USGS
science for a changing world

The Effects of Management Practices on Grassland Birds—Sprague's Pipit (*Anthus spragueii*)

Chapter W of

The Effects of Management Practices on Grassland Birds

Professional Paper 1842–W

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

Cover. Sprague's Pipit. Photograph by John C. Carlson, used with permission.
Background photograph: Northern mixed-grass prairie in North Dakota, by Rick Bohn, used with permission.

The Effects of Management Practices on Grassland Birds—Sprague's Pipit (*Anthus spragueii*)

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] Travis L. Wooten,[1,4] Jason P. Thiele,[1,5] and Betty R. Euliss[1]

Chapter W of

The Effects of Management Practices on Grassland Birds

Edited by Douglas H. Johnson,[1] Lawrence D. Igl,[1] Jill A. Shaffer,[1] and John P. DeLong[1,6]

---

[1]U.S. Geological Survey.

[2]South Dakota Game, Fish and Parks (current).

[3]U.S. Fish and Wildlife Service (current).

[4]San Diego Zoo Institute for Conservation Research (current).

[5]Nebraska Game and Parks Commission (current).

[6]University of Nebraska-Lincoln (current).

Professional Paper 1842–W

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

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

U.S. Geological Survey
James F. Reilly II, Director

U.S. Geological Survey, Reston, Virginia: 2020

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment—visit https://www.usgs.gov or call 1–888–ASK–USGS.

For an overview of USGS information products, including maps, imagery, and publications, visit https://store.usgs.gov.

Suggested citation:
Shaffer, J.A., Igl, L.D., Johnson, D.H., Sondreal, M.L., Goldade, C.M., Nenneman, M.P., Wooten, T.L., Thiele, J.P., and Euliss, B.R., 2020, The effects of management practices on grassland birds—Sprague's Pipit (*Anthus spragueii*), chap. W *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, 21 p., https://doi.org/10.3133/pp1842W.

ISSN 2330-7102 (online)

Contents

Figure

Table

Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
hectare (ha)	2.471	acre
square kilometer (km^2)	247.1	acre
hectare (ha)	0.003861	square mile (mi^2)
square kilometer (km^2)	0.3861	square mile (mi^2)

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
CV	coefficient of variation
n.d.	no date
NDVI	Normalized Difference Vegetation Index
SD	standard deviation
spp.	species (applies to two or more species within the genus)

Acknowledgments

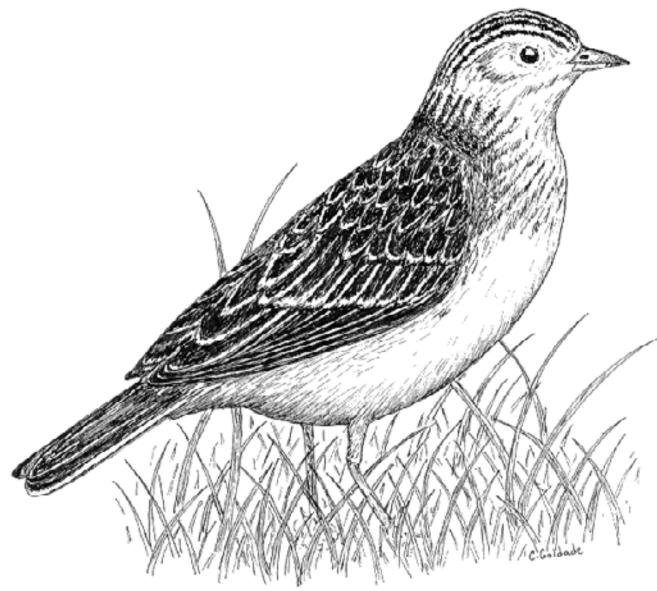
Major funding for this effort was provided by the Prairie Pothole Joint Venture, the U.S. Fish and Wildlife Service, and the U.S. Geological Survey. Additional funding was provided by the U.S. Forest Service, The Nature Conservancy, and the Plains and Prairie Potholes Landscape Conservation Cooperative. We thank the following cooperators who provided access to their bibliographic files: Louis B. Best, Carl E. Bock, Brenda C. Dale, Stephen K. Davis, James J. Dinsmore, Fritz L. Knopf (deceased), Rolf R. Koford, David R. C. Prescott, Mark R. Ryan, David W. Sample, David A. Swanson, Peter D. Vickery (deceased), and John L. Zimmerman. We thank Christopher M. Goldade for his illustration of the Sprague's Pipit and the U.S. Geological Survey's Patuxent Wildlife Research Center, Laurel, Maryland, for providing the range map. We thank Courtney L. Amundson, Joel S. Brice, Rachel M. Bush, James O. Church, Shay F. Erickson, Silka L.F. Kempema, Emily C. McLean, Susana Rios, Bonnie A. Sample, and Robert O. Woodward for their assistance with various aspects of this effort. Lynn M. Hill and Keith J. Van Cleave, U.S. Geological Survey, acquired many publications for us throughout this effort, including some that were very old and obscure. Earlier versions of this account benefitted from insightful comments from Stephanie L. Jones, Scott G. Somershoe, and Brian A. Tangen.

The Effects of Management Practices on Grassland Birds—Sprague's Pipit (*Anthus spragueii*)

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] Travis L. Wooten,[1,4] Jason P. Thiele,[1,5] and Betty R. Euliss[1]

Capsule Statement

Keys to Sprague's Pipit (*Anthus spragueii*) management include providing suitable grassland habitat, especially native prairie, with intermediate vegetation height and low visual obstruction, and controlling succession therein. Sprague's Pipits have been reported to use habitats with no more than 49 centimeters (cm) average vegetation height, 4–14 cm visual obstruction reading, 15–53 percent grass cover, less than (<) 21 percent forb cover, <18 percent shrub cover, <44 percent bare ground, 10–63 percent litter cover, and less than or equal to 11 cm litter depth. The descriptions of key vegetation characteristics are provided in table W1 (after the "References" section). Vernacular and scientific names of plants and animals follow the Integrated Taxonomic Information System (https://www.itis.gov).



Sprague's Pipit. Illustration by Christopher M. Goldade, U.S. Geological Survey.

Breeding Range

Sprague's Pipits breed from north-central Alberta to central Manitoba, south to Montana and north-central South Dakota, and east to northwestern Minnesota (National Geographic Society, 2011). The relative densities of Sprague's Pipits in the United States and southern Canada, based on North American Breeding Bird Survey (BBS) data (Sauer and others, 2014), are shown in figure W1 (not all geographic places mentioned in report are shown on figure).

Suitable Habitat

Sprague's Pipits use grasslands characterized by vegetation of intermediate height and sparse-to-intermediate vegetation density (Dale, 1983; Madden, 1996; Prescott and Murphy, 1996; Sutter, 1996; Sutter and Brigham, 1998; Fisher and Davis, 2011a). Other suitable habitat features include low visual obstruction (that is, vegetation height-density), moderate litter cover, and little or no woody vegetation (Faanes, 1983; Dale, 1992; Anstey and others, 1995; Madden, 1996; Sutter, 1996; Davis and Duncan, 1999; Madden and others, 2000). Vegetation in dry lake bottoms and bordering alkali lakes also can be suitable for Sprague's Pipits (Saunders, 1914; Stewart, 1975; Wershler and others, 1991). In Saskatchewan, Sprague's Pipits occurred more frequently in the mixed grassland and the cypress upland ecoregions than in the aspen (*Populus* species [spp.]) parkland or moist mixed grassland ecoregions (Davis and others, 1999).

[1]U.S. Geological Survey.

[2]South Dakota Game, Fish and Parks (current).

[3]U.S. Fish and Wildlife Service (current).

[4]San Diego Zoo Institute for Conservation Research (current).

[5]Nebraska Game and Parks Commission (current).

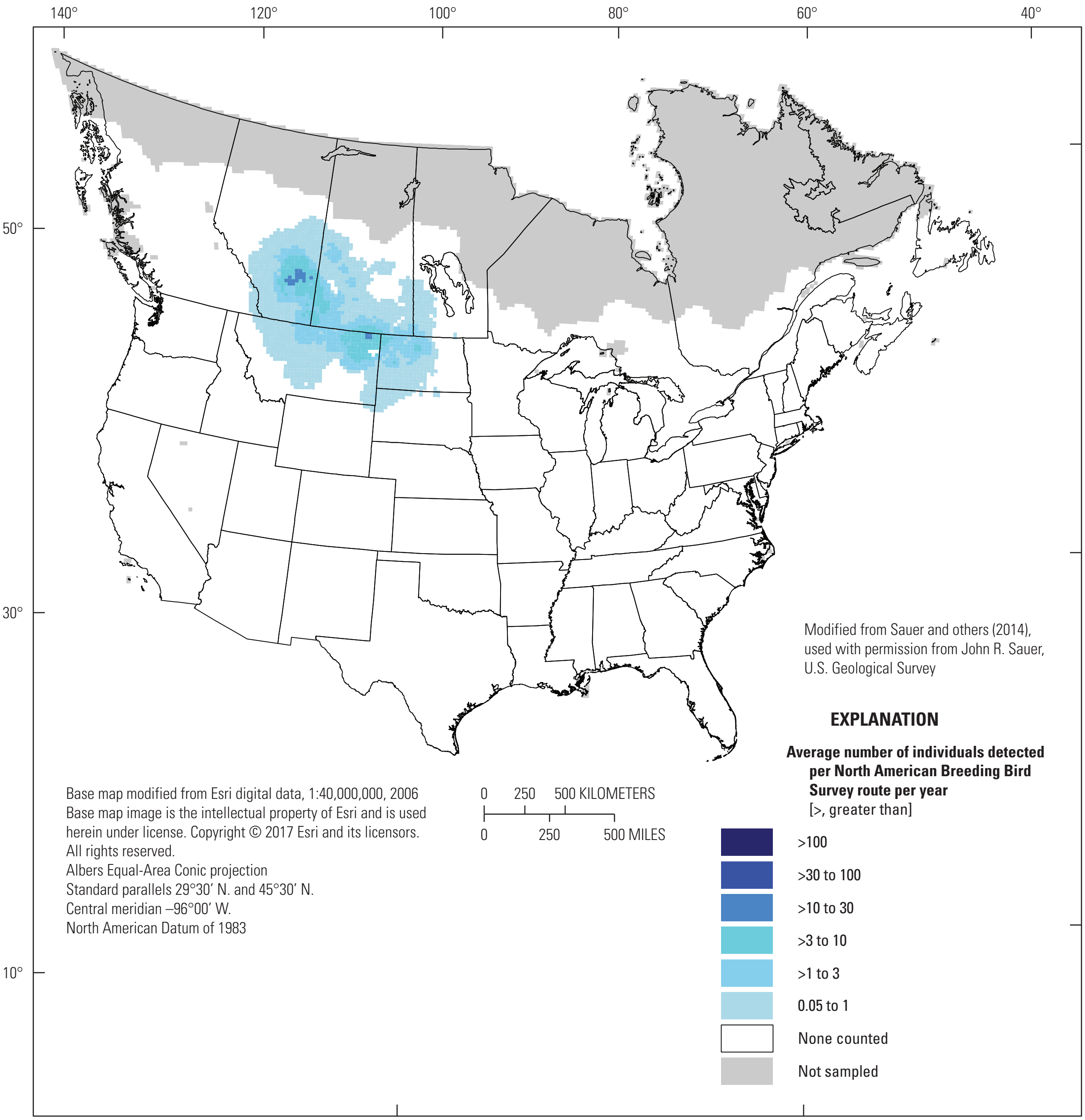


Figure W1. The breeding distribution of the Sprague's Pipit (*Anthus spragueii*) in the United States and southern Canada, based on North American Breeding Bird Survey (BBS) data, 2008–12. The BBS abundance map provides only an approximation of breeding range edges.

Rangewide, Sprague's Pipits show a preference for native grasslands over tame grasslands and agricultural fields. Several researchers have reported that although Sprague's Pipits will use planted, exotic, or introduced (that is, "tame") vegetation, the species is significantly more abundant in native prairies (Stewart, 1975; Wilson and Belcher, 1989; Dale, 1992; Hartley, 1994; Anstey and others, 1995; Madden, 1996; Prescott and Murphy, 1996; Prescott and Wagner, 1996; Sutter, 1996; Davis and Duncan, 1999). In Alberta and Saskatchewan, Fisher (2010) and Davis and others (2013) reported that Sprague's Pipits were more common in native mixed-grass prairies than in tame grasslands planted for grazing or haying activities. In Saskatchewan, Sprague's Pipits preferred native pastures to tame pastures (Anstey and others, 1995; Sutter, 1996; Sutter and Brigham, 1998; Davis and Duncan, 1999; Davis and others, 2016) or to tame hayfields (Davis and others, 2016), and pipits did not occur in planted dense nesting cover or wheat (*Triticum* spp.) fields (Hartley, 1994). In planted grasslands enrolled in the Conservation Reserve Program in North Dakota, South Dakota, and Montana, Sprague's Pipits were rare (Igl, 2009). In a statewide study in North Dakota, Igl and others (2008) recorded Sprague's Pipits at low densities in cropland (defined as land used for the production of annual field crops, land under summer fallow, and land cleared for annual field crops). In contrast to the above studies, Davis and others (1999) and Dohms (2009) did not find a clear preference by Sprague's Pipits for native grasslands over tame grasslands in Saskatchewan. Sprague's Pipits occurred as frequently in tame pastures as in native pastures and more frequently in pastures than in hayland or cropland (Davis and others, 1999). Dohms (2009) reported no differences in the nestling provisioning rate of adult pipits or in arthropod biomass between native and tame grasslands.

In Alberta and Saskatchewan, Davis and others (2016) and Davis (2018) examined the difference in reproductive success between Sprague's Pipits nesting in native grasslands and pipits nesting in grasslands planted to nonnative species, such as Kentucky bluegrass (*Poa pratensis*), smooth brome (*Bromus inermis*), and alfalfa (*Medicago sativa*). Over a 2-year study in southern Saskatchewan, Davis and others (2016) reported that pipit nests were located in native mixed-grass pastures but not in tame hayfields or pastures. In a later 3-year study in southern Saskatchewan, Fisher (2010) and Fisher and Davis (2011a) reported a similar number of pipit nesting territories in native and planted grasslands and slightly more nests in native grasslands. Davis (2018) reported that although native and planted grasslands attracted Sprague's Pipits at the beginning of the breeding season, pipit densities in planted grasslands declined precipitously during the breeding season, potentially because vegetation became too tall and dense for suitable nesting habitat. Pipit clutch size, overall nest survival, and fledging success were similar between grassland types, but daily survival rate peaked at hatching in planted grasslands and then declined thereafter, and nest predation accounted for a greater proportion of unsuccessful nests in planted grasslands than in native grasslands. Although the mean number of young fledged per nest in May was slightly greater in planted grasslands than in native grasslands, overall seasonal productivity was higher in native grasslands; only three nests were initiated in planted grasslands after May, and all were unsuccessful. Pipit young fledged at higher rates from nests initiated in June and July in native pastures than from nests initiated in May in planted grasslands (Davis, 2018).

Sprague's Pipit occurrence may be tied to plant species composition. In Saskatchewan mixed-grass and tame pastures, occurrence was positively associated with junegrass (*Koeleria macrantha*), bluegrass (*Poa* spp.), and thickspike wheatgrass (*Elymus macrourus*) (Davis and Duncan, 1999). Within tame pastures in Saskatchewan, Sprague's Pipits occurred more frequently in pure stands of crested wheatgrass (*Agropyron cristatum*) than in mixed stands of crested wheatgrass and alfalfa (Davis and Duncan, 1999). In a comparison of Saskatchewan mixed-grass prairies consisting of drier, upland portions with underlying glacial till (termed upland) versus valley portions (termed lowland) with underlying alluvial deposits and till, Sprague's Pipit abundance in upland areas was positively related to streambank wheatgrass (*Elymus lanceolatus*), needle and thread (*Hesperostipa comata*), and western wheatgrass (*Pascopyrum smithii*); in lowland areas of mixed-grass prairies, Sprague's Pipit abundance was positively related to increased cover of fringed sagewort (*Artemisia frigida*), common dandelion (*Taraxacum officinale*), and silverleaf scurfpea (*Pediomelum argophyllum*) (Molloy, 2014). In a study comparing pipit use of mixed-grass prairies and planted grasslands in Alberta and Saskatchewan, Fisher (2010) reported that Sprague's Pipits used narrow-leaved grasses, which typically were associated with native grass species, and avoided broad-leaved grasses, which typically were associated with tame grass species. Fisher (2010) suggested that Sprague's Pipits may be avoiding the taller and denser structure of tame grass species. In Manitoba, Sprague's Pipit abundance was positively correlated with junegrass and negatively correlated with smooth brome (Wilson and Belcher, 1989). Within grazed mixed-grass prairies in central and northwestern North Dakota, abundance of Sprague's Pipits was higher in plant communities dominated by native grasses (*Stipa* spp., *Bouteloua* spp., *Koeleria* spp., and *Schizachyrium* spp.) and lower in plant communities dominated by Kentucky bluegrass and native grasses (Schneider, 1998). In mixed-grass prairies in north-central North Dakota, Grant and others (2004) compared vegetation composition in grasslands that were occupied by Sprague's Pipits to grasslands that were unoccupied by Sprague's Pipits. Sprague's Pipits were present in grasslands with a higher percentage cover of native grass and forb species, a higher percentage cover of Kentucky bluegrass, and a lower percentage cover of smooth brome and quackgrass (*Elymus repens*) compared to grasslands that were unoccupied. Occurrence was not related to percentage cover of tame legumes (Grant and others, 2004).

Sprague's Pipit abundance and occurrence may be related to vegetation structure. In Alberta native grasslands, Sprague's Pipits preferred areas with moderate cover diversity, moderate grass height and height variation, and a moderate-to-high grass-to-forb ratio (Prescott and Murphy, 1996). In southeastern Alberta mixed-grass prairies, density of Sprague's Pipits decreased as litter depth increased (Ludlow and others, 2015). In Saskatchewan mixed-grass prairies, Sprague's Pipit occurrence was negatively related to the number of forb contacts and, in 1 of 2 years each, positively related to the amount of bare ground and the distance to shrubs (Davis, 2003a, 2004). In southern Saskatchewan mixed-grass prairies, Davis and others (2016) reported that Sprague's Pipit abundance was positively associated with native grasslands characterized by increased coverage of shrubs, narrow-leaved rhizomatous grasses, and standing dead vegetation. In southwestern Saskatchewan mixed-grass pastures, Sprague's Pipit abundance was positively related to litter coverage, litter depth, and standing dead vegetation coverage and negatively related to exposed bare ground and shrub coverage (White, 2009). In another study in southwestern Saskatchewan mixed-grass pastures, Sprague's Pipit probability of occurrence increased with litter mass (kilograms per hectare), and occurrence and abundance increased with vegetation height-density (Henderson and Davis, 2014). In upland mixed-grass prairies in Saskatchewan, Sprague's Pipit abundance was negatively related to bare ground cover and positively related to forb cover; in low-lying areas of mixed-grass prairies, Sprague's Pipit abundance responded negatively to shrub cover (Molloy, 2014). In Saskatchewan mixed-grass and tame pastures, occurrence was positively associated with standing dead vegetation (Davis and Duncan, 1999). In other Saskatchewan studies, Sprague's Pipit abundance in mixed-grass and tame pastures was positively associated with narrow-leaved grasses less than or equal to 10 cm tall and negatively associated with shrubs 20–100 cm tall (Anstey and others, 1995), and the species used areas with more litter coverage than adjacent unused areas (Dale, 1983). Also in Saskatchewan, Sutter and Brigham (1998) determined that Sprague's Pipit abundance in lightly grazed native pastures was positively correlated with bare ground coverage and forb density. Sprague's Pipit abundance was negatively correlated with grass, sedge (*Carex* spp.), and litter coverage; litter depth; and number of vegetation contacts higher than 10 cm. In lightly grazed crested wheatgrass pastures, Sprague's Pipit abundance was positively related to grass and sedge coverage, litter depth, and number of vegetation contacts <10 cm tall (Sutter and Brigham, 1998). Within moderately grazed mixed-grass prairies in Saskatchewan, Bleho (2009) evaluated the relationship between Sprague's Pipit abundance and vegetation structure at the plot and pasture levels, whereby plots were circular areas of 100-meter (m) radii located 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, Sprague's Pipit abundance was positively associated with percentage cover of exposed moss and lichen (species' names not provided), with the two statistical measures for patchiness of exposed moss and lichen coverage, and with the CV-derived measure for patchiness of shrub coverage. Abundance at the plot level was negatively associated with percentage shrub cover, the SD-derived measure for patchiness of bare ground and shrub coverage, and the CV-derived measure for patchiness of vegetation height-density and litter coverage. At the pasture level, Sprague's Pipit abundance was negatively associated with the SD- and CV-derived measures for patchiness of vegetation height-density (Bleho, 2009). In grazed mixed-grass prairies in southcentral Saskatchewan, Davis and others (2014a) reported little influence of vegetation structure or plant vigor (that is, an assessment of the structure and appearance of individual plants, the size and appearance of the plant community, and the presence of expected life forms for the given range site) on the abundance of Sprague's Pipits. Abundance increased with range condition (that is, visual estimates of rangeland integrity, including grazing use, plant vigor, and residual cover, as well as measurements of percent dry weight of biomass consisting of plant species that decrease in the presence of heavy grazing and an allowable consideration of plant species that increase in the presence of heavy grazing). In a 2-year study in mixed-grass prairies in southwestern Manitoba, the abundance of Sprague's Pipits was positively associated with percentage cover of grass in both years and negatively associated with percentage cover of shrubs and forbs in one year (Ranellucci, 2010).

In Alberta and Saskatchewan, Fisher (2010) studied the relationship between Sprague's Pipit territory use and vegetation characteristics of planted hayfields established within the past 30 years. The presence of Sprague's Pipits in both Provinces was influenced by type of grass (narrow- versus broad-leaved), the alfalfa/sweetclover content, the amount of bare ground, and vegetation height. Within planted grasslands, the highest probability of territory use was in areas with 25-cm vegetation height, a height considered "intermediate" (Fisher, 2010). Fisher (2010) suggested that once vegetation becomes too tall and dense, Sprague's Pipits will discontinue using a site and that pipits have an alfalfa height/density threshold, as the species disappeared from hayfields by July. Nests were placed in areas with 20–30 cm vegetation height. Vegetation height of nests in hayfields was about 5 cm higher on average than vegetation height in native grasslands. Age of these hayfields was likely important, as the well-established fields were patchy in terms of forb coverage and were largely grass-dominated, which was preferable for Sprague's Pipits (Fisher, 2010).

In northeastern Montana, Sprague's Pipit preferred grasslands with moderate herbaceous cover (Lipsey and Naugle, 2017). Pipit abundance was positively related to grass, forb, and small clubmoss (*Selaginella densa*) coverage; density of live and dead herbaceous vegetation; and litter depth; and negatively related to coverage of shrubs, bare ground, and tame vegetation. In northwestern North Dakota mixed-grass prairies, Madden and others (2000) reported visual obstruction to be the best predictor of Sprague's Pipit occurrence. The probability of occurrence decreased with increasing visual obstruction: model-predicted probabilities were 50 percent at 8-cm visual obstruction and 5 percent at 19-cm visual obstruction. Sprague's Pipits preferred prairie with short and sparse cover, avoiding unburned prairie with deep litter (Madden, 1996). In the same area in northwestern North Dakota, Robbins (1998) reported that male breeding territories were located on ridgetops and other elevated areas characterized by short grass and low sedge and forb densities. In north-central North Dakota, Sprague's Pipits were present in mixed-grass prairies with lower litter depth, lower maximum vegetation height, and lower percentage cover of shrubs than in unoccupied grasslands (Grant and others, 2004). Occurrence was not related to percentage cover of total live vegetation. In North Dakota mixed-grass prairies in central and northwestern North Dakota, Schneider (1998) reported that Sprague's Pipit abundance was positively correlated with percentage cover of small clubmoss and negatively correlated with percentage cover of grass, litter depth, density of low shrubs, and total number of vegetation contacts. The strongest predictors of Sprague's Pipit occurrence were decreasing litter and decreasing percentage cover of bare ground.

The placement of nests by Sprague's Pipit may be tied to vegetation structure. In Saskatchewan mixed-grass pastures, Sprague's Pipit nests were in areas positively related to the density of standing dead vegetation 10–20 cm above the ground, the number of live grass contacts 10–20 cm above the ground, vegetation height, and litter depth, and they were negatively related to the density of live grass 0–10 cm above the ground (Davis, 2003a). In southern Saskatchewan, pipit nest survival was affected primarily by temporal factors (nest age and date) rather than by habitat or landscape features (Davis and others, 2016). In two studies in mixed-grass pastures in Saskatchewan, nest sites were in areas with significantly higher grass and sedge coverage and maximum plant height, and lower forb and shrub coverage, bare ground coverage, and forb density, than nonnest sites (Sutter, 1997; Pipher, 2011). Similarly, in another Saskatchewan study, Davis (2005) found Sprague's Pipit nests in areas with moderately tall, thick cover and few shrubs. In native pastures and hayfields in Saskatchewan, Fisher and Davis (2011a) determined that Sprague's Pipits selected nest sites with intermediate vegetation height (about 25–30 cm). Fisher and Davis (2011b) studied postfledging habitat in native pastures and tame grasslands used for hay production in southern Saskatchewan. Sprague's Pipit fledglings were associated with vegetation about 3 cm taller than the surrounding available vegetation in native pastures. In tame hayfields, vegetation was more uniform in height, but pipit fledglings were associated with vegetation that was about 11 cm taller than the vegetation utilized in native pastures. Fisher and Davis (2011b) indicated that the taller vegetation in the tame hayfields may have been unsuitable for fledglings to effectively forage or to detect and avoid predators. In Alberta, Ludlow and others (2015) determined that nest survival was lower in areas with a high percentage cover of crested wheatgrass. In Montana, Sprague's Pipit nest sites were characterized by taller and denser vegetation relative to the areas within a 5-m radius of the nest sites (that is, the nest plots), and nest plots were characterized by greater litter coverage and depth and less cactus coverage than random areas (Dieni and Jones, 2003). In northeastern Montana and southwestern North Dakota, Bernath-Plaisted and others (2019) reported that Sprague's Pipit nest success was lower at intermediate values of vegetation density around nest sites.

Moisture levels may affect the abundance, occurrence, or productivity of Sprague's Pipits, but as Niemuth and others (2017) indicated, the biological meaning of climate variables in models characterizing bird-environment relationships is unclear; climate variables are likely correlates of other factors (for example, plant community composition, primary and secondary productivity) that more directly influence species occurrence, likely in concert with other factors such as soils and landform. In mixed-grass prairies in southeastern Alberta, precipitation was included in the best model for explaining variation in daily nest survival of pipits, but the confidence limits overlapped at zero (Ludlow and others, 2014). In a second study in native grasslands of southeastern Alberta, Wiens and others (2008) reported that the best model of Sprague's Pipit occurrence included a positive relationship with a Conserved Soil Moisture index, which is an estimate of soil moisture on May 1 using a weighted combination of precipitation data from the previous 2 years. In a third study in southeastern Alberta, Sprague's Pipit occurrence was negatively correlated with a compound topographic index, indicating that the species selects 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. In northeastern Montana and southwestern North Dakota, Sprague's Pipit nest success was negatively affected by maximum daily temperature but unaffected by precipitation-related variables (Bernath-Plaisted and others, 2019). In western North Dakota, density of Sprague's Pipits declined during a severe drought but returned to normal levels 1 year postdrought (George and others, 1992). 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 ºC. Sprague's Pipits ranked low in vulnerability during the breeding season at a 1.5 ºC increase, moderate at 2 ºC, and high at 3 ºC, with a projected 95 percent loss of the modeled current breeding distribution.

Several studies have used data from the North American BBS to evaluate the influence of precipitation, temperature, and other environmental variables in shaping the distribution and occurrence of Sprague's Pipits. Using a combination of BBS, eBird (ebird.org; Sullivan and others, 2009), and point-count data, Nixon and others (2016) modeled the impact of future climate change scenarios on Sprague's Pipit breeding distribution along the boreal forest-prairie ecotone in Alberta and predicted that pipits would shift dramatically northward within the next 80 years, with limited potential for expansion of areal coverage of suitable breeding habitat and only small core areas of stable climate remaining. Using BBS data for four States that constitute the Badlands and Prairies Bird Conservation Region, Gorzo and others (2016) reported that Sprague's Pipit abundance was not related to within- or previous-year standardized temperature or precipitation indices. Using BBS data for seven States that constitute the United States portion of the northern Great Plains, Niemuth and others (2017) reported that the occurrence of Sprague's Pipits was negatively associated with long-term (30-year) mean annual precipitation and positively associated with current-year and previous-year precipitation anomalies. Current-year precipitation anomaly was defined as the subtraction of current-year March–June precipitation from the long-term mean, and previous-year precipitation anomaly was the difference between previous year's precipitation and long-term mean precipitation. Sprague's Pipits also exhibited a quadratic relationship with the long-term (30-year) mean August temperature. Niemuth and others (2008) examined the influence of seasonal moisture on Sprague's Pipit abundance and distribution along 13 BBS routes in northern North Dakota and reported that pipit abundance was negatively associated with the number of prairie potholes containing water in May of the same year and in May of the previous year. Pipit distribution was not influenced by moisture. Using BBS data and other point-count data, Lipsey and others (2015) evaluated the role of precipitation and landscape variables in shaping Sprague's Pipit distribution throughout the species' breeding range. Pipits selected landscapes with a high proportion of continuous grassland within a relatively cool, moist climate. The strongest predictors of pipit occurrence were the Palmer Drought Severity Index, growing-season precipitation, and summer precipitation balance. More specifically, the probability of occurrence declined with increases in the Palmer Drought Severity Index and growing-season precipitation. Sprague's Pipit probability of occurrence exhibited a quadratic relationship with summer precipitation balance; pipit occurrence was lowest at intermediate values of summer precipitation balance (Lipsey and others, 2015).

Area Requirements and Landscape Associations

In Saskatchewan, average Sprague's Pipit territory size was 1.9 hectares (ha; 94 territories) in native pastures and 1.7 ha (97 territories) in tame hayfields (Fisher and Davis, 2011a). In a Saskatchewan study evaluating post-fledging movements of Sprague's Pipits, the average territory size for adult males was 2.5 ha (30 territories) during the first week after fledging (Davis and Fisher, 2009). In mixed-grass prairies in northern Montana, average territory size was 0.45 ha (Jones, 2011).

Most studies of Sprague's Pipits have been conducted in extensive grasslands (for example, Maher, 1973; Owens and Myres, 1973; Dale, 1983; Faanes, 1983; Wilson and Belcher, 1989; Pylypec, 1991; Madden, 1996; Davis and others, 2006), suggesting that the species is most common in large grassland areas. In a 2-year study in Saskatchewan, Davis (2003a, 2004) reported that Sprague's Pipits were area sensitive, and that the minimum area requirement was about 145 ha. Occurrence of Sprague's Pipits was negatively related to edge-to-area ratio in the first year and positively related to patch size in the second year. Furthermore, the number of young produced in successful nests increased with the size of the habitat patch. In another Saskatchewan study, Davis and others (2006) determined that the density of Sprague's Pipits and nest survival increased with pasture size.

Proximity to habitat edges may influence Sprague's Pipit distribution, abundance, or productivity. In mixed-grass prairies in southern Alberta, relative abundance of Sprague's Pipits increased as the distance to water, cropland, and forage increased; Sprague's Pipit abundance was not related to distance to roads (Koper and Schmiegelow, 2006; Koper and others, 2009; Sliwinski and Koper, 2012). Sprague's Pipit abundance increased by at least 0.3 individual per point count per kilometer (km) away from cropland and forage fields. Models predicted that only 3.4 percent of the grassland patches in the study area contained habitat that would support at least 50 percent of the maximum relative abundance of Sprague's Pipits because edge effects extended for long distances (Koper and Schmiegelow, 2006; Koper and others, 2009). Sprague's Pipits declined in abundance by 25 percent or more within 0.91 km of cropland edges and within 0.35 km of wetland edges (Sliwinski and Koper, 2012). In Saskatchewan, most of 47 nests were within 100 m of roads and an average of 20.7 m from the nearest perch (shrub or rock) (Sutter, 1996). In Montana mixed-grass prairies, Jones and White (2012) reported no effect of distance to edge on daily survival of pipit nests. Edge types were secondary paved roads, tertiary improved roads, unimproved dirt roads, an agricultural field, an active railroad right-of-way, and a lacustrine shoreline. In Manitoba mixed-grass prairies, Sprague's Pipit occurrence was negatively affected by density of forest edge (described as a perimeter-area ratio) at scales of 1,200; 1,600; 2,400; and 3,200 m, but not at scales of 800; 4,000; or 4,800 m (Durán, 2009). Abundance of Sprague's Pipits was negatively associated with edge density from 1,200 to 3,200 m (Durán, 2009). In North Dakota mixed-grass prairies, Grant and others (2004) compared species' sensitivity to woody encroachment at the territory and landscape levels. Sprague's Pipits were present in grasslands with low amounts of aspen woodland within 100 m; occurrence was not related to the percentage of aspen woodland within 500 m.

The amount of grassland surrounding a particular grassland patch may positively affect Sprague's Pipit distribution and abundance. Within the Prairie Pothole Region of Canada, Fedy and others (2018) examined the influence of grassland, cropland, shrubland, woodland, and wetland habitats at 4 scales (400; 800; 1,600; and 3,200 m within BBS stops) on the relative probability of occurrence of Sprague's Pipits. The best model for predicting occurrence indicated the species' preference for landscapes consisting of tame grasslands and other perennial cropland grown for hay, pasture, or seed within 1,600 m; tame and native grasslands within 1,600 m; and an abundance of wetland basins within 3,200 m. The model indicated avoidance of wooded landscapes within 3,200 m of BBS stops. Using a spatially hierarchical approach with data from over 32,000 point-count surveys conducted within the northern Great Plains of the United States and Canadian Prairie Provinces, Lipsey and others (2017) found that Sprague's Pipit occupancy was positively related to grass coverage at the intermediate level of three scales (2.6, 93, and 1,492 square kilometers [km^2]) and with Normalized Difference Vegetation Index (NDVI), an indication of live green biomass, at all scales. Pipit occupancy was positively related to the interaction of grassland coverage and NDVI at intermediate and broad scales, indicating that the positive relationship with NDVI occurred only when grassland amount also was high. In mixed-grass prairies in northeastern Montana, Lipsey and others (2015, 2017) evaluated the role of landscape factors influencing Sprague's Pipit breeding distribution by examining grassland bird distribution and abundance at four spatial extents (0.7, 2.6, 93, and 1,492 km^2). Sprague's Pipits preferred landscapes with a high proportion of continuous grassland. More specifically, the probability of occurrence increased as the proportion of grassland within 1 km^2 of avian survey points and grassland aggregation within 10.4 km^2 (a measure of fragmentation) increased. A 260-ha patch of grassland was three times more likely to be occupied by Sprague's Pipits if situated in a landscape with a high proportion of grasslands at intermediate (93-km^2) and broad (1,492-km^2) scales compared to landscapes with a low proportion of grasslands. Lipsey (2015) further estimated that a 40,469-ha grassland embedded in a landscape consisting of 40 percent grass would support 4,900 Sprague's Pipits, whereas the same area embedded in a landscape consisting of 15 percent grass would support 800 Sprague's Pipits. Davis and others (2013) examined the extent to which the amount and type of grassland in the surrounding landscape influenced the abundance of Sprague's Pipits on native and planted grasslands in Alberta and Saskatchewan. Sprague's Pipit abundance in native and tame grasslands increased with the amount of native grassland in the landscape. The amount of planted grassland in the landscape had little effect on pipit abundance in Alberta. In the dry mixed-grass prairie and northern fescue grassland regions in southeastern Alberta, Sprague's Pipit occurrence was positively influenced by increasing grassland cover within a 400-m radius of point-count centers (Clements, 2014). In a Saskatchewan study in native and planted pastures and hayfields, Davis and others (2016) reported that Sprague's Pipit abundance increased with the amount of native grassland within 400 m of the study plots and declined with the amount of cropland surrounding the grassland study plots. Niemuth and others (2017) investigated the relationship between Sprague's Pipit occurrence and land use within 1,200 m of BBS point counts throughout the northern Great Plains; occurrence was positively associated with percent coverage of grasslands (native and tame) and negatively associated with percent coverage of open water and topographic variation. Sprague's Pipits exhibited a quadratic relationship with percent coverage of cropland. Using point-count surveys collected over 4 years throughout the northern Great Plains, Dreitz and others (2017) demonstrated that occupancy of Sprague's Pipits was positively related to latitude and to percentage of grassland and sagebrush habitat within 1-km^2 survey plots and negatively related to public landownership. Using data from 16,728 point-count surveys in the northern Great Plains, Correll and others (2019) quantified the relationship between grassland habitat specialism and species population trends; the authors determined that species with high specialism rankings, such as the Sprague's Pipit, are vulnerable to declining population trends.

Brood Parasitism by Cowbirds and Other Species

Brood parasitism of Sprague's Pipit nests by Brown-headed Cowbirds (*Molothrus ater*) is uncommon and has been reported only in Saskatchewan, Manitoba, and Montana (De Smet, 1992; Davis, 1994, 2003b; Davis and Sealy, 2000; Jones and others, 2010). Sprague's Pipit nests may be multiply parasitized (Friedmann, 1963; Davis and Sealy, 2000; Davis, 2003b). Shaffer and others (2019) summarized rates of Brown-headed Cowbird brood parasitism in Sprague's Pipit nests from the literature; cowbird parasitism rates varied from 0 percent (several studies in Shaffer and others, 2019) to 18 percent of 17 nests (Davis, 1994; Davis and Sealy, 2000). In a Saskatchewan study, 15 percent of 65 nests were parasitized, and no cowbird young successfully fledged (Davis, 2003b). In Montana, 2 percent of 128 nests were parasitized, and two cowbird young fledged (Jones and others, 2010).

In Manitoba, Brown-headed Cowbird brood parasitism was higher in Sprague's Pipit nests on a smaller (22 ha) site than on two larger (64 ha) sites (Davis and Sealy, 2000), but in Saskatchewan, there was no relationship between parasitism and patch size (Davis, 2003a). Parasitism frequency or intensity did not vary with pasture size or year, nor were they related to the ratio of cowbird to host density (Davis, 2003a). In Saskatchewan, parasitized nests were significantly farther from cowbird perch sites than unparasitized nests (S.K. Davis, Canadian Wildlife Service, Regina, Saskatchewan, written commun. [n.d.]). There was no difference in concealment cover between parasitized and unparasitized nests. Davis (2003b) also found that clutch size, the number of host eggs hatched, and the numbers of host young fledged per nest were lower in parasitized nests than in nonparasitized nests. The number of host eggs incubated full term that hatched, and the number of host young fledged per successful nest were not significantly different in parasitized and non-parasitized nests.

Breeding-Season Phenology and Site Fidelity

Sprague's Pipits arrive on the breeding grounds in April and early May and depart for their wintering grounds in September and October (Bent, 1965; Maher, 1973; Stewart, 1975; Robbins, 1998; Davis, 2003b; Davis and others, 2014b). Bimodal song displays (Robbins, 1998) and clutch initiations (Maher, 1973) during the breeding season suggest that at least some Sprague's Pipits raise two clutches (Davis and others, 2014b). In Saskatchewan, Maher (1973) reported clutch initiation dates ranging from May 11 to July 29, whereas Davis and Holmes (2012) reported dates ranging from May 14 to July 12. Sutter (1996), also working in Saskatchewan, found two peaks of breeding activity (May 21–31 and July 1–10) in 1994 and a single peak (June 1–10) in 1995. Davis (2018) found that a peak initiation period of mid- to late May was similar between native and tame grasslands in Saskatchewan, but that pipits continued to initiate clutches until mid- to late July in native grasslands but not in tame grasslands. In Montana, clutch initiation dates ranged from May 7 to July 31, with a peak date of May 23 (Jones and others, 2010). In North Dakota, (Stewart, 1975) reported two periods of breeding activity for Sprague's Pipits: the first from late April to early June and the second from mid-July to early September. Using radio-tagged birds, Sutter and others (1996) and Davis (2009) determined that females lay replacement clutches and that some females are double-brooded. Dohms and Davis (2009) documented the first record of polygyny for this species.

Site fidelity has not been well-studied for the Sprague's Pipit. In Montana mixed-grass prairies, Sprague's Pipits exhibited low site fidelity; 2.1 percent of 48 adult males and 0 percent of 160 nestlings captured and banded during a 7-year period returned to the study site (Jones and others, 2007). In Saskatchewan, Brewster (2009) examined whether landscape, habitat, or territory characteristics affected fidelity rates for Sprague's Pipits. No relationship was detected in fidelity rates between grass-dominated and crop-dominated landscapes or between native and tame grasslands, or in distances from the point of pipit capture to the nearest crop, road, or percentage of native grass, planted grass, water, or woody vegetation within landscape and territory buffers around the capture point. In another Saskatchewan study, Van Wilgenburg and others (2012) examined breeding philopatry and dispersal and reported that a relatively high proportion of pipits were apparent immigrants into the breeding population rather than local birds, which suggested low breeding philopatry at this study area.

Species' Response to Management

Sprague's Pipits are generally most abundant in idle native grasslands, but they also occur in grasslands that have experienced light-to-heavy grazing, prescribed burning, and, in some cases, mowing in the previous year (Maher, 1973; Owens and Myres, 1973; Karasiuk and others, 1977; Kantrud, 1981; Faanes, 1983; Dale, 1984; Pylypec, 1991; Wershler and others, 1991; Bock and others, 1993; Anstey and others, 1995; Skeel and others, 1995; Madden, 1996; Prescott and Wagner, 1996; Sutter, 1996; Dale and others, 1997; Bleho, 2009; White, 2009; Fisher and Davis, 2011a; Pipher, 2011; Sliwinski, 2011; Richardson, 2012; Lusk and Koper, 2013). Nevertheless, nesting success may be reduced by disturbances associated with burning or haying (Maher, 1973; Stewart, 1975), heavy grazing (Owens and Myres, 1973; Kantrud and Kologiski, 1982; Bock and others, 1993; Anstey and others, 1995; Davis and others, 1999), or by research activities, such as radio telemetry (Sutter, 1996), if the activities occur between late April and early September.

Several studies have evaluated the effects of the time since the last burn, frequencies of burns, and the interaction between burning and grazing systems on Sprague's Pipit breeding populations. In a south-central Saskatchewan study on native grasslands of plains rough fescue (*Festuca hallii*), Sprague's Pipit populations declined for the first 2 years following fall burns and then recovered to densities similar to those in unburned areas (Pylypec, 1991). In southwestern Saskatchewan mixed-grass prairies, White (2009) evaluated the interaction between burning and grazing on Sprague's Pipit abundance over 2 years. In the first year post-burn, Sprague's Pipit abundance was reduced on burned prairies, regardless of whether the prairies had been grazed or ungrazed. In the second year post-burn, Sprague's Pipit abundance was greatly reduced by burning and slightly reduced by grazing. Within the same Saskatchewan mixed-grass prairies, Richardson and others (2014) evaluated the interaction between burning and grazing on Sprague's Pipit abundance 1–5 years post-burn. Over 5 years, Sprague's Pipit abundance was always higher at undisturbed sites that were neither grazed nor burned and lowest in sites that were both burned and grazed. Richardson and others (2014) concluded that Sprague's Pipits showed stronger initial avoidance of burned sites than grazed sites, but the effects of burning were similarly negative in grazed compared to ungrazed sites. In Manitoba, density of Sprague's Pipits in mixed-grass prairies was not related to time since the last burn, measured as 1-, 2-, 7-, and 40-years post-burn (Champagne, 2011). In northwestern North Dakota, Sprague's Pipits were absent from unburned, idle grasslands; highest abundance was reached in areas burned 2 years previously (Madden, 1996). Abundance was highest in grasslands that had been burned four times in the previous 15 years, compared to unburned areas and areas burned one to two times in the previous 15 years (Madden and others, 1999). Working in the same mixed-grass prairies as Madden (1996), Danley and others (2004) reported that the frequency of occurrence of singing male Sprague's Pipits was similar in plots that had been prescribe-burned only and plots that had been 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).

The effects of haying on Sprague's Pipit abundance or productivity have been poorly studied. Owens and Myres (1973) and Dale and others (1997) indicated that periodically hayed lands were avoided, but Sprague's Pipits often returned to haylands the first year after mowing, when vegetation had recovered sufficiently. In Saskatchewan, Sprague's Pipits were more abundant and had higher productivity indices in idle native grasslands than in either native haylands or tame haylands (Dale and others, 1997). Fisher and Davis (2011a) reported that Saskatchewan hayfields mowed in late July provided suitable nesting habitat for Sprague's Pipits in the following breeding season. Davis (2018) similarly reported that planted grasslands mowed the previous growing season attracted Sprague's Pipits but cautioned that these grasslands may become unsuitable later in the breeding season as the species of tame grasses become too tall and dense for suitable nesting habitat. In a study of avian use of grazed and hayed native prairies in North Dakota, Kantrud (1981) indicated that Sprague's Pipits were absent from haylands mowed the previous year, possibly due to excessively thick vegetation and absence of litter. De Smet and Conrad (1991) reported little direct damage to nests from mowing; however, Dale and others (1997) reported consistently higher productivity indices in unmowed hayland than in hayland mowed during the nesting season. In recent years, several studies have evaluated the use of reproductive indices, such as the one used by Dale and others (1997), as an alternative to nest searching and monitoring of grassland birds and suggested that reproductive indices often lack the ability to predict nest fate or to provide reliable estimates of reproductive performance at the territory or plot level (Rivers and others, 2003; Althoff and others, 2009; Morgan and others, 2010). The results related to productivity reported by Dale and others (1997) should be evaluated within the context and caveats of the growing body of literature on this topic.

Heavily grazed grasslands generally support fewer Sprague's Pipits than ungrazed grasslands, as heavy grazing often reduces vegetation height and density below levels preferred by Sprague's Pipits (Maher, 1973; Owens and Myres, 1973; Dale, 1984; Bock and others, 1993; Sutter, 1996; Sliwinski, 2011; but see Kantrud [1981] for Sprague's Pipit use of heavily grazed pastures). Lightly to moderately grazed grasslands are used by pipits throughout their breeding range (Owens and Myres, 1973; Kantrud and Kologiski, 1982; Bock and others, 1993; Anstey and others, 1995; Davis and others, 1999; Bleho, 2009; White, 2009; Pipher, 2011; Richardson, 2012; Lusk and Koper, 2013). In Saskatchewan, Sprague's Pipit occurrence in native pastures was negatively associated with heavy grazing and moist mixed-grass prairies (Davis and others, 1999). The species occurred more frequently in lightly to moderately grazed native pastures than in heavily grazed native pastures. Also in Saskatchewan, Bleho (2009) reported no difference in Sprague's Pipit abundance between moderately grazed and ungrazed mixed-grass prairies. In northeastern Montana, Lipsey and Naugle (2017) reported no relationship between Sprague's Pipit abundance and the amount of biomass removed by grazing livestock and that cattle use, without a consideration of precipitation amount and soil productivity, was a poor predictor of herbaceous cover.

Grazing intensity, livestock type, and grazing system may influence the nesting success or abundance of Sprague's Pipit. In a meta-analysis of 18 grazing studies conducted in Canada, Bleho and others (2014) determined that nest destruction was highest at moderate stocking rates, possibly because the species avoids heavily grazed pastures. Probability of nest destruction was 0.2 at a stocking rate of 0.8–0.9 animal unit month (AUM) per ha but was zero at 0.2–0.4 and 1.3 AUMs per ha. Nest survival rates and probability of nests not being depredated were higher in ungrazed pastures than grazed pastures. Of grazed pastures, nest survival rates and probability of nests not being depredated were higher in moderately grazed pastures (that is, 33–65 percent of available forage used) than in lightly grazed pastures (that is, 33 percent of available forage used) (Bleho and others, 2014). In Saskatchewan mixed-grass prairies, nest success in lightly and moderately grazed pastures (0.25–0.54 AUM per ha) was not influenced by stocking rates in either of the 2 years of a study by Lusk (2009) and Lusk and Koper (2013). Working in the same grasslands, Pipher and others (2016) reported that grazing intensity and years grazed had a nonlinear effect on nest survival in 1 of 2 years. Grazing intensity and years grazed interacted such that nests in pastures grazed for several years had lowest survival rates at low to intermediate grazing intensities (0.2–0.4 AUM per ha). Nests in pastures grazed for more than 15 years had a lower survival rate than nests in pastures grazed for 2–3 years at similar grazing intensities. In another Saskatchewan study, Sliwinski (2011) determined that Sprague's Pipits were most abundant in ungrazed pastures and decreased in abundance with increased grazing intensity; declines were more severe in American bison (*Bison bison*)-grazed pastures than in cattle-grazed pastures. In North Dakota, Sprague's Pipits were among the most common species on plots grazed by cattle, but they were absent from plots grazed by bison (Lueders and others, 2006). In mixed-grass prairies in northeastern Montana, Sprague's Pipits did not respond to grazing intensity during controlled grazing experiments, despite being one of the most common species surveyed (Lipsey, 2015).

In a meta-analysis of 18 grazing studies conducted in Canada, Bleho and others (2014) reported that the rate of cattle-induced nest destruction (that is, direct destruction or abandonment) for Sprague's Pipits remained constant among season-long (May–September) and rotational grazing (that is, rest rotation and deferred) systems. In Alberta, Sprague's Pipits preferred early-season native pastures (grazed in early summer), infrequently occupied early-season tame pastures (grazed from late April to mid-June) and season-long grazed native pastures, and were fairly common in deferred-grazed native pastures (grazed after July 15) (Prescott and Wagner, 1996). In a two-year study in southcentral Saskatchewan mixed-grass pastures, Davis and others (2014a) reported no difference in the abundance of Sprague's Pipits on season-long versus rotational grazing pastures subjected to similar grazing intensity. In Manitoba, Sprague's Pipits showed no preference between plots managed with season-long grazing and plots managed with twice-over rotational grazing; however, the species was more abundant on grazed plots than on idle plots (Ranellucci, 2010; Ranellucci and others, 2012). Likewise, in North Dakota, Schneider (1998) compared relative abundances of grassland birds in plots under different grazing regimes and reported no difference in relative abundances for Sprague's Pipit between plots grazed season-long and plots grazed using a twice-over rotational grazing system.

Sprague's Pipits exhibit inconsistent responses to the presence of trails and roads. Several studies have examined the impact of trails and roads on Sprague's Pipit abundance, occurrence, nest-site selection, and productivity in southeastern Alberta (Linnen, 2008; Dale and others, 2009; Ludlow and others, 2015; Bernath-Plaisted and Koper, 2016; Nenninger and Koper, 2018; Daniel and Koper, 2019) and Saskatchewan (Sutter and others, 2000). Linnen (2008) reported that the relative abundance and occurrence of Sprague's Pipits were significantly lower 50 m from access roads than at 150, 250, 350, or 450 m from access roads; there also were significantly fewer Sprague's Pipits at 150 and 250 m from access roads than at 350 m. Dale and others (2009) indicated that Sprague's Pipit territories were negatively associated with two-track trails in grasslands; pipit territories rarely crossed these trails. Sprague's Pipits avoided nesting within 100 m of trails associated with oil and gas development, but not gravel roads (Ludlow and others, 2015). Fewer young were fledged from successful nests near trails than nests further from trails; proximity to roads did not influence density or nest success, and no relationship was found between frequency of brood parasitism (based on a combination of all parasitized nests for the suite of songbird species evaluated) and distance to gravel roads or trails. Bernath-Plaisted and Koper (2016) and Daniel and Koper (2019) reported no relationship between nest success and distance to nearest road; however, Daniel and Koper (2019) reported that Sprague's Pipit abundance was lower near roads, whereas clutch size was higher near roads. In lightly to moderately grazed native prairies in Saskatchewan, Sprague's Pipits were significantly more abundant alongside trails (single pairs of wheel ruts visually indistinct from surrounding habitat in terms of plant structure and composition) than alongside roads (traveling surfaces with adjacent drainage ditches planted to smooth brome and ending with a fence 11–18 m from the traveling surface) (Sutter and others, 2000). Nenninger and Koper (2018) determined that Sprague's Pipit densities increased farther from roads in Alberta. In another Alberta study, average Sprague's Pipit abundance was nearly two times lower on roadside point counts (mean abundance 0.156 bird per point count) than on off-road point counts (that is, 800 m from the nearest roadside count; 0.284 bird per point count) (Wellicome and others, 2014). Fisher (2010) examined the relationship between Sprague's Pipit probability of occurrence and distance to roads, cropland, water, and woody vegetation. In Alberta, pipit probability of occurrence was higher further from water (range of 100 to 1,200 m), but the effect was weak; in Saskatchewan, pipit probability of occurrence increased 0.2 between the closest (100 m) and farthest (3,000 m) distances away from a road edge. No relationships were found between probability of occurrence and distance to cropland or woody vegetation (Fisher, 2010).

Sprague's Pipit abundance, occurrence, and productivity often are lower near energy infrastructure. Van Wilgenburg and others (2013) estimated the magnitude of nest loss for Sprague's Pipits in Canada due to habitat disturbances created by oil and gas exploration. The estimate of potential lost recruitment was 336–775 pipits per year. Sutter and others (2016) assessed the effects of construction of an oil pipeline that extends from eastern Alberta to southwestern Manitoba on Sprague's Pipit productivity and nesting behavior. Sprague's Pipit nests were evenly distributed across close plots (that is, adjacent to pipeline) and distant plots (that is, 600 m away from the pipeline). Daily nest survival and number of young surviving to day eight increased with increasing distance from the pipeline right-of-way. Estimates of pipit daily survival rate at 0, 350, and 1,000 m from the right-of-way equates to nest success of 29, 43, and 62 percent, respectively. Mean maximum noise levels during pipeline activity included frequencies that overlapped the song range of Sprague's Pipits; noise levels exceeded the 49-decibel threshold (that is, the level set for an upper limit for continuous noise within breeding habitat) within 250 m of the pipeline right-of-way (Sutter and others, 2016).

Several studies have examined the impact of oil and gas extraction in southeastern Alberta (Linnen, 2008; Dale and others, 2009; Hamilton and others, 2011; Rodgers, 2013; Bernath-Plaisted and Koper, 2016; Rodgers and Koper, 2017; Nenninger and Koper, 2018; Daniel and Koper, 2019). Linnen (2008) reported that relative abundance and occurrence were significantly lower 50 m from oil wells than at 150, 250, 350, or 450 m from oil wells; there also were significantly fewer Sprague's Pipits at 150 and 250 m from oil wells than at 350 m. Dale and others (2009) determined that Sprague's Pipit abundance decreased as density of natural gas wells increased from 1.5 to 6.2 wells per km^2, and the species also showed an avoidance of nonnative vegetation associated with gas and oil development. Hamilton and others (2011) found that Sprague's Pipits were less abundant in areas with high natural gas well density (6.2 wells per km^2) than in areas with low well density (3.5 wells per km^2); overall, human disturbance to vegetation was negatively related to the occurrence of pipits. Rodgers (2013) and Rodgers and Koper (2017) reported that Sprague's Pipit abundance increased at greater distances from natural gas wells; no relationship was found between abundance and well density (ranging from 0 to 7.7 wells per km^2) or vegetation structure. Daniel and Koper (2019) determined that Sprague's Pipit abundance increased steadily up to 149 m from oil wells and 760 m from natural gas wells. Abundance declined above a gas well density of 6 wells per section (with a range from 0 to 36 well pads per km^2). Clutch size increased as distance to natural gas wells increased, whereas no relationship was found between clutch size and distance to oil wells or to density of wells, and no relationships were found between nest success and distance to oil or natural gas wells or to density of wells (Daniel and Koper, 2019). Ludlow and others (2015) reported that Sprague's Pipit nest locations relative to oil and gas wells did not differ from random locations. Well proximity did not affect nest survival, and well presence did not influence the frequency of cowbird brood parasitism (based on a combination of all parasitized nests for the suite of songbird species evaluated). Bernath-Plaisted and Koper (2016) examined the influence on nest success of several types of oil and gas infrastructure, including pumpjacks, screwpumps, and compressors, and found no relationship between Sprague's Pipit nest success and infrastructure. Nenninger and Koper (2018) found that Sprague's Pipit densities were nearly 2.5 times greater on control sites (legal quarter-sections at least 800 m from oil structures) than on legal quarter-sections with oil infrastructure. On oil sites, Sprague's Pipit densities were more than 31 percent higher 400 m from the center point of survey transects than at 100 m. On control sites, Sprague's Pipit densities were more than two times higher than on generator-powered well sites and four times higher than on grid-powered well sites. On pumpjack sites, Sprague's Pipit densities were 51 percent higher 400 m from pumpjacks than at 100 m. On screwpump sites, Sprague's Pipit densities remained low across all distances (100–400 m) (Nenninger and Koper, 2018).

In southwestern Saskatchewan, abundance of Sprague's Pipit was not influenced by proximity or density (ranging from 0 to 15.7 wells per km^2) of natural gas wells or to vegetation structure (Kalyn Bogard and Davis, 2014). In Saskatchewan, Sprague's Pipits tended to avoid minimal-disturbance gas wells and associated trails, although not significantly so (Linnen, 2008). In northwestern North Dakota, Thompson and others (2015) estimated a 350-m avoidance distance for Sprague's Pipits at single-bore oil-well sites. Using BBS data, Bohannon and Blinnikov (2019) examined the relationship between Sprague's Pipit abundance and habitat fragmentation in western North Dakota and eastern Montana caused by oil-extraction activities. The local pipit population significantly declined with increasing edge density (that is, the amount of linear edge per total landscape area).

Beston and others (2016) developed a prioritization system to identify avian species most likely to experience population declines in the United States from wind facilities based on the species' current conservation status and the species' expected risk from wind turbines. The Sprague's Pipit scored a 2.10 out of nine based on 428 species evaluated. Beston and others (2016) estimated that 1.71 percent of the Sprague's Pipit breeding population in the United States is exposed to wind facilities.

Management Recommendations from the Literature

Protecting or restoring large tracts of grassland habitat, especially native grasslands, will maintain viable Sprague's Pipit populations and decrease rates of nest depredation and cowbird brood parasitism (Stewart, 1975; De Smet and Conrad, 1991; Davis and Sealy, 2000; Davis, 2003a; Skinner, 2004; Davis and others, 2006). Protecting native grasslands is especially critical for Sprague's Pipits, as this species infrequently uses or nests in tame grasslands (Davis and others, 2013, 2016). Conservation of private grazing lands is vital, as most of the Sprague's Pipit population in the United States and Canada occur on private rangeland (Lipsey and others, 2015). Skinner and Clark (2008) cautioned that conservation actions that target areas to support higher duck species richness may not provide adequate essential habitat for Sprague's Pipits if conservation focuses only on areas of moderate-to-high wetland density without consideration of the surrounding landscape composition or configuration.

Converting nonnative uplands, including hayland, pasture, and cropland, to native vegetation may benefit Sprague's Pipits, especially if the parcels are located near existing native grasslands (Berkey and others, 1993; Sutter, 1996; Dale and others, 1997; Fisher, 2010; Davis and others, 2013). Fisher and Davis (2011b) determined that tame grasslands planted to nonnative species, such as bluegrass and smooth brome, had lower postfledging survival rates and higher fledgling dispersal distances than native grasslands. Fisher (2010) recommended that planted grasslands be planted with narrow-leaved grass species and that seeding mixtures contain <10 percent alfalfa. Davis and others (2013) cautioned against seeding cultivated land with exotic grasses and forbs, which may benefit grassland songbird generalists more than Sprague's Pipit and other grassland specialists; however, converting cropland to nonnative grassland near existing native grassland may benefit specialist grassland birds in a cropland-dominated landscape.

Maintaining grasslands free of woody vegetation is beneficial to nesting Sprague's Pipits (Faanes, 1983; Berkey and others, 1993; Anstey and others, 1995; Madden, 1996). Grant and others (2004) recommended the cessation of programs that encourage the planting of trees and tall shrubs within grasslands. In grassland areas that have been heavily invaded by woody vegetation, Grant and others (2004) suggested that managers should 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. To prevent the encroachment of woody vegetation into grasslands, Madden (1996) and Madden and others (1999) recommended burning grasslands once every 2 to 4 years and cautioned that Sprague's Pipit populations can be expected to decline immediately after burning because vegetation must recover before Sprague's Pipit will recolonize areas.

Haying all or portions of fields in alternate years or delaying haying within a season may provide suitable vegetation structure for nesting Sprague's Pipits. Dale and others (1997) recommended dividing large fields in half, with each half being mowed in alternate years; this may ensure productivity of a hay crop and birds, whereas idling of an entire hayfield may be detrimental for Sprague's Pipits. Delaying mowing until after July 15 may allow higher fledging rates, at least in years with normal breeding phenology (Berkey and others, 1993; Dale and others, 1997). In years with delayed nesting, mowing may have to be delayed until late July or August to protect most nests and fledglings (Dale and others, 1997). Mowing hayfields in late summer also may provide suitable breeding habitat for the next season (Fisher and Davis, 2011a). However, Fisher and Davis (2011a) and Davis (2018) indicated that planted grasslands become unsuitable for pipits as the breeding season progresses, likely because of the rapid growth of tame vegetation. Fisher and Davis (2011a) demonstrated that tame hayfields with a low amount of alfalfa coverage and with vegetation height around 20–30 cm are important for attracting nesting Sprague's Pipits, but that recently established hayfields with a high coverage of forbs are unsuitable as breeding habitat. Davis (2018) cautioned that planted grasslands managed with mowing may become ecological traps, even when mowing is done outside of the breeding season.

Throughout the Sprague's Pipit's breeding range, light-to-moderate grazing may be beneficial to nesting pipits, but heavy grazing is considered detrimental (Maher, 1973; Kantrud and Kologiski, 1982; Dale, 1983; Wershler and others, 1991; Bock and others, 1993; Sutter, 1996; Pipher, 2011; Lusk and Koper, 2013). Pipher (2011) suggested that maintaining tracts of ungrazed pastures or maintaining grazed pastures at stocking rates of about 0.5 AUM per ha, but no higher, may be beneficial for increasing nest success. The meta-analysis by Bleho and others (2014) indicated that nest destruction was highest at moderate stocking rates, perhaps because pipits avoided nesting in heavily grazed grasslands. Sliwinski (2011) determined that Sprague's Pipits were most abundant in ungrazed pastures and decreased in abundance with increased grazing intensity. Davis and others (2014a) recommended improving range condition in pastures classified as low and fair while ensuring that pastures with higher range conditions are maintained. Grazing tame pastures in spring allows disturbances in native pastures to be deferred until later in the season, which improves habitat conditions in the native pastures for Sprague's Pipits (Prescott and Wagner, 1996). To benefit Sprague's Pipits and other grassland birds, Lipsey and Naugle (2017) advocated for a holistic view of grazing management in which the annual removal of herbaceous cover by livestock is monitored within the context of environmental constraints such as soil productivity and weather pattern.

To protect Sprague's Pipit populations from the effects of excessive noise levels on reproductive success near oil infrastructure, Sutter and others (2016) recommended a minimum set-back distance of 350 m for high-disturbance activities, such as pipeline construction. Thompson and others (2015) reported that Sprague's Pipits avoided areas within 350 m of unconventional oil-well sites. Thompson and others (2015) also recommended minimizing the footprint of oil development by clustering oil wells along corridors and on bore pads rather than placing numerous single-bore well pads throughout the landscape. Ludlow and others (2015) recommended minimizing the effects of oil and gas development on grassland birds by minimizing trail creation associated with oil and gas developments, by using directional drilling of multiple wells from one lease site, and by minimizing the spread of crested wheatgrass in native grasslands. Nenninger and Koper (2018) and Daniel and Koper (2019) suggested that the most effective way to minimize the effects of oil and gas extraction on Sprague's Pipits would be to minimize aboveground infrastructure and roads. Examples of mitigation include burying power distribution lines, dismantling and reclaiming inoperative oil wells, and horizontal drilling of new wells from existing well pads (Nenninger and Koper, 2018).

References

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.

Bent, A.C., 1965, Sprague's Pipit (*Anthus spragueii*), in Bent, A.C., ed., Life histories of North American wagtails, shrikes, vireos, and their allies. Order Passeriformes: New York, N.Y., Dover Publications, Inc., p. 52–62. [Also available at https://doi.org/10.5479/si.03629236.197.1.]

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 birds 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.

Bernath-Plaisted, J., and Koper, N., 2016, Physical footprint of oil and gas infrastructure, not anthropogenic noise, reduces nesting success of some grassland songbirds: Biological Conservation, v. 204, p. 434–441. [Also available at https://doi.org/10.1016/j.biocon.2016.11.002.]

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.]

Bock, C.E., Saab, V.A., Rich, T.D., and Dobkin, D.S., 1993, Effects of livestock grazing on Neotropical migratory landbirds in western North America, *in* Finch, D.M., and Stangel, P.W., eds., Status and management of Neotropical migratory birds: Fort Collins, Colo., U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-229, p. 296–309.

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.]

Brewster, K.R., 2009, Role of landscape composition and geographical location on breeding philopatry in grassland passerines—A stable isotope approach: Saskatoon, Saskatchewan, University of Saskatchewan, Master's Thesis, 125 p.

Champagne, J., 2011, Effects of fire on the distribution and abundance of Sprague's Pipit (*Anthus spragueii*) and their invertebrate prey: Winnipeg, Manitoba, University of Manitoba, Master's Thesis, 79 p.

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.]

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.

Daniel, J., and Koper, N., 2019, Cumulative impacts of roads and energy infrastructure on grassland songbirds: The Condor, v. 121, no. 2, p. 1–21.

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. [Also available at https://academic.oup.com/auk/article/121/4/1130/5562398.]

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://doi.org/10.1093/condor/107.3.605.]

Davis, S.K., 2009, Renesting intervals and duration of the incubation and nestling periods of Sprague's Pipits: Journal of Field Ornithology, v. 80, no. 3, p. 265–269. [Also available at https://dx.doi.org/10.1111/j.1557-9263.2009.00229.x.]

Davis, S.K., 2018, Sprague's Pipit breeding biology and reproductive success in planted and native grasslands: Journal of Avian Biology, v. 49, no. 4, p. 1–12. [Also available at https://doi.org/10.1111/jav.01547.]

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., 2014a, Response of grassland songbirds to grazing system type and range condition: Proceedings of the North American Prairie Conference, v. 23, 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., and Fisher, R.J., 2009, Post-fledging movements of Sprague's Pipit: The Wilson Journal of Ornithology, v. 121, no. 1, p. 198–202. [Also available at https://doi.org/10.1676/08-025.1.]

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., and Holmes, T.G., 2012, Sprague's Pipit incubation behavior, *in* Ribic, C.A., Thompson, F.R., III, and Pietz, P.J., eds., Video surveillance of nesting birds: Studies in Avian Biology, v. 43, p. 67–76.

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., Robbins, M.B., and Dale, B.C., 2014b, Sprague's Pipit (*Anthus spragueii*) (ver. 2.0), *in* Poole, A.F., ed., The birds of North America: Ithaca, N.Y., Cornell Lab of Ornithology, accessed November 2019 at https://birdsna.org/Species-Account/bna/species/sprpip/introduction. [Also available at https://doi.org/10.2173/bna.439.]

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., 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.]

Dohms, K.M., 2009, Sprague's Pipit (*Anthus spragueii*) nestling provisioning and growth rates in native and planted grasslands: Regina, Saskatchewan, University of Regina, Master's Thesis, 94 p.

Dohms, K.M., and Davis, S.K., 2009, Polygyny and male parental care by Sprague's Pipit: The Wilson Journal of Ornithology, v. 121, no. 4, p. 826–830. [Also available at https://doi.org/10.1676/08-165.1.]

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.]

Durán, S.M., 2009, An assessment of the relative importance of Wildlife Management Areas to the conservation of grassland songbirds in south-western Manitoba: Winnipeg, Manitoba, University of Manitoba, Master's Thesis, 81 p.

Faanes, C., 1983, Breeding birds of wooded draws in western North Dakota: Prairie Naturalist, v. 15, no. 4, p. 173–187.

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.]

Fisher, R.J., 2010, Landscape and local factors affecting the use of native and planted grasslands by Sprague's Pipits: Regina, Saskatchewan, University of Regina, Ph.D. Dissertation, 204 p.

Fisher, R.J., and Davis, S.K., 2011a, Habitat use by Sprague's Pipits (*Anthus spragueii*) in native pastures and planted, non-native hay fields: The Auk, v. 128, no. 2, p. 273–282. [Also available at https://doi.org/10.1525/auk.2011.10148.]

Fisher, R.J., and Davis, S.K., 2011b, Post-fledging dispersal, habitat use, and survival of Sprague's Pipits—Are planted grasslands a good substitute for native?: Biological Conservation, v. 144, no. 1, p. 263–271. [Also available at https://doi.org/10.1016/j.biocon.2010.08.024.]

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.]

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.

Hamilton, L.E., Dale, B.C., and Paszkowski, C.A., 2011, Effects of disturbance associated with natural gas extraction on the occurrence of three grassland songbirds: Avian Conservation and Ecology, v. 6, no. 1, article 7. [Also available at https://dx.doi.org/10.5751/ACE-00458-060107.]

Hartley, M.J., 1994, Passerine abundance and productivity indices in grasslands managed for waterfowl nesting cover in Saskatchewan, Canada: Baton Rouge, La., Louisiana State University, Master's Thesis, 42 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., 2009, Breeding bird use of grasslands enrolled in the Conservation Reserve Program in the northern Great Plains: Fargo, N. Dak., North Dakota State University, Ph.D. Dissertation, 199 p.

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.

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 northcentral 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 White, G.C., 2012, The effect of habitat edges on nest survival of Sprague's Pipits: The Wilson Journal of Ornithology, v. 124, no. 2, p. 310–315. [Also available at https://doi.org/10.1676/11-151.1.]

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 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.

Karasiuk, D., Vriend, H., Stelfox, J.G., and McGillis, J.R., 1977, Avifauna—Study results from Suffield, 1976, *in* Stelfox, J.G., compiler, Effects of livestock grazing on mixed prairie range and wildlife within PFRA pastures, Suffield Military Reserve: Edmonton, Alberta, Canadian Wildlife Service, Range Wildlife Study Commission, p. 33–44.

Koper, N., and Schmiegelow, F.K.A., 2006, A multi-scaled analysis of avian response to habitat amount and fragmentation in the Canadian dry mixed-grass prairie: Landscape Ecology, v. 21, p. 1045–1059. [Also available at https://dx.doi.org/10.1007/s10980-006-0004-0.]

Koper, N., Walker, D.J., and Champagne, J., 2009, Nonlinear effects of distance to habitat edge on Sprague's Pipits in southern Alberta, Canada: Landscape Ecology, v. 24, no. 10, p. 1287–1297. [Also available at https://doi.org/10.1007/s10980-009-9375-3.]

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., Doherty, K.E., Naugle, D.E., Fields, S., Evans, J.S., Davis, S.K., and Koper, N., 2015, One step ahead of the plow—Using cropland conversion risk to guide Sprague's Pipit conservation in the northern Great Plains: Biological Conservation, v. 194, p. 739–749. [Also available at https://doi.org/10.1016/j.biocon.2015.08.030.]

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.]

Lipsey, M.K., Naugle, D.E., Nowak, J., and Lukacs, P.M., 2017, Extending utility of hierarchical models to multi-scale habitat selection: Diversity and Distributions, v. 23, no. 7, p. 783–793. [Also available at https://doi.org/10.1111/ddi.12567.]

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.

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 a 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. 124–33. [Also available at https://doi.org/10.1016/j.biocon.2017.11.014.]

Niemuth, N.D., Estey, M.E., Fields, S.P., Wangler, B., Bishop, A.A., Moore, P.J., Grosse, R.C., and Ryba, A.J., 2017, Developing spatial models to guide conservation of grassland birds in the U.S. northern Great Plains: The Condor, v. 119, no. 3, p. 506–525. [Also available at https://dx.doi.org/10.1650/CONDOR-17-14.1.]

Niemuth, N.D., Reynolds, R.E., Granfors, D.A., Johnson, R.R., Wangler, B., and Estey, M.E., 2008, Landscape-level planning for conservation of wetland birds in the U.S. Prairie Pothole Region, *in* Millspaugh, J.J., and Thompson, F.R., III, eds., Models for planning wildlife conservation in large landscapes: Burlington, Mass., Elsevier Science, p. 533–560. [Also available at https://dx.doi.org/10.1016/B978-0-12-373631-4.00020-4.]

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.]

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.]

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://doi.org/10.1016/j.rama.2016.07.001.]

Prescott, D.R.C., and Murphy, A.J., 1996, Habitat associations of grassland birds on native and tame pastures of the aspen parkland in Alberta: Edmonton, Alberta, Alberta North American Waterfowl Management Plan Centre, NAWMP-021, 36 p.

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 North American Waterfowl Management Plan 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.

Ranellucci, C.L., 2010, Effects of twice-over rotation grazing on the relative abundances of grassland birds in the mixed-grass prairie region of southwestern Manitoba: Winnipeg, Manitoba, University of Manitoba, Master's Thesis, 144 p.

Ranellucci, C.L., Koper, N., and Henderson, D.C., 2012, Twice-over rotational grazing and its impacts on grassland songbird abundance and habitat structure: Rangeland Ecology and Management, v. 65, no. 2, p. 109–118. [Also available at https://dx.doi.org/10.2111/REM-D-11-00053.1.]

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.]

Robbins, M.B., 1998, Display behavior of male Sprague's Pipits: The Wilson Bulletin, v. 110, no. 3, p. 435–438.

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.]

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 November 2019 at https://www.mbr-pwrc.usgs.gov/bbs/bbs2012.shtml.

Saunders, A.A., 1914, The birds of Teton and northern Lewis and Clark counties, Montana: The Condor, v. 16, no. 3, p. 124–144. [Also available at https://dx.doi.org/10.2307/1362243.]

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 November 2019 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., 2012, Grassland bird response to three edge types in a fragmented mixed-grass prairie: Avian Conservation and Ecology, v. 7, no. 2, article 6. [Also available at https://dx.doi.org/10.5751/ACE-00534-070206.]

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

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. Dissertation, 144 p.

Sutter, G.C., 1997, Nest-site selection and nest-entrance orientation in Sprague's Pipit: The Wilson Bulletin, v. 109, no. 3, p. 462–469.

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., Davis, S.K., Skiffington, J.C., Keating, L.M., and Pittaway, L.A., 2016, Nesting behaviour and reproductive success of Sprague's Pipit (*Anthus spragueii*) and Vesper Sparrow (*Pooecetes gramineus*) during pipeline construction: Canadian Field-Naturalist, v. 130, no. 2, p. 99–109. [Also available at https://dx.doi.org/10.22621/cfn.v130i2.1833.]

Sutter, G.C., Sawatzky, D., Cooper, D.M., and Brigham, R.M., 1996, Renesting intervals in Sprague's Pipit, *Anthus spragueii*: Canadian Field-Naturalist, v. 110, no. 4, p. 694–697.

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.]

Van Wilgenburg, S.L., Hobson, K.A., Bayne, E.M., and Koper, N., 2013, Estimated avian nest loss associated with oil and gas exploration and extraction in the western Canadian sedimentary basin: Avian Conservation and Biology, v. 8, no. 2, article 9. [Also available at https://dx.doi.org/10.5751/ACE-00585-080209.]

Van Wilgenburg, S.L., Hobson, K.A., Brewster, K.R., and Welker, J.M., 2012, Assessing dispersal in threatened migratory birds using stable hydrogen isotope (δD) analysis of feathers: Endangered Species Research, v. 16, no. 1, p. 17–29. [Also available at https://dx.doi.org/10.3354/esr00383.]

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, 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.]

Wilson, S.D., and Belcher, J.W., 1989, Plant and bird communities of native prairie and introduced Eurasian vegetation in Manitoba, Canada: Conservation Biology, v. 3, no. 1, p. 39–44. [Also available at https://dx.doi.org/10.1111/j.1523-1739.1989.tb00222.x.]

Table W1. Measured values of vegetation structure and composition in Sprague's Pipit (*Anthus spragueii*) 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; ≤, less than or equal to; --, no data; <, less than; >, greater than; n.d., no date; 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)
Anstey and others, 1995	Saskatchewan	Mixed-grass prairie, tame grassland	Grazed	≤10	--	--	--	--	--	--	--
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	--
Champagne, 2011 (plots)	Manitoba	Mixed-grass prairie	Burned	34.2	--	--	--	--	8.9	--	2.9
Davis, 2005 (nests)	Saskatchewan	Mixed-grass prairie	--	<25	--	--	--	--	<10	--	<5
Davis and others, 1999	Saskatchewan	Mixed-grass prairie	Light grazing intensity	--	--	--	--	--	<10	--	--
Dieni and Jones, 2003 (nests)	Montana	Mixed-grass prairie	Idle	31.7	14[a]	50.2	14.5	0.5	0.7	10.9	11.2
Dieni and Jones, 2003 (nest vicinity)	Montana	Mixed-grass prairie	Idle	25.9	9[a]	--	--	--	--	--	--
Fisher, R.J., written commun. [n.d.], (nests)	Saskatchewan	Mixed-grass prairie	Grazed	22	--	--	13.8	--	1.8	--	0.5
Fisher, R.J., written commun. [n.d.], (nests)	Saskatchewan	Tame grassland	Hayed	27.2	--	--	6.4	--	2.5	--	0.7
Fisher, R.J., written commun. [n.d.], (territories)	Saskatchewan	Mixed-grass prairie	Grazed	19.8	--	--	9.7	--	5.8	--	--
Fisher, R.J., written commun. [n.d.], (territories)	Saskatchewan	Tame grassland	Hayed	19.4	--	--	4.8	--	7.7	--	--
Grant and others, 2004	North Dakota	Mixed-grass prairie	Multiple	49	--	--	--	10.7	--	--	2.6
Kalyn Bogard, 2011	Saskatchewan	Mixed-grass prairie	Grazed	10.3	--	44.7	9.5	--	43.7	--	0.2
Lueders and others, 2006	North Dakota	Mixed-grass prairie	Cattle-grazed	--	7[a]	35.3[b]	11.7	0.4	22.4	24.6	1.2
Lusk, 2009[c] (nests)	Saskatchewan	Mixed-grass prairie	Grazed, ungrazed	--	--	26	2.7	2.8	0	41.3	1.8
Madden, 1996	North Dakota	Mixed-grass prairie	Burned	--	13[a]	43.9	21.3	17.8	--	--	3.1

Table W1. Measured values of vegetation structure and composition in Sprague's Pipit (*Anthus spragueii*) 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; ≤, less than or equal to; --, no data; <, less than; >, greater than; n.d., no date; 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)
Pipher, 2011 (nests)	Saskatchewan	Mixed-grass prairie	Grazed	46.1	--	--	--	--	--	--	2.5
Rodgers, 2013	Alberta	Mixed-grass prairie	--	22.8	--	35.8	11.1	--	2.9	--	0.2
Schneider, 1998	North Dakota	Mixed-grass prairie	Grazed	--	8.3[a]	33.3	13.7	--	2.8	--	1.2
Sliwinski, 2011	Saskatchewan	Mixed-grass prairie	Cattle- and bison (*Bison bison*)-grazed	30.8	--	29.9	4.9	--	1.4	34.3	4.7
Sutter, 1997 (nests)	Saskatchewan	Mixed-grass prairie	Grazed	27.7	--	52.7[b]	--	10.5[d]	16.8	15.2	2.4
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

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

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

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

[d]Forb and shrub cover combined.

For more information about this publication, contact:
Director, USGS Northern Prairie Wildlife Research Center
8711 37th Street Southeast
Jamestown, ND 58401
701–253–5500

For additional information, visit: https://www.usgs.gov/centers/npwrc

Publishing support provided by the
Rolla Publishing Service Center

Shaffer and others—**The Effects of Management Practices on Grassland Birds—Sprague's Pipit (*Anthus spragueii*)**—Professional Paper 1842–W

ISSN 2330-7102 (online)
https://doi.org/10.3133/pp1842W