implement a before-after control-impact study. Bleho (2009), Lusk and Koper (2013), Molloy (2014), and Pipher and others (2016) included additional pasture units in the lightly to moderately grazed (0.25 to 0.55 AUM per ha) Mankato Community Pastures adjacent to Grasslands National Park. Lusk and Koper (2013) reported that Baird's Sparrow nest success was not affected by stocking rates in either year of a 2-year study, whereas Pipher and others (2016) determined that nest success was not affected by the number of years that a site had been grazed or by stocking rate. Bleho (2009) reported that Baird's Sparrow abundance was 1.22 times higher in ungrazed than grazed pastures, 1.38 times higher in upland than lowland pastures, and 1.31 times more abundant in ungrazed lowland pastures than grazed lowland pastures. In upland pastures, Molloy (2014) reported that Baird's Sparrow abundance declined at even low (below 0.3 AUM per ha) grazing intensities. In lowland pastures, Baird's Sparrows also exhibited a negative effect of stocking rate (Molloy, 2014). Sliwinski and Koper (2015) reported Baird's Sparrow abundance was higher in ungrazed pastures than grazed pastures and decreased with increased grazing intensity. Baird's Sparrow abundance was unaffected by stocking rate within the first month that cattle were reintroduced to pastures after an absence of 16–21 years, but abundance declined after the first and second years of grazing. Pastures with the highest stocking rates had 3 and 4 fewer Baird's Sparrows per pasture after 1 and 2 years of grazing, respectively (Sliwinski and Koper, 2015). Fischer and others (2020) reported high variability in the response of Baird's Sparrows to stocking rate, with highest abundances occurring on control pastures and pastures with the highest stocking rates. This effect disappeared after 1 year of rest from grazing but was again detectable after 2 years of rest. On lowland sites, the abundance of Baird's Sparrows declined as stocking rate increased, but abundances returned to pregrazing levels after 1 year of rest. Fischer and others (2020) attributed the variable response to grazing to average and above-average precipitation levels and cautioned that these conditions likely increased plant biomass production, making all pastures suitable for Baird's Sparrows and masking the species' response to stocking rates during the first year of rest.

In other research conducted on grazing intensity, Mahon (1995), who worked in southwestern Alberta, reported that grazing at stocking rates of 0.32–0.41 AUM per ha provided suitable habitat for Baird's Sparrows in pastures dominated by rough fescue or crested wheatgrass-alfalfa. Salo and others (2004) reported that Baird's Sparrows in mixed-grass prairies in central North Dakota occurred only in moderately grazed pastures (defined as 50 percent of forage produced in an average year remaining, equating to an average grazing rate of 2.4 AUMs per ha) that were characterized by tall and dense grassland habitat and did not occur in lightly, heavily, or extremely grazed pastures.

Upon examination of the effect of cattle and American bison (*Bison bison*) grazing on the abundance of Baird's Sparrows in Saskatchewan, Sliwinski (2011) concluded that Baird's Sparrow abundance was higher in currently ungrazed pastures and decreased with increased grazing intensity; declines were more severe in bison-grazed pastures than in cattle-grazed pastures. A cattle stocking rate of 0.4 AUM per ha was identified as the ecological threshold at which Baird's Sparrows began to decline in abundance (Sliwinski, 2011). In mixed-grass prairies in the Little Missouri National Grassland in western North Dakota, Lueders and others (2006) reported that densities of Baird's Sparrow were higher in cattle-grazed plots than periodically burned bison-grazed plots; bison plots contained more shrubs, which Baird's Sparrows tended to avoid. In that same study, Baird's Sparrow densities did not change with distance from cattle water developments, despite increases in vegetation height-density and litter depth associated with reduced grazing pressure (Fontaine and others, 2004).

Grazing systems that result in range conditions of moderate vegetative and litter cover will provide optimal habitat for Baird's Sparrows (Anstey and others, 1995; Mahon, 1995). Kantrud and Kologiski (1982) indicated that optimum habitat in the northern Great Plains for the Baird's Sparrow includes lightly grazed grasslands on typic boroll soils. Rotational grazing systems in North Dakota may support higher numbers of Baird's Sparrows than other grazing systems (for example, season-long grazed, short-duration) (Messmer, 1990). However, in Alberta, frequency of Baird's Sparrow occurrence did not

significantly differ between four grazing treatments: early-season tame (grazed from late April to mid-June), early-season native (grazed in early summer), deferred-grazed native (grazed after July 15), and season-long grazed native (Prescott and Wagner, 1996). In mixed-grass prairies in North Dakota, frequency of occurrence of male Baird's Sparrows was similar in plots that were prescribe-burned only and plots that 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 period between grazing treatments) (Danley and others, 2004).

There is little information on Baird's Sparrow use of cropland areas. In Alberta, Baird's Sparrows occurred in minimum-tillage fields but not in conventional-tillage fields, and no evidence of reproductive success was found in any cropland type (Martin and Forsyth, 2003). In southern Alberta, Baird's Sparrow numbers increased by at least 0.3 individual per point count per km away from cropland and forage fields (Koper and Schmiegelow, 2006). In another Alberta study, Sliwinski and Koper (2012) reported that Baird's Sparrows exhibited a spatially nonlinear response to distance to cropland edges, and the species neither consistently avoided nor was attracted to cropland edges. Abundance declined by 25 percent within 0.5 km of a cropland edge. In the northern Great Plains, Baird's Sparrow density within CRP fields was higher than those within cropland (Johnson and Schwartz, 1993; Johnson and Igl, 1995). Johnson and Igl (1995) estimated that the North Dakota population of Baird's Sparrows would decline by 3.6 percent if CRP grasslands in the State reverted back to cropland. In Alberta, Saskatchewan, and Manitoba, Baird's Sparrows were more common in grasslands enrolled in the PCP than in cropland; frequency of occurrence was higher in hayed PCP fields than in grazed PCP fields (McMaster and Davis, 2001). In a statewide study in North Dakota, Igl and others (2008) recorded low densities of Baird's Sparrows in land used to produce annual field crops, land under summer fallow, and land cleared for annual field crops.

Pesticides may have deleterious effects on Baird's Sparrows. In Alberta, plots sprayed with carbofuran (application rate of 132 grams [g] active ingredient per ha) to control grasshopper (Acrididae) infestations had fewer Baird's Sparrow productive territories (defined as having evidence of young, either in nest or fledged, based on a behavioral reproductive index) and a greater number of abandoned territories than control plots or plots sprayed with deltamethrin (6.25 g active ingredient per ha) (Martin and others, 2000). In recent years, several studies have evaluated the use of reproductive indices, such as the one used by Martin and others (2000), 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). Results from Martin and others (2000) related to productivity should be evaluated within the context and caveats of the growing body of literature on this topic.

Several studies have evaluated Baird's Sparrow response to roads and trails and reported a generally negative response to roads, trails, or both (Koper and Schmiegelow, 2006; Sliwinski and Koper, 2012; Wellicome and others, 2014; Ludlow and others, 2015; Nenninger and Koper, 2018). Ludlow and others (2015) reported that the species avoided nesting within 100 m of gravel roads and trails and fledged fewer young from successful nests near trails, although distance to gravel roads did not affect Baird's Sparrow density or overall reproductive success. No relationship was found between frequency of brood parasitism and distance to gravel roads or trails. Kalyn Bogard (2011) determined that Baird's Sparrow abundance was negatively associated with trail area. Trails were associated with shorter vegetation because of mowing and vehicular traffic. Koper and Schmiegelow (2006), Sliwinski and Koper (2012), and Nenninger and Koper (2018) reported that Baird's Sparrow abundance and density increased as distance to roads and wetland edges increased. Avoidance was detected at distances as much as 0.8 km from roads, but this distance was an underestimate because the species' response did not reach an asymptote (Sliwinski and Koper, 2012). Baird's Sparrow abundance was more than 16 times lower on roadside point counts (mean abundance 0.009 bird per point count) than on off-road point counts (that is, 800 m from the nearest roadside count; 0.147 bird per point count) (Wellicome and others, 2014). Sutter and others (2000) determined that Baird's Sparrows were less abundant in grasslands alongside roads (that is, traveling surfaces with adjacent drainage ditches planted to smooth brome and ending with a fence 11–18 m from the traveling surface) than in grasslands alongside trails (that is, single pair of wheel ruts visually indistinct from surrounding habitat in terms of plant structure and composition). In mixed-grass prairies in western North Dakota, Baird's Sparrow densities decreased with increasing density of roads (Chepulis, 2016).

Several studies in Alberta and Saskatchewan have examined the effect of energy development on Baird's Sparrows and reported that the species exhibited no response or a negative response (Linnen, 2008; Dale and others, 2009; Ludlow and others, 2015; Nenninger and Koper, 2018). In Alberta, Dale and others (2009) determined that Baird's Sparrow abundance decreased as well density increased. An increase in well density from four wells per 2.59 km^2 to 16 wells per km^2 would result in an estimated 73 percent decrease in Baird's Sparrow abundance. In the same study area, Linnen (2008) reported significant increases in the relative abundance of Baird's Sparrows 450 m from oil wells and associated roads relative to 50, 150, 250, or 450 m. Ludlow and others (2015) concluded that the distance from Baird's Sparrow nests to oil and gas wells did not differ from random locations, and no effect of well proximity on nest survival was detected. Rodgers (2013) and Rodgers and Koper (2017) reported that Baird's Sparrow abundance was unaffected by gas-well proximity and density, whereas Nenninger and Koper (2018) reported that Baird's Sparrow abundance was three times greater at control sites than at sites centered around oil infrastructure. Baird's Sparrow density increased with distance to well type, by 2.2 times when 400 m from pumpjacks

and 1.6 times when 400 m from screwpumps. Power source also affected Baird's Sparrow density, as density was more than three times higher on control sites than on generator-powered well sites and five times higher on control sites than on grid-powered well sites. Sites with generator-powered wells had nearly three times more Baird's Sparrows than grid-powered wells. Baird's Sparrow density increased with distance to power source: by 56 percent when 400 m away from generator-powered wells and 2.8 times when 400 m from grid-powered wells. Abundance of Baird's Sparrows did not differ between sites with active wells and sites with inactive wells (Nenninger and Koper, 2018). In Saskatchewan, Baird's Sparrows tended to avoid minimal-disturbance gas wells and associated trails, although the results were not significant (Linnen, 2008). In a 2-year study in native pastures in southwestern Saskatchewan, abundance of Baird's Sparrows was unaffected by proximity or density of natural gas wells (Kalyn Bogard and Davis, 2014). In mixed-grass prairies in northwestern North Dakota, Baird's Sparrow densities were lower within at least 550 m of single-bore unconventional oil wells than on control sites (Thompson and others, 2015). In mixed-grass prairies in western North Dakota, Baird's Sparrow densities were unrelated to density of unconventional oil wells within 1.6 km of study plot boundaries (Chepulis, 2016). Using BBS data, Bohannon and Blinnikov (2019) reported no relationship between Baird's Sparrow abundance and habitat fragmentation in western North Dakota and eastern Montana caused by oil-extraction activities, but acknowledged limitations owing to low sample size and characteristics of the BBS dataset. Curry and others (2018) evaluated the vocal response of Baird's Sparrows to the simulated noise of the drilling of oil wells and reported that the species altered its song in the presence of the noise. 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 Baird's Sparrow scored a 2.14 out of nine, where nine indicated high risk; 0.58 percent of the Baird's Sparrow breeding population in the United States was estimated to be exposed to wind facilities.

Management Recommendations from the Literature

Protecting native grasslands occupied by Baird's Sparrows is important in maintaining the species' population, as is establishing additional suitable grasslands (Winter, 1994; Anstey and others, 1995; Mahon, 1995; Skinner, 2004; Greer, 2009; Sliwinski and Koper, 2012; Davis and others, 2016). The protection of large grasslands is especially important, given the species' area sensitivity (Ribic and others, 2009). Protecting dry and wet habitats (for example, wet meadows and mesic grasslands) provides alternative breeding sites during droughts or wet periods, even if sites are not used every year (Wershler and others, 1991; Johnson, 1996). Landscapes of primarily grassland habitats contribute to increasing populations of Baird's Sparrows (McMaster and Davis, 1998; Skinner and Clark, 2008; Greer, 2009; Davis and others, 2013).

Maintaining vegetative diversity (scattered forbs, a mixture of grass heights, and patches of litter-covered ground) within grasslands is important to Baird's Sparrows (Winter, 1994; Mahon, 1995), as is the prevention of woody vegetation encroachment. In grassland areas that have been heavily invaded by woody vegetation, Grant and others (2004) suggested that managers focus initial restoration efforts on grasslands with <20 percent woodland encroachment because these grasslands would have the most immediate and lasting conservation benefit for grassland birds. Programs that encourage the planting of trees and tall shrubs within grasslands should be discouraged (Grant and others, 2004). Prescribed burning, mowing, and grazing can be used to maintain the early successional stage preferred by Baird's Sparrows, including moderately deep litter and low shrub cover (Berkey and others, 1993; Winter, 1994; Madden, 1996; Johnson, 1997). Timing and type of management must be adjusted according to local and regional conditions (soil types, climate, vegetation types) and annual precipitation (Madden, 1996; Jones and Green, 1998).

The use of prescribed burns may be necessary to sustain Baird's Sparrow populations in the eastern part of its range in mixed-grass prairies, but this is not necessarily the case in the western portion of the breeding range (Winter, 1999). Burning large areas on a rotational basis, burning portions of the total area each year, and burning small areas periodically all are useful approaches (Renken, 1983; Renken and Dinsmore, 1987; Johnson, 1997). Ensuring that adjacent areas are burned in different years helps to create a variety of successional stages (Madden, 1996; Johnson, 1997), as does treating small, isolated areas as part of a larger mosaic (Renken, 1983; Renken and Dinsmore, 1987; Madden, 1996; Johnson, 1997). Using management treatment intervals that approximate the historic fire-return intervals for the region is encouraged (Madden, 1996). For example, suggested intervals are 3–4 years in tallgrass prairies; 4 years in sandhill prairies; 6 years in northern mixed-grass prairies; 5–10 years in shortgrass prairies; and as many as 25 years in dry, western mixed-grass prairies (Madden, 1996).

When possible (for example, on Federal lands or through cooperation with private landowners), delaying the mowing of hayfields until mid-July or August may allow many birds to raise at least one brood in years with normal breeding phenology; mowing should be delayed further if nesting is delayed by inclement spring weather (Mahon, 1995; Dale and others, 1997). When mowing must be done during the breeding season, one suggestion is to mow one-half of each field every other year to provide refuge for fledglings (Dale and others, 1997).

Managing stocking rates to achieve optimal grazing intensity for Baird's Sparrows depends on factors such as grassland type, interannual variability in precipitation levels, and soil productivity (Sliwinski and Koper, 2015; Lipsey and Naugle, 2017). Low-to-moderate grazing is compatible with the habitat needs of Baird's Sparrows, but overgrazing should be avoided (Messmer, 1990; Berkey and others, 1993;

Mahon, 1995). In the northern mixed-grass prairies of Saskatchewan, maintaining stocking rates below about 0.4 AUM per ha may not negatively affect Baird's Sparrow abundance (Mahon, 1995; Sliwinski, 2011) or nest survival (Lusk and Koper, 2013; Pipher and others, 2016). However, Sliwinski and Koper (2015) cautioned that any level of livestock grazing has the potential to negatively affect Baird's Sparrow abundance, whereas any reduction in stocking rate would likely be beneficial. Fischer and others (2020) reported that, under conditions of average and above-average precipitation, Baird's Sparrows could tolerate high stocking rates but cautioned that continuous application of high stocking rates could harbor a transition to irreversible and possibly undesirable plant communities. Fischer and others (2020) suggested that grazing at lower stocking rates and allowing for periods of rest from grazing would better allow grasslands to recover from grazing effects.

To benefit a suite of grassland birds that include Baird's Sparrows, Sliwinski and Koper (2015) and Pipher and others (2016) recommended that land managers use stocking rates to increase heterogeneity in vegetation structure, which can be achieved by using low stocking rates or rest on some pastures and heavy stocking rates on others; the specific stocking rates used will depend on the region and precipitation within a given year. Lipsey and Naugle (2017) suggested that land managers evaluate current cover conditions and provide the cover most limiting for birds at the time of evaluation. Salo and others (2004) recognized that Baird's Sparrow densities were higher in moderately grazed pastures than in lightly grazed, heavily grazed, or extremely heavily grazed pastures, but that grasslands grazed at low-to-moderate rates had greater biomass reserves that benefitted the suite of grassland bird species while maintaining acceptable daily rates of gain for individual cattle. The suite of grassland bird species was best maintained on average at 2.4 AUMs per ha, whereas livestock production and economic benefits to operators were best achieved on average at stocking rates from 2.4 to 4.2 AUMs per ha, adjusted for annual precipitation and soil moisture reserves (Salo and others, 2004).

Within northern mixed-grass prairies, rotational grazing systems may not confer greater advantages, in terms of bird productivity or vegetation structure, than continuous grazing systems (Prescott and Wagner, 1996; Danley and others, 2004; Bleho and others, 2014). As with stocking rate, the effect on vegetation of abiotic factors such as interannual variability in precipitation levels and soil type may be as important in governing the abundance and distribution of bird species as grazing system (Lipsey and Naugle, 2017; Bleho and others, 2014). Bleho and others (2014) cautioned that grazing systems that produce uniform vegetation structure may produce unfavorable habitat conditions. Davis and others (2014) recommended that greater effort be taken to improving range condition in pastures categorized as low-to-fair and in maintaining pastures in good condition, rather than focusing on grazing systems.

To lessen the negative effects of natural gas and oil development on Baird's Sparrows, Ludlow and others (2015) recommended creating fewer trails associated with future oil and gas developments, using directional drilling of multiple wells from one lease site, and minimizing the spread of crested wheatgrass in native grasslands. Thompson and others (2015) also identified minimizing the footprint of oil development by clustering oil wells along corridors and on multi-bore pads rather than placing numerous single-bore well pads throughout the landscape. Nenninger and Koper (2018) advocated for the minimization of unnecessary aboveground infrastructure and roads. Examples of mitigation include burying power distribution lines, dismantling and reclaiming inoperative oil wells, and horizontally drilling of new wells from existing wells.

References

Ahlering, M.A., 2005, Settlement cues and resource use by Grasshopper Sparrows and Baird's sparrows in the Upper Great Plains: Columbia, Mo., University of Missouri, Ph.D. Dissertation, 179 p.

Ahlering, M.A., Johnson, D.H., and Faaborg, J., 2009, Factors associated with arrival densities of Grasshopper Sparrow (*Ammodramus savannarum*) and Baird's Sparrow (*A. bairdii*) in the upper Great Plains: The Auk, v. 126, no. 4, p. 799–808. [Also available at https://doi.org/10.1525/auk.2009.08154.]

Althoff, D., Gipson, P., Pontius, J., and Japuntich, R., 2009, Evaluation of a reproductive index to estimate Grasshopper Sparrow and Eastern Meadowlark reproductive success: Wildlife Biology in Practice, v. 5, no. 1, p. 33–44.

Anstey, D.A., Davis, S.K., Duncan, D.C., and Skeel, M., 1995, Distribution and habitat requirements of eight grassland songbird species in southern Saskatchewan: Regina, Saskatchewan, Saskatchewan Wetland Conservation Corporation, 11 p.

Arnold, T.W., and Higgins, K.F., 1986, Effects of shrub coverages on birds of North Dakota mixed-grass prairies: Canadian Field-Naturalist, v. 100, no. 1, p. 10–14.

Berkey, G., Crawford, R., Galipeau, S., Johnson, D., Lambeth, D., and Kreil, R., 1993, A review of wildlife management practices in North Dakota—Effects on nongame bird populations and habitats: Denver, Colo., U.S. Fish and Wildlife Service, Report submitted to Region 6, 51 p.

Bernath-Plaisted, J., Correll, M.D., Guido, N.A., and Panjabi, A.O., 2019, Demographic monitoring of breeding grassland songbirds in the northern Great Plains: Brighton, Colo., Bird Conservancy of the Rockies, 2018 Annual Report, 51 p., accessed February 2020 at https://birdconservancy.org/wp-content/uploads/2019/03/2018_Demographic_Monitoring_NGP_Annual_Report.pdf.

Beston, J.A., Diffendorfer, J.E., Loss, S.R., and Johnson, D.H., 2016, Prioritizing avian species for their risk of population-level consequences from wind energy development: PLoS One, v. 11, no. 3, p. e0150813. [Also available at https://doi.org/10.1371/journal.pone.0150813.]

Bleho, B., 2009, Passerine relationship with habitat heterogeneity and grazing at multiple scales in northern mixed-grass prairie: Winnipeg, Manitoba, University of Manitoba, Master's Thesis, 124 p.

Bleho, B.I., Koper, N., and Machtans, C.S., 2014, Direct effects of cattle on grassland birds in Canada: Conservation Biology, v. 28, no. 3, p. 724–734. [Also available at https://dx.doi.org/10.1111/cobi.12259.]

Bohannon, R., and Blinnikov, M., 2019, Habitat fragmentation and breeding bird populations in western North Dakota after the introduction of hydraulic fracturing: Annals of the American Association of Geographers, v. 109, no. 5, p. 1471–1492. [Also available at https://doi.org/10.1080/24694452.2019.1570836.]

Browder, S.F., Johnson, D.H., and Ball, I.J., 2002, Assemblages of breeding birds as indicators of grassland condition: Ecological Indicators, v. 2, no. 3, p. 257–270. [Also available at https://doi.org/10.1016/S1470-160X(02)00060-2.]

Cartwright, B.W., Short, T.M., and Harris, R.D., 1937, Baird's Sparrow: Transactions of the Royal Canadian Institute, v. 46, p. 153–198.

Chepulis, B.J., 2016, Grassland bird response to landscape-level and site-specific variables in the Little Missouri National Grassland: Fargo, N. Dak, North Dakota State University, Master's Thesis, 139 p.

Chesser, R.T., Burns, K.J., Cicero, C., Dunn, J.L., Kratter, A.W., Lovette, I.J., Rasmussen, P.C., Remsen, J.V., Jr., Stotz, D.F., Winger, B.M., and Winker, K., 2018, Fifty-ninth supplement to the American Ornithological Society's Check-list of North American Birds: The Auk, v. 135, no. 3, p. 798–813. [Also available at https://doi.org/10.1642/AUK-18-62.1.]

Clements, N.D., 2014, Using occupancy models to predict grassland bird distributions in southeastern Alberta: Regina, Saskatchewan, University of Regina, Master's Thesis, 122 p.

Correll, M.D., Strasser, E.H., Green, A.W., and Panjabi, A.O., 2019, Quantifying specialist avifaunal decline in grassland birds of the northern Great Plains: Ecosphere, v. 10, no. 1, p. e02523. [Also available at https://dx.doi.org/10.1002/ecs2.2523.]

Curry, C.M., Antze, B., Warrington, M.H., Des Brisay, P., Rosa, P., and Koper, N., 2018, Ability to alter song in two grassland songbirds exposed to simulated anthropogenic noise is not related to pre-existing variability: Bioacoustics, v. 27, no. 2, p. 105–130. [Also available at https://dx.doi.org/10.1080/09524622.2017.1289123.]

Dale, B., 1992, North American waterfowl management plan implementation program related to non-game studies within the Prairie Habitat Joint Venture area, Annual report 1991–1992: Saskatoon, Saskatchewan, Canadian Wildlife Service, 66 p.

Dale, B.C., 1983, Habitat relationships of seven species of passerine birds at Last Mountain Lake, Saskatchewan: Regina, Saskatchewan, University of Regina, Master's Thesis, 119 p.

Dale, B.C., 1984, Birds of grazed and ungrazed grasslands in Saskatchewan: Blue Jay, v. 42, no. 2, p. 102–105.

Dale, B.C., Martin, P.A., and Taylor, P.S., 1997, Effects of hay management regimes on grassland songbirds in Saskatchewan: Wildlife Society Bulletin, v. 25, no. 3, p. 616–626.

Dale, B.C., Wiens, T.S., and Hamilton, L.E., 2009, Abundance of three grassland songbirds in an area of natural gas infill drilling in Alberta, Canada, *in* Rich, T.D., Arizmendi, C., Demarest, D.W., and Thompson, C., eds., Proceedings of the fourth International Partners in Flight Conference—Tundra to Tropics: McAllen, Tex., Partners in Flight, p. 194–204.

Danley, R.F., Murphy, R.K., Madden, E.M., and Smith, K.A., 2004, Species diversity and habitat of grassland passerines during grazing of a prescribe-burned, mixed-grass prairie: Western North American Naturalist, v. 64, no. 1, p. 72–77.

Davis, S.K., 1994, Cowbird parasitism, predation and host selection in fragmented grasslands of southwestern Manitoba: Winnipeg, Manitoba, University of Manitoba, Master's Thesis, 77 p.

Davis, S.K., 2003a, Habitat selection and demography of mixed-grass prairie songbirds in a fragmented landscape: Regina, Saskatchewan, University of Regina, Ph.D. Dissertation, 131 p.

Davis, S.K., 2003b, Nesting ecology of mixed-grass prairie songbirds in southern Saskatchewan: The Wilson Bulletin, v. 115, no. 2, p. 119–130. [Also available at https://dx.doi.org/10.1676/02-138.]

Davis, S.K., 2004, Area sensitivity in grassland passerines—Effects of patch size, patch shape, and vegetation structure on bird abundance and occurrence in southern Saskatchewan: The Auk, v. 121, no. 4, p. 1130–1145.

Davis, S.K., 2005, Nest-site selection patterns and the influence of vegetation on nest survival of mixed-grass prairie passerines: The Condor, v. 107, no. 3, p. 605–616. [Also available at https://dx.doi.org/10.1650/0010-5422(2005)107%5B0605:NSPATI%5D2.0.CO;2.]

Davis, S.K., Brigham, R.M., Shaffer, T.L., and James, P.C., 2006, Mixed-grass prairie passerines exhibit weak and variable responses to patch size: The Auk, v. 123, no. 3, p. 807–821. [Also available at https://dx.doi.org/10.1642/0004-8038(2006)123%5B807:MPPEWA%5D2.0.CO;2.]

Davis, S.K., Dale, B.C., Harrison, T., and Duncan, D.C., 2014, Response of grassland songbirds to grazing system type and range condition, *in* Jacques, C.N., ed., Celebrating our prairie heritage—Proceedings of the twenty-third North American Prairie Conference: Winnipeg, Manitoba, University of Manitoba, p. 110–119.

Davis, S.K., and Duncan, D.C., 1999, Grassland songbird occurrence in native and crested wheatgrass pastures of southern Saskatchewan, *in* Vickery, P.D., and Herkert, J.R., eds., Ecology and conservation of grassland birds of the Western Hemisphere: Studies in Avian Biology, v. 19, p. 211–218.

Davis, S.K., Duncan, D.C., and Skeel, M., 1999, Distribution and habitat associations of three endemic grassland songbirds in southern Saskatchewan: The Wilson Bulletin, v. 111, no. 3, p. 389–396.

Davis, S.K., Duncan, D.C., and Skeel, M.A., 1996, The Baird's Sparrow—Status resolved: Blue Jay, v. 54, no. 4, p. 185–191.

Davis, S.K., Fisher, R.J., Skinner, S.L., Shaffer, T.L., and Brigham, R.M., 2013, Songbird abundance in native and planted grassland varies with type and amount of grassland in the surrounding landscape: The Journal of Wildlife Management, v. 77, no. 5, p. 908–919. [Also available at https://dx.doi.org/10.1002/jwmg.537.]

Davis, S.K., Ludlow, S.M., and McMaster, D.G., 2016, Reproductive success of songbirds and waterfowl in native mixed-grass pasture and planted grasslands used for pasture and hay: The Condor, v. 118, no. 4, p. 815–834. [Also available at https://dx.doi.org/10.1650/CONDOR-16-16.1.]

Davis, S.K., and Sealy, S.G., 1998, Nesting biology of Baird's Sparrows in southwestern Manitoba: The Wilson Bulletin, v. 110, no. 2, p. 262–270.

Davis, S.K., and Sealy, S.G., 2000, Cowbird parasitism and nest predation in fragmented grasslands of southwestern Manitoba, *in* Smith, J.N.M., Cook, T.L., Rothstein, S.I., Robinson, S.K., and Sealy, S.G., eds., Ecology and management of cowbirds and their hosts: Austin, Tex., University of Texas Press, p. 220–228.

De Smet, K.D., 1991, Manitoba's threatened and endangered grassland birds, 1990 update: Winnipeg, Manitoba, Manitoba Natural Resources, Manuscript report 91–09, 47p.

De Smet, K.D., 1992, Manitoba's threatened and endangered grassland birds—1991 update and five-year summary: Winnipeg, Manitoba, Manitoba Natural Resources, Manuscript report 92–03, 77 p.

De Smet, K.D., and Conrad, M.P., 1991, Management and research needs for Baird's Sparrows and other grassland species in Manitoba, *in* Holroyd, G.L., Burns, G., and Smith, H.C., eds., Proceedings of the second endangered species and prairie conservation workshop: Edmonton, Alberta, Provincial Museum of Alberta, Natural History Occasional Paper, no. 15, p. 83–86.

Dieni, J.S., and Jones, S.L., 2003, Grassland songbird nest site selection patterns in northcentral Montana: The Wilson Bulletin, v. 115, no. 4, p. 388–396. [Also available at https://dx.doi.org/10.1676/03-055.]

Dreitz, V.J., Stinson, L.T., Hahn, B.A., Tack, J.D., and Lukacs, P.M., 2017, A large-scale perspective for managing prairie avifauna assemblages across the western US—Influences of habitat, land ownership and latitude: PeerJ, v. 5, p. e2879. [Also available at https://doi.org/10.7717/peerj.2879.]

Faanes, C.A., 1982, Avian use of Sheyenne Lake and associated habitats in central North Dakota: Washington, D.C., Department of the Interior, U.S. Fish and Wildlife Service, Resource Publication, no. 144, 24 p.

Fedy, B., Devries, J.H., Howerter, D.W., and Row, J.R., 2018, Distribution of priority grassland bird habitats in the Prairie Pothole Region of Canada: Avian Conservation and Ecology, v. 13, no. 1, article 4. [Also available at https://doi.org/10.5751/ACE-01143-130104.]

Fischer, S, Henderson, D.C., and Koper, N., 2020, A resilient system—North American mixed-grass prairie responds to livestock exclusion: Biological Conservation, v. 243. [Also available at https://doi.org/10.1016/j.biocon.2020.108453.]

Fontaine, A.L., Kennedy, P.L., and Johnson, D.H., 2004, Effects of distance from cattle water developments on grassland birds: Journal of Range Management, v. 57, no. 3, p. 238–242. [Also available at https://dx.doi.org/10.2307/4003790.]

Friedmann, H., 1963, Host relations of the parasitic cowbirds: Washington, D.C., Smithsonian Institution, U.S. National Museum, Bulletin 233, 276 p. [Also available at https://dx.doi.org/10.5479/si.03629236.233.]

Friedmann, H., and Kiff, L.F., 1985, The parasitic cowbirds and their hosts: Proceedings of the Western Foundation of Vertebrate Zoology, v. 2, no. 4, p. 226–304.

George, T.L., Fowler, A.C., Knight, R.L., and McEwen, L.C., 1992, Impacts of a severe drought on grassland birds in western North Dakota: Ecological Applications, v. 2, no. 3, p. 275–284. [Also available at https://doi.org/10.2307/1941861.]

Gorzo, J.M., Pidgeon, A.M., Thogmartin, W.E., Allstadt, A.J., Radeloff, V.C., Heglund, P.J., and Vavrus, S.J., 2016, Using the North American Breeding Bird Survey to assess broad-scale response of the continent's most imperiled avian community, grassland birds, to weather variability: The Condor, v. 118, no. 3, p. 502–512. [Also available at https://doi.org/10.1650/CONDOR-15-180.1.]

Grant, T.A., Madden, E., and Berkey, G.B., 2004, Tree and shrub invasion in northern mixed-grass prairie—Implications for breeding grassland birds: Wildlife Society Bulletin, v. 32, no. 3, p. 807–818. [Also available at https://doi.org/10.2193/0091-7648(2004)032[0807:TASIIN]2.0.CO;2.]

Green, M.T., 1992, Adaptations of Baird's Sparrow (*Ammodramus bairdii*) to grasslands—Acoustic communication and nomadism: Chapel Hill, N.C., University of North Carolina, Ph.D. Dissertation, 102 p.

Green, M.T., Lowther, P.E., Jones, S.L., Davis, S.K., and Dale, B.C., 2020, Baird's Sparrow (*Centronyx bairdii*) (ver. 1.0), *in* Poole, A.F., and Gill, F.B. eds., Birds of the world: Ithaca, N.Y., Cornell Lab of Ornithology, accessed April 2020 at https://birdsoftheworld.org/bow/species/baispa/1.0/introduction. [Also available at https://doi.org/10.2173/bow.baispa.01.]

Greer, M.J., 2009, An evaluation of habitat use and requirements for grassland bird species of greatest conservation need in central and western South Dakota: Brookings, S. Dak., South Dakota State University, Master's Thesis, 158 p.

Henderson, A.E., and Davis, S.K., 2014, Rangeland health assessment—A useful tool for linking range management and grassland bird conservation?: Rangeland Ecology and Management, v. 67, no. 1, p. 88–98. [Also available at https://doi.org/10.2111/REM-D-12-00140.1.]

Igl, L.D., and Johnson, D.H., 2016, Effects of haying on breeding birds in CRP grasslands: The Journal of Wildlife Management, v. 80, no. 7, p. 1189–1204. [Also available at https://dx.doi.org/10.1002/jwmg.21119.]

Igl, L.D., Johnson, D.H., and Kantrud, H.A., 2008, A historical perspective—Changes in grassland breeding bird densities within major habitats in North Dakota between 1967 and 1992–1993, *in* Springer, J.T., and Springer, E.C., eds., Prairie invaders—Proceedings of the twentieth North American Prairie Conference: Kearney, Nebr., University of Nebraska, p. 275–295.

Johnson, D.H., 1996, Management of northern prairies and wetlands for the conservation of Neotropical migratory birds, *in* Thompson, F.R., III, ed., Management of midwestern landscapes for the conservation of Neotropical migratory birds: St. Paul, Minn., U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station, General Technical Report NC-187, p. 53–67.

Johnson, D.H., 1997, Effects of fire on bird populations in mixed-grass prairie, *in* Knopf, F.L., and Samson, F.B., eds., Ecology and conservation of Great Plains vertebrates: New York, N.Y., Springer-Verlag, p. 181–206. [Also available at https://doi.org/10.1007/978-1-4757-2703-6_8.]

Johnson, D.H., and Igl, L.D., 1995, Contributions of the Conservation Reserve Program to populations of breeding birds in North Dakota: The Wilson Bulletin, v. 107, no. 4, p. 709–718.

Johnson, D.H., and Igl, L.D., 2001, Area requirements of grassland birds—A regional perspective: The Auk, v. 118, no. 1, p. 24–34. [Also available at https://dx.doi.org/10.2307/4089756.]

Johnson, D.H., and Schwartz, M.D., 1993, The Conservation Reserve Program—Habitat for grassland birds: Great Plains Research, v. 3, no. 2, p. 273–295.

Jones, S.L., 2011, Territory size in mixed-grass prairie songbirds: Canadian Field-Naturalist, v. 125, no. 1, p. 12–15. [Also available at http://dx.doi.org/10.22621/cfn.v125i1.1115.]

Jones, S.L., Dieni, J.S., and Gouse, P.J., 2010, Reproductive biology of a grassland songbird community in north-central Montana: The Wilson Journal of Ornithology, v. 122, no. 3, p. 455–464. [Also available at https://dx.doi.org/10.1676/08-171.1.]

Jones, S.L., Dieni, J.S., Green, M.T., and Gouse, P.J., 2007, Annual return rates of breeding grassland songbirds: The Wilson Journal of Ornithology, v. 119, no. 1, p. 89–94. [Also available at https://dx.doi.org/10.1676/05-158.1.]

Jones, S.L., and Green, M.T., 1998, Baird's Sparrow status assessment and conservation plan: Denver, Colo., U.S. Fish and Wildlife Service, Administrative report, 24 p.

Kalyn Bogard, H.J., 2011, Natural gas development and grassland songbird abundance in southwestern Saskatchewan—The impact of gas wells and cumulative disturbance: Regina, Saskatchewan, University of Regina, Master's Thesis, 154 p.

Kalyn Bogard, H.J., and Davis, S.K., 2014, Grassland songbirds exhibit variable responses to the proximity and density of natural gas wells: The Journal of Wildlife Management, v. 78, no. 3, p. 471–482. [Also available at https://dx.doi.org/10.1002/jwmg.684.]

Kantrud, H.A., 1981, Grazing intensity effects on the breeding avifauna of North Dakota native grasslands: Canadian Field-Naturalist, v. 95, no. 4, p. 404–417.

Kantrud, H.A., and Faanes, C.A., 1979, Range expansion of Baird's Sparrow in South Dakota: Prairie Naturalist, v. 11, p. 111–112.

Kantrud, H.A., and Kologiski, R.L., 1982, Effects of soils and grazing on breeding birds of uncultivated upland grasslands of the northern Great Plains: Washington, D.C., U.S. Fish and Wildlife Service, Wildlife Research Report 15, 33 p.

Klippenstine, D.R., and Sealy, S.G., 2008, Differential ejection of cowbird eggs and non-mimetic eggs by grassland passerines: The Wilson Journal of Ornithology, v. 120, no. 4, p. 667–673. [Also available at https://dx.doi.org/10.1676/07-074.1.]

Koper, N., and Schmiegelow, F.K.A., 2006, Effects of habitat management for ducks on target and nontarget species: The Journal of Wildlife Management, v. 70, no. 3, p. 823–834. [Also available at https://doi.org/10.2193/0022-541X(2006)70[823:EOHMFD]2.0.CO;2.]

Lane, J., 1968, Baird's Sparrow (*Ammodramus bairdii*), *in* Austin, O.L., Jr., ed., Life histories of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows, and allies. Order Passeriformes—Family Fringillidae. Part two—Genera *Pipilo* (part) through *Spizella*: New York, N.Y., Dover Publications, Inc., p. 745–765. [Also available at https://doi.org/10.5479/si.03629236.237.1.]

Lein, R., 1968, The breeding biology of the Savannah Sparrow, *Passerculus sandwichensis* (Gmelin), at Saskatoon, Saskatchewan: Saskatoon, Saskatchewan, University of Saskatchewan, Master's Thesis, 171 p.

Linnen, C.G., 2008, Effects of oil and gas development on grassland birds: Saskatoon, Saskatchewan, Northern EnviroSearch Ltd., Report prepared for Petroleum Technology Alliance Canada, 26 p.

Lipsey, M.K., 2015, Cows and plows—Science-based conservation for grassland songbirds in agricultural landscapes: Missoula, Mont., University of Montana, Ph.D. Dissertation, 137 p.

Lipsey, M.K., and Naugle, D.E., 2017, Precipitation and soil productivity explain effects of grazing on grassland songbirds: Rangeland Ecology and Management, v. 70, no. 3, p. 331–340. [Also available at https://doi.org/10.1016/j.rama.2016.10.010.]

Ludlow, S.M., Brigham, R.M., and Davis, S.K., 2014, Nesting ecology of grassland songbirds—Effects of predation, parasitism, and weather: The Wilson Journal of Ornithology, v. 126, no. 4, p. 686–699. [Also available at https://dx.doi.org/10.1676/13-176.1.]

Ludlow, S.M., Brigham, R.M., and Davis, S.K., 2015, Oil and natural gas development has mixed effects on the density and reproductive success of grassland songbirds: The Condor, v. 117, no. 1, p. 64–75. [Also available at https://dx.doi.org/10.1650/CONDOR-14-79.1.]

Lueders, A.S., Kennedy, P.L., and Johnson, D.H., 2006, Influences of management regimes on breeding bird densities and habitat in mixed-grass prairie—An example from North Dakota: The Journal of Wildlife Management, v. 70, no. 2, p. 600–606. [Also available at https://dx.doi.org/10.2193/0022-541X(2006)70%5B600:IOMROB%5D2.0.CO;2.]

Lusk, J., 2009, The effects of grazing on songbird nesting success in Grasslands National Park of Canada: Winnipeg, Manitoba, University of Manitoba, Master's Thesis, 78 p.

Lusk, J.S., and Koper, N., 2013, Grazing and songbird nest survival in southwestern Saskatchewan: Rangeland Ecology and Management, v. 66, no. 4, p. 401–409. [Also available at https://doi.org/10.2111/REM-D-11-00203.1.]

Madden, E.M., 1996, Passerine communities and bird-habitat relationships on prescribe-burned, mixed-grass prairie in North Dakota: Bozeman, Mont., Montana State University, Master's Thesis, 153 p.

Madden, E.M., Hansen, A.J., and Murphy, R.K., 1999, Influence of prescribed fire history on habitat and abundance of passerine birds in northern mixed-grass prairie: Canadian Field-Naturalist, v. 113, no. 4, p. 627–640.

Madden, E.M., Murphy, R.K., Hansen, A.J., and Murray, L., 2000, Models for guiding management of prairie bird habitat in northwestern North Dakota: American Midland Naturalist, v. 144, no. 2, p. 377–392. [Also available at https://dx.doi.org/10.1674/0003-0031(2000)144%5B0377:MFGMOP%5D2.0.CO;2.]

Maher, W.J., 1973, Matador Project—Birds I. Population dynamics: Saskatoon, Saskatchewan, University of Saskatchewan, Canadian Committee for the International Biological Programme, Matador Project, Technical Report 34, 56 p.

Mahon, C.L., 1995, Habitat selection and detectability of Baird's Sparrow in southwestern Alberta: Edmonton, Alberta, University of Alberta, Master's Thesis, 70 p.

Martin, P.A., Johnson, D.L., Forsyth, D.J., and Hill, B.D., 2000, Effects of two grasshopper control insecticides on food resources and reproductive success of two species of grassland songbirds: Environmental Toxicology and Chemistry, v. 19, no. 12, p. 2987–2996. [Also available at https://doi.org/10.1002/etc.5620191220.]

McMaster, D.G., and Davis, S.K., 1998, Non-game evaluation of the Permanent Cover Program: Regina, Saskatchewan, Saskatchewan Wetland Conservation Corporation, 75 p.

McMaster, D.G., and Davis, S.K., 2001, An evaluation of Canada's Permanent Cover Program—Habitat for grassland birds?: Journal of Field Ornithology, v. 72, no. 2, p. 195–210. [Also available at https://dx.doi.org/10.1648/0273-8570-72.2.195.]

McMaster, D.G., Devries, J.H., and Davis, S.K., 1999, An integrated evaluation of cropland conversion in the Missouri Coteau of Saskatchewan—Productivity of pintail and other grassland birds: Regina, Saskatchewan, Saskatchewan Wetland Conservation Corporation; Oak Hammock Marsh, Manitoba, Institute for Wetland and Waterfowl Research; Oak Hammock Marsh, Manitoba, Ducks Unlimited Canada, 11 p.

Mengel, R.M., 1970, The North American Central Plains as an isolating agent in bird speciation, *in* Dort, W., and Jones, J.K., eds., Pleistocene and recent environments of the central Great Plains: Lawrence, Kans., University of Kansas Press, p. 280–340.

Messmer, T.A., 1990, Influence of grazing treatments on nongame birds and vegetation structure in south central North Dakota: Fargo, N. Dak., North Dakota State University, Ph.D. Dissertation, 164 p.

Molloy, K., 2014, Grassland songbird community relationships mediated by cattle stocking rates and plant community composition in two habitats in a northern mixed grass prairie: Winnipeg, Manitoba, University of Manitoba, Master's Thesis, 91 p.

Morgan, M.R., Norment, C., and Runge, M.C., 2010, Evaluation of reproductive index for estimating productivity of grassland breeding birds: The Auk, v. 127, no. 1, p. 86–93. [Also available at https://doi.org/10.1525/auk.2009.09132.]

National Geographic Society, 2011, Field guide to the birds of North America (6th ed.): Washington, D.C., National Geographic Society, 576 p.

Nenninger, H.R., and Koper, N., 2018, Effects of conventional oil wells on grassland songbird abundance are caused by presence of infrastructure, not noise: Biological Conservation, v. 218, p. 124–133. [Also available at https://doi.org/10.1016/j.biocon.2017.11.014.]

Niemuth, N.D., Solberg, J.W., and Shaffer, T.L., 2008, Influence of moisture on density and distribution of grassland birds in North Dakota: The Condor, v. 110, no. 2, p. 211–222. [Also available at https://dx.doi.org/10.1525/cond.2008.8514.]

Nixon, A.E., Fisher, R.J., Stralberg, D., Bayne, E.M., and Farr, D.R., 2016, Projected responses of North American grassland songbirds to climate change and habitat availability at their northern range limits in Alberta, Canada: Avian Conservation and Ecology, v. 11, no. 2, article 2. [Also available at https://dx.doi.org/10.5751/ACE-00866-110202.]

O'Connor, R.J., Jones, M.T., Boone, R.B., and Lauber, T.B., 1999, Linking continental climate, land use, and land patterns with grassland bird distribution across the conterminous United States, *in* Vickery, P.D., and Herkert, J.R., eds., Ecology and conservation of grassland birds of the Western Hemisphere: Studies in Avian Biology, v. 19, p. 45–59.

Owens, R.A., and Myres, M.T., 1973, Effects of agriculture upon populations of native passerine birds of an Alberta fescue grassland: Canadian Journal of Zoology, v. 51, no. 7, p. 697–713. [Also available at https://dx.doi.org/10.1139/z73-104.]

Peña-Peniche, A., Ruvalcaba-Ortega, I., and Rojas-Soto, O., 2018, Climate complexity in the migratory cycle of *Ammodramus bairdii*: PLoS One, v. 13, no. 8, p. e0202678. [Also available at https://doi.org/10.1371/journal.pone.0202678.]

Peterson, A.T., 2003, Projected climate change effects on Rocky Mountain and Great Plains birds—Generalities of biodiversity consequences: Global Change Biology, v. 9, no. 5, p. 647–655. [Also available at https://doi.org/10.1046/j.1365-2486.2003.00616.x.]

Pipher, E.N., 2011, Effects of cattle stocking rate and years grazed on songbird nesting success in the northern mixed-grass prairie: Winnipeg, Manitoba, University of Manitoba, Master's Thesis, 104 p.

Pipher, E.N., Curry, C.M., and Koper, N., 2016, Cattle grazing intensity and duration have varied effects on songbird nest survival in mixed-grass prairies: Rangeland Ecology and Management, v. 69, no. 6, p. 437–443. [Also available at https://dx.doi.org/10.1016/j.rama.2016.07.001.]

Prescott, D.R.C., and Wagner, G.M., 1996, Avian responses to implementation of a complementary/rotational grazing system by the North American Waterfowl Management Plan in southern Alberta—The Medicine Wheel Project: Edmonton, Alberta, Alberta NAWMP Centre, NAWMP-018, 24 p.

Pylypec, B., 1991, Impacts of fire on bird populations in a fescue prairie: Canadian Field-Naturalist, v. 105, no. 3, p. 346–349.

Pylypec, B., 1991, Impacts of fire on bird populations in a fescue prairie: Canadian Field-Naturalist, v. 105, no. 3, p. 346–349.

Renken, R.B., 1983, Breeding bird communities and bird-habitat associations on North Dakota waterfowl production areas of three habitat types: Ames, Iowa, Iowa State University, Master's Thesis, 90 p.

Renken, R.B., and Dinsmore, J.J., 1987, Nongame bird communities on managed grasslands in North Dakota: Canadian Field-Naturalist, v. 101, no. 4, p. 551–557.

Ribic, C.A., Koford, R.R., Herkert, J.R., Johnson, D.H., Niemuth, N.D., Naugle, D.E., Bakker, K.K., Sample, D.W., and Renfrew, R.B., 2009, Area sensitivity in North American grassland birds—Patterns and processes: The Auk, v. 126, no. 2, p. 233–244. [Also available at https://dx.doi.org/10.1525/auk.2009.1409.]

Richardson, A.N., 2012, Changes in grassland songbird abundances through time in response to burning and grazing in the northern mixed-grass prairie: Winnipeg, Manitoba, University of Manitoba, Master's Thesis, 73 p.

Richardson, A.N., Koper, N., and White, K.A., 2014, Interactions between ecological disturbances—Burning and grazing and their effects on songbird communities in northern mixed-grass prairies: Avian Conservation and Ecology, v. 9, no. 2, article 5. [Also available at https://dx.doi.org/10.5751/ACE-00692-090205.]

Rivers, J.W., Althoff, D.P., Gipson, P.S., and Pontius, J.S., 2003, Evaluation of a reproductive index to estimate Dickcissel reproductive success: The Journal of Wildlife Management, v. 67, no. 1, p. 136–143. [Also available at https://doi.org/10.2307/3803069.]

Robel, R.J., Briggs, J.N., Dayton, A.D., and Hulbert, L.C., 1970, Relationships between visual obstruction measurements and weight of grassland vegetation: Journal of Range Management, v. 23, no. 4, p. 295–297. [Also available at https://dx.doi.org/10.2307/3896225.]

Rodgers, J.A., 2013, Effects of shallow gas development on relative abundances of grassland songbirds in a mixed-grass prairie: Winnipeg, Manitoba, University of Manitoba, Master's Thesis, 178 p.

Rodgers, J.A., and Koper, N., 2017, Shallow gas development and grassland songbirds—The importance of perches: The Journal of Wildlife Management, v. 81, no. 3, p. 406–416. [Also available at https://dx.doi.org/10.1002/jwmg.21210.]

Salo, E.D., Higgins, K.F., Patton, B.D., Bakker, K.K., and Barker, W.T., 2004, Grazing intensity effects on vegetation, livestock and non-game birds in North Dakota mixed-grass prairie, *in* Egan, D., and Harrington, J.A., eds., Proceedings of the nineteenth North American Prairie Conference: Madison, Wis., University of Wisconsin, p. 205–215.

Salt, W.R., and Salt, J.R., 1976, The birds of Alberta: Edmonton, Alberta, Hurtig Publishers, 498 p.

Saskatchewan Wetland Conservation Corporation, 1997, Grassland bird conservation through Saskatchewan's native prairie stewardship program: Regina, Saskatchewan, Saskatchewan Wetland Conservation Corporation, 25 p.

Sauer, J.R., Hines, J.E., Fallon, J.E., Pardieck, K.L., Ziolkowski, D.J., Jr., and Link, W.A., 2014, The North American Breeding Bird Survey, Results and Analysis 1966–2012 (ver. 02.19.2014): Laurel, Md., U.S. Geological Survey, Patuxent Wildlife Research Center, accessed February 2020 at https://www.mbr-pwrc.usgs.gov/bbs/bbs2012.shtml.

Schneider, N.A., 1998, Passerine use of grasslands managed with two grazing regimes on the Missouri Coteau in North Dakota: Brookings, S. Dak., South Dakota State University, Master's Thesis, 94 p.

Shaffer, J.A., Igl, L.D., and Johnson, D.H., 2019, The effects of management practices on grassland birds—Rates of Brown-headed Cowbird (*Molothrus ater*) parasitism in nests of North American grassland birds, chap. PP *of* Johnson, D.H., Igl, L.D., Shaffer, J.A., and DeLong, J.P., eds., The effects of management practices on grassland birds: U.S. Geological Survey Professional Paper 1842, 24 p., accessed February 2020 at https://doi.org/10.3133/pp1842PP.

Skeel, M.A., Duncan, D.C., and Davis, S.D., 1995, Abundance and distribution of Baird's Sparrows in Saskatchewan: Regina, Saskatchewan, Saskatchewan Wetland Conservation Corporation, 13 p.

Skinner, S.P., 2004, Linking decision support systems for ducks with relative abundance of other grassland bird species: Saskatoon, Saskatchewan, University of Saskatchewan, Master's Thesis, 115 p.

Skinner, S.P., and Clark, R.G., 2008, Relationships between duck and grassland bird relative abundance and species richness in southern Saskatchewan: Avian Conservation and Ecology, v. 3, no. 1, article 1. [Also available at https://dx.doi.org/10.5751/ACE-00208-030101.]

Sliwinski, M.S., 2011, Changes in grassland songbird abundance and diversity in response to grazing by bison and cattle in the northern mixed-grass prairie: Winnipeg, Manitoba, University of Manitoba, Master's Thesis, 156 p.

Sliwinski, M.S., and Koper, N., 2015, Managing mixed-grass prairies for songbirds using variable cattle stocking rates: Rangeland Ecology and Management, v. 68, no. 6, p. 470–475. [Also available at https://dx.doi.org/10.1016/j.rama.2015.07.010.]

Sousa, P.J., and McDonal, W.N., 1983, Habitat suitability index models: Baird's Sparrow: Washington, D.C., U.S. Department of Interior, Fish and Wildlife Service, FWS/OBS-82/10.44, 12 p.

Sullivan, B.L., Wood, C.L., Iliff, M.J., Bonney, R.E., Fink, D., and Kelling, S., 2009, eBird—A citizen-based bird observation network in the biological sciences: Biological Conservation, v. 142, no. 10, p. 2282–2292. [Also available at https://doi.org/10.1016/j.biocon.2009.05.006.]

Stewart, R.E., 1975, Breeding birds of North Dakota: Fargo, N. Dak., Tri-College Center for Environmental Studies, 295 p.

Sutter, G.C., 1996, Habitat selection and prairie drought in relation to grassland bird community structure and the nesting ecology of Sprague's Pipit, *Anthus spragueii*: Regina, Saskatchewan, University of Regina, Ph.D. Thesis, 144 p.

Sutter, G.C., and Brigham, R.M., 1998, Avifaunal and habitat changes resulting from conversion of native prairie to crested wheatgrass—Patterns at songbird community and species levels: Canadian Journal of Zoology, v. 76, no. 5, p. 869–875. [Also available at https://doi.org/10.1139/z98-018.]

Sutter, G.C., Davis, S.K., and Duncan, D.C., 2000, Grassland songbird abundance along roads and trails in southern Saskatchewan: Journal of Field Ornithology, v. 71, no. 1, p. 110–116. [Also available at https://dx.doi.org/10.1648/0273-8570-71.1.110.]

Sutter, G.C., Troupe, T., and Forbes, M., 1995, Abundance of Baird's Sparrows, *Ammodramus bairdii*, in native prairie and introduced vegetation: Ecoscience, v. 2, no. 4, p. 344–348. [Also available at https://doi.org/10.1080/11956860.1995.11682302.]

Thompson, S.J., Johnson, D.H., Niemuth, N.D., and Ribic, C.A., 2015, Avoidance of unconventional oil wells and roads exacerbates habitat loss for grassland birds in the North American Great Plains: Biological Conservation, v. 192, p. 82–90. [Also available at https://dx.doi.org/10.1016/j.biocon.2015.08.040.]

Wellicome, T.I., Kardynal, K.J., Franken, R.J., and Gillies, C.S., 2014, Off-road sampling reveals a different grassland bird community than roadside sampling—Implications for survey design and estimates to guide conservation: Avian Conservation and Ecology, v. 9, no. 1, article 4. [Also available at https://dx.doi.org/10.5751/ACE-00624-090104.]

Wershler, C., Smith, W.W., and Wallis, C., 1991, Status of the Baird's Sparrow in Alberta—1987/1988 update with notes on other grassland sparrows and Sprague's Pipit, *in* Holroyd, G.L., Burns, G., and Smith, H.C., eds., Proceedings of the second Endangered Species and Prairie Conservation Workshop: Edmonton, Alberta, Provincial Museum of Alberta, Natural History Occasional Paper, no. 15, p. 87–89.

White, K., 2009, Songbird diversity and habitat use in response to burning on grazed and ungrazed mixed-grass prairie: Winnipeg, Manitoba, University of Manitoba, Master's Thesis, 88 p.

Wiens, J.A., 1969, An approach to the study of ecological relationships among grassland birds: Ornithological Monographs, no. 8, p. 1–93. [Also available at https://dx.doi.org/10.2307/40166677.]

Wiens, T.S., Dale, B.C., Boyce, M.S., and Kershaw, G.P., 2008, Three way *k*-fold cross-validation of resource selection functions: Ecological Modelling, v. 212, no. 3–4, p. 244–255. [Also available at https://doi.org/10.1016/j.ecolmodel.2007.10.005.]

Wilsey, C., Taylor, L., Bateman, B., Jensen, C., Michel, N., Panjabi, A., and Langham, G., 2019, Climate policy action needed to reduce vulnerability of conservation-reliant grassland birds in North America: Conservation Science and Practice, v. 1, no. 4, p. e21. [Also available at https://doi.org/10.1111/csp2.21.]

Winter, M., 1994, Habitat selection of Baird's Sparrows in the northern mixed-grass prairie: Tübingen, Germany, Universität Tübingen, Diplomarbeit, 108 p.

Winter, M., 1999, Relationship of fire history to territory size, breeding density, and habitat of Baird's Sparrow in North Dakota, *in* Vickery, P.D., and Herkert, J.R., eds., Ecology and conservation of grassland birds of the Western Hemisphere: Studies in Avian Biology, v. 19, p. 171–177.

Youngberg, E.N., Bankert, A.R., Panjabi, A.O., Conrey, R.Y., Meyer, A., and Correll, M.D., 2020, Southward breeding range expansion of the Baird's Sparrow: Ecology, v. 101, no. 2, p. e02872. [Also available at https://doi.org/10.1002/ecy.2872.]

Table HH1. Measured values of vegetation structure and composition in Baird's Sparrow (*Centronyx bairdii*) 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; <, less than; DNC, dense nesting cover; >, greater than; spp., species]

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)
Bleho, 2009	Saskatchewan	Mixed-grass prairie	Ungrazed	--	7.4[a]	15.6	4.5	6.2	4.7	60.9	--
Bleho, 2009	Saskatchewan	Mixed-grass prairie	Cattle-grazed	--	4[a]	17.9	6.9	3.6	8.4	45.2	--
Dale, 1983	Saskatchewan	Mixed-grass prairie	Grazed, ungrazed	--	21[b]	65	--	1	--	--	--
Davis, 2005 (nests)	Saskatchewan	Mixed-grass prairie	Grazed	<30	--	--	--	--	<4	--	<1.2
De Smet and Conrad, 1991	Manitoba	Multiple	Multiple	--	--	--	--	10–50	--	--	--
Dieni and Jones, 2003 (nests)	Montana	Mixed-grass prairie	Idle	34.9	18[a]	70.8	11.9	0.4	0.2	11.2	21.3
Dieni and Jones, 2003 (nest vicinity)	Montana	Mixed-grass prairie	Idle	33.6	14[a]	--	--	--	--	--	--
Grant and others, 2004	North Dakota	Mixed-grass prairie	Multiple	54	--	--	--	7	--	--	4.7
Greer, 2009[c]	South Dakota	Mixed-grass prairie	Multiple	101[d]	16[a]	60.8	29.3	0.7	3.6	23.1	1.7
Kalyn Bogard and Davis, 2014	Saskatchewan	Mixed-grass prairie	Grazed	10.7	--	44.8	10.2	--	43.7	--	1.6
Lueders and others, 2006	North Dakota	Mixed-grass prairie	Cattle-grazed	--	8[a]	29.1[e]	11	0.6	24.7	25.9	1.5
Lueders and others, 2006	North Dakota	Mixed-grass prairie	Bison (*Bison bison*)-grazed	--	18[a]	29[e]	11.8	10.4	9.5	36.7	3.1
Lusk, 2009[c] (nests)	Saskatchewan	Mixed-grass prairie	Grazed, ungrazed	--	--	37.3	3	3.5	0	64.5	3
Madden, 1996	North Dakota	Mixed-grass prairie	Burned	--	16[a]	44.4	25.2	20.1	--	--	3.7
Pipher, 2011 (nests)	Saskatchewan	Mixed-grass prairie	Grazed	60.4	--	--	--	--	--	--	3.6
Renken, 1983[f]	North Dakota	Tame grassland (DNC)	Idle, grazed	--	15[a]	65.9	29.2	0.4	0.4	99	3
Rodgers, 2013	Alberta	Mixed-grass prairie	Grazed	22.8[d]	--	35.8	11.1	--	2.9	--	0.2
Salo and others, 2004	North Dakota	Mixed-grass prairie	Moderate grazing intensity	48.3[d]	45.8[a]	--	--	--	--	--	4.6
Schneider, 1998	North Dakota	Mixed-grass prairie	Grazed	--	8.3[a]	35.8	13.9	--	3.6	--	1.4
Sliwinski, 2011	Saskatchewan	Mixed-grass prairie	Bison- and cattle-grazed	30.8	--	29.9	4.9	--	1.4	34.3	4.7

Table HH1. Measured values of vegetation structure and composition in Baird's Sparrow (*Centronyx bairdii*) 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; <, less than; DNC, dense nesting cover; >, greater than; spp., species]

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)
White, 2009	Saskatchewan	Mixed-grass prairie	Burned, cattle-grazed	37.2	3.5[a]	30.7	6.1	0.7	19.5	14.9	1.6
White, 2009	Saskatchewan	Mixed-grass prairie	Burned, ungrazed	39.4	4[a]	31.4	6.8	0.5	15.4	10.4	1.1
White, 2009	Saskatchewan	Mixed-grass prairie	Unburned, cattle-grazed	41.4	3.4[a]	17.3	7.8	0.4	3.2	47.3	2.1
White, 2009	Saskatchewan	Mixed-grass prairie	Unburned, ungrazed	41.7	7.2[a]	14.8	5.1	2.1	1.6	62.8	5.1
Winter, 1999	North Dakota	Mixed-grass prairie	Unburned	23.9	16.3[a]	--	--	--	--	--	3.3
Winter, 1999	North Dakota	Mixed-grass prairie	Burned twice	18.5	13.7[a]	--	--	--	0	--	2.8
Winter, 1999	North Dakota	Mixed-grass prairie	Burned four times	13.8	6.3[a]	--	--	--	11.4	--	0.1

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

[b]Effective vegetation height.

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

[d]Mean grass height.

[e]Grass and sedge (*Carex* spp.) combined.

[f]The sum of the percentages is greater >100%, based on the modified point-quadrat technique of Wiens (1969).

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