

The Effects of Management Practices on Grassland Birds— Sedge Wren (*Cistothorus stellaris*)

Chapter V of

The Effects of Management Practices on Grassland Birds



Professional Paper 1842–V
Version 1.1, July 2022

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

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Background photograph: Northern mixed-grass prairie in North Dakota, by Rick Bohn, used with permission.

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The Effects of Management Practices on Grassland Birds

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

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DAVID BERNHARDT, Secretary

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Conversion Factors

International System of Units to U.S. customary units

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

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as
 $^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32.$

Abbreviations

BBS	Breeding Bird Survey
CRP	Conservation Reserve Program
DNC	dense nesting cover
n.d.	no date
PPR	Prairie Pothole Region
spp.	species (applies to two or more species within the genus)

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Capsule Statement

Keys to Sedge Wren (*Cistothorus stellaris*) management include providing tall, dense grasslands with moderate forb coverage and minimizing disturbances during the breeding season. Sedge Wrens have been reported to use habitats with 30–166 centimeters (cm) average vegetation height, 8–80 cm visual obstruction reading, 15–75 percent grass cover, 3–78 percent forb cover, less than or equal to (\leq) 15 percent shrub cover, less than ($<$) 35 percent bare ground, 10–30 percent litter cover, and \leq 6 cm litter depth. The descriptions of key vegetation characteristics are provided in table V1 (after the “References” section). Vernacular and scientific names of plants and animals follow the Integrated Taxonomic Information System (<https://www.itis.gov>).

Breeding Range

Sedge Wrens breed in North and South America; there are 19 recognized subspecies of Sedge Wren, including 1 in North America, 8 in Mexico and Central America, and 10 in South America (Robbins and Nyári, 2014). This account will focus on the North American subspecies (*Cistothorus stellaris stellaris*). In North America, the species breeds from eastern Saskatchewan through southern Manitoba and southern Ontario to southern Maine and New Brunswick; south from northeastern Montana and central North Dakota, through eastern South Dakota, to eastern Kansas and eastern Oklahoma; and east to New Jersey, Rhode Island, and New Hampshire (National Geographic Society, 2011). The relative densities of Sedge Wrens in the United States and southern Canada, based on North American Breeding Bird Survey (BBS) data (Sauer and others, 2014), are shown in figure V1 (not all geographic places mentioned in report are shown on figure).



Sedge Wren. Illustration by Patsy D. Renz, used with permission.

Suitable Habitat

Sedge Wrens use a wide variety of habitats, generally preferring mesic or upland habitats with tall, dense herbaceous vegetation and moderate forb coverage (Bent, 1964; Stewart, 1975; Renken, 1983; Skinner and others, 1984; Clausen, 1989; Sample, 1989; Herkert and others, 2020), although the species also has been reported in mesic grasslands of short (30 cm) and moderate (1.2 meter [m]) heights in Nebraska and Kansas (Tordoff and Young, 1951; Bedell, 1987). Sedge Wrens use natural and restored wetlands (Cink, 1973; Brady, 1983; Dault, 2001; Begley and others, 2012; Igl and others, 2017). The species breeds in vegetation around fresh and alkaline wetlands and in wet meadows, sedge (*Carex* species [spp.]) meadows, fens, peatlands, bogs, cattail (*Typha* spp.)-dominated wetlands,

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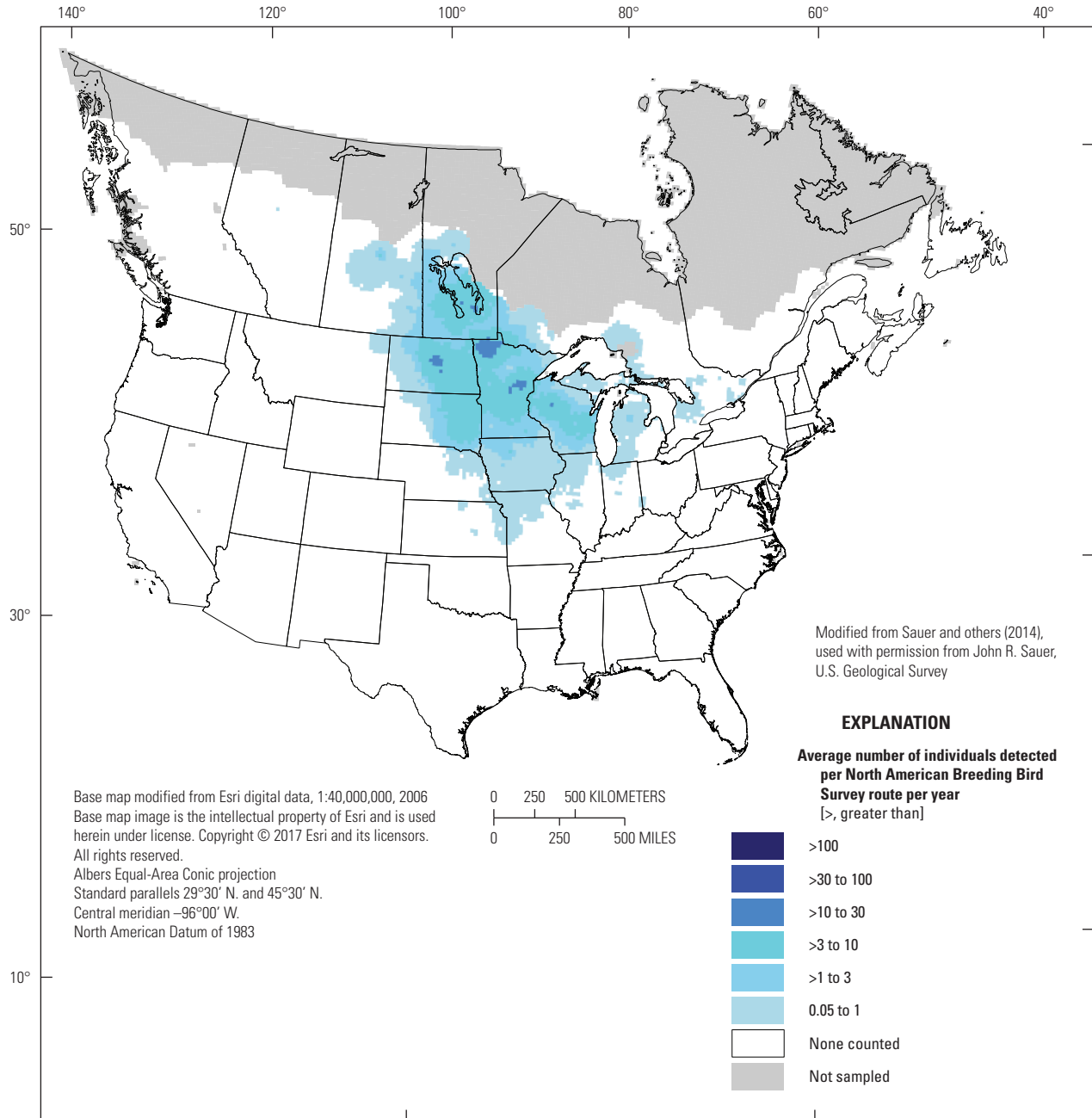


Figure V1. The breeding distribution of the Sedge Wren (*Cistothorus stellaris*) in the United States and southern Canada, based on North American Breeding Bird Survey (BBS) data, 2008–12. The BBS abundance map provides only an approximation of breeding range edges.

and shrubby wetlands. The species' range of these mesic habitats include the boreal wetlands of Canada (Morissette and others, 2013; Taylor, 2018), the numerous basins within the Prairie Pothole Region (PPR) of the northern United States and southern Canada (Stewart, 1975; Knapton, 1979; Johnsgard, 1980; Taylor, 2018; Anderson and others, 2019), the wet meadows along the Platte River of Nebraska (Cink, 1973; Bedell, 1987; Lingle and Bedell, 1989; Bedell, 1996; Helzer, 1996; Helzer and Jelinski, 1999), the peatlands and marshes of Minnesota and Wisconsin (Niemi and Hanowski, 1984; Niemi,

1985; Mancini and Rusch, 1988), and the peatlands and coastal wetlands around the Great Lakes (Terrill, 1922; Mousley, 1934; Walkinshaw, 1935; Riffell and others, 2003; Robert and others, 2009; Gnass Giese and others, 2018). Sedge Wrens use native and tame vegetation in mesic or dry grasslands that are idled, burned, mowed, or lightly grazed (Eddleman, 1974; Johnsgard, 1980; Faanes, 1981; Skinner and others, 1984; Bedell, 1987; Clausen, 1989; Sample, 1989; Herkert, 1994a; Bakker and others, 2002; Renfrew and Ribic, 2002; Grant and others, 2004; Cunningham and Johnson, 2006; Mozel, 2010;

Pillsbury and others, 2011; Bruinsma, 2012; Igl and Johnson, 2016; Elliott and Johnson, 2017). The species inhabits planted cover (for example, Conservation Reserve Program [CRP] fields and dense nesting cover [DNC]) (Renken and Dinsmore, 1987; Johnson and Schwartz, 1993b; Dhol and others, 1994; Hartley, 1994; Jones, 1994; King and Savidge, 1995; Best and others, 1997; Prescott and Murphy, 1999; McCoy and others, 2001; Roth and others, 2005; Vogel, 2011; Osborne and Sparling, 2013), riparian filter strips (Henningsen and Best, 2005), grassed waterways (Bryan and Best, 1994), and grassy terraces (Hultquist and Best, 2001).

Sedge Wrens occupy many types of mesic grasslands and wetlands. In a survey of 1,190 wetlands throughout the PPR of North Dakota and South Dakota, Sedge Wrens were associated with 127 wetlands ranging from fresh to saline and varying widely in size and permanence (Igl and others, 2017). The species was observed in nearly equal proportions regardless of wetland type (alkali, permanent, semipermanent, seasonal, or temporary [wetland classification based on Stewart and Kantrud, 1971]), management (natural or restored), or ownership (private or public). Wetlands inhabited by Sedge Wrens were characterized as having an average of 36 percent emergent vegetation, 34 percent wet meadow, 29 percent open water, and 2 percent shore/mudflat (Igl and others, 2017). In eastern Nebraska, the species was found in bluestem (species was not provided) prairies adjacent to wetlands (Bedell, 1987); in wetlands dominated by cattail, prairie cordgrass (*Spartina pectinata*), and reed canary grass (*Phalaris arundinacea*) and surrounded by wet meadow (Cink, 1973); in wet meadows dominated by big bluestem (*Andropogon gerardii*), prairie cordgrass, Indiangrass (*Sorghastrum nutans*), smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), and redtop (*Agrostis stolonifera*) (Helzer and Jelinski, 1999); and near wetland borders where predominant wetland vegetation included water sedge (*Carex aquatilis*), common ragweed (*Ambrosia artemisiifolia*), and river bulrush (*Bolboschoenus fluviatilis*) (Lingle and Bedell, 1989). In northern Minnesota peatlands, Sedge Wrens inhabited sedge fens, open bogs (dominated by swamp birch [*Betula pumila*]), low-shrub communities (dominated by *Ericacea* spp.), and high-shrub (that is, shrub-swamp) communities (dominated by willows [*Salix* spp.]) but did not inhabit black spruce (*Picea mariana*) communities (Nevers and others, 1981; Niemi and Hanowski, 1984). In central Minnesota, Sedge Wrens were observed within wetlands invaded by hybrid cattail (*Typha* × *glauca*) (Anderson and others, 2019). In northwestern Iowa, Sedge Wrens nested in natural seasonal and semipermanent wetlands and restored wetlands (Dault, 2001) and in drier parts of wetlands consisting of reed canary grass and river bulrush (Crawford, 1977). Within agricultural landscapes in Iowa, the species established territories in grassy, weedy edges between hayland and waterways (Frawley, 1989) and in CRP filter strips adjacent to cropland (Henningsen and Best, 2005). In northeastern Illinois riparian bottomland south of Lake Michigan, the species used wet meadows dominated by sedges and bluejoint (*Calamagrostis canadensis*) (Birkenholz, 1973).

Along Green Bay of Wisconsin and Michigan, Sedge Wrens used shallow coastal wetlands; dominant vegetation consisted of sedges, grasses, cattails, common reed (*Phragmites australis*), bulrushes (*Schoenoplectus* spp.), and reed canary grass (Gnass Giese and others, 2018). Along the northern shoreline of Lake Huron in Michigan, Sedge Wrens inhabited seasonally or shallowly flooded wet meadows dominated by sedges and hummock-forming grasses, such as bluejoint, and varying amounts of bulrush (*Scirpus* spp.), cattail, and shrubs (Riffell and others, 2003). Throughout Michigan, the species preferred nesting in dense sedge meadows, where water was not always present; dominant vegetation consisted of small-leaved sedges, small grasses, ferns (sensitive fern [*Onoclea sensibilis*] and marsh fern [*Thelypteris palustris*]), and willows (Walkinshaw, 1935). In fens in southern Quebec, territory occupancy was not related to coverage of dominant plant species; Sedge Wrens selected territories with high lateral visibility (that is, low vertical cover) and low coverage of shrubs (Robert and others, 2009).

Sedge Wrens show no clear preference for native or tame grasslands. In mixed-grass prairies in north-central North Dakota, Grant and others (2004) found that Sedge Wren occurrence was not related to percentage cover of native grass and forb species, Kentucky bluegrass, or smooth brome and quackgrass (*Elymus repens*) combined. Occurrence was positively related to percentage cover of sweetclover (*Melilotus* spp.) within a 100-m radius. In south-central North Dakota, Sedge Wrens were the most common species within fields seeded to native grasses (western wheatgrass [*Pascopyrum smithii*] and green needlegrass [*Nassella viridula*]) (Higgins and others, 1984). In eastern South Dakota and western Minnesota, Sedge Wren density was higher in fields seeded to a mixture of cool- and warm-season grasses than in monotypic fields of switchgrass (*Panicum virgatum*) or intermediate wheatgrass (*Thinopyrum intermedium*), or in native, unbroken prairie (Bakker and Higgins, 2009). In CRP grasslands in Nebraska, the species preferred native warm-season grasses more than nonnative cool-season grass-legume fields (Delisle and Savidge, 1997). In another Nebraska study, the species used areas around wetlands that had been seeded to dense, native grasses, such as big bluestem, switchgrass, tall mannagrass (*Glyceria* spp.), or Indiangrass (Clausen, 1989). In eastern Nebraska and western Iowa, Sedge Wren density was lowest in warm-season grasslands planted with a high-diversity seeding mixture and highest in warm-season grasslands planted with a low-diversity seeding mixture (Cox and others, 2014). In Iowa, Sedge Wren density was higher in grasslands planted to cool-season, tame grass species than in newly planted grasslands seeded to warm-season, native grass species (Vogel, 2011). Sedge Wren density did not differ, however, among several other plantings, including mature stands of native, warm-season grasslands and grasslands planted to a high-diversity mix of over 40 species of native grasses and forbs (Vogel, 2011). Within CRP filter strips in Iowa, Sedge Wren density did not differ between strips planted to cool-season plant mixtures and strips planted to warm-season mixtures (Henningsen and Best, 2005).

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In Missouri, Sedge Wrens were present at low but similar abundances in CRP fields that had been planted to either cool-season or warm-season grasses (McCoy and others, 2001). In northeastern Illinois, Sedge Wren abundance was unaffected by the invasion of reed canary grass (coverage ranging from zero to nearly 100 percent) in wetlands (Spyreas and others, 2010).

Sedge Wrens prefer tall, dense vegetation with deep litter. In mixed-grass prairies in North Dakota, Sedge Wrens were present in grasslands characterized by deep litter and high maximum vegetation height; occurrence was not related to the percentage cover of live vegetation (Grant and others, 2004). In tame grasslands in northeastern North Dakota, Sedge Wren abundance was positively related to live vegetation height and visual obstruction reading (Cole, 2016). In eastern South Dakota, Sedge Wren occurrence was positively related to mean height of the tallest grass in tallgrass and mixed-grass prairies and to mean height of the tallest forb in tallgrass prairies (Bakker and others, 2002). In tallgrass prairies, Sedge Wren density was positively associated with mean height of the tallest forb and litter depth, whereas in mixed-grass prairies, density was positively associated with mean height of the tallest grass and negatively associated with litter depth. In planted grasslands in eastern South Dakota, Sedge Wren abundance was positively correlated with greater height of dead vegetation, litter depth, and percentage cover of dead vegetation, and negatively correlated with greater percentage cover of live vegetation, alfalfa (*Medicago sativa*), and bare ground (Bahm and others, 2011). In southwestern Minnesota grassland patches, Sedge Wren density increased with increasing visual obstruction reading; increasing vegetation height up to 60 cm; and increasing coverage of litter, forbs, and dead vegetation (Elliott and Johnson, 2017). Abundance decreased with increasing coverage of grass. Sedge Wren density showed a linear correlation with less bare ground, but the species was generally unaffected by bare ground. In central Minnesota wetlands managed for invasion by hybrid cattail, Sedge Wrens were not associated with cattail density or vegetation biomass (Anderson and others, 2019). In Wisconsin, Sedge Wrens preferred habitats with a high density of standing and prostrate residual vegetation (Sample, 1989). Densities of Sedge Wrens were positively related to maximum vegetation height, vegetation height-density (that is, visual obstruction), herbaceous coverage, standing residual cover, and water cover. Abundance was negatively related to exposed soil (Sample, 1989). In another Wisconsin study, abundance of Sedge Wrens was similar in upland and lowland pastures and was positively associated with vegetation height-density (Renfrew and Ribic, 2002). In tallgrass prairies of Iowa and Missouri, densities of Sedge Wrens were positively associated with vegetation height-density and litter cover (Pillsbury, 2010; Pillsbury and others, 2011). On lightly grazed or idle prairies in Missouri, Sedge Wren habitat included the following combined mean percentages of grass and forb cover at four heights: 23 percent at 1 cm, 64 percent at 25 cm, 17 percent at 50 cm, and <1 percent at 100 cm (Skinner and others, 1984). In Illinois tallgrass

prairies, Sedge Wren densities were positively associated with average grass height, average number of live grass contacts, total vegetation richness, vegetation heterogeneity, and total number of contacts of live grasses, forbs, and residual vegetation (Herkert, 1991a). Densities were negatively associated with percentage of live vegetation contacts. Positive predictors of occurrence were high average number of contacts of grass, forb, and dead plant material, and high variability in litter depth, vegetation height, and vegetation density; the only negative predictor was average vegetation height (Herkert, 1994b). Within Illinois tallgrass prairie fragments, Sedge Wren densities were positively related to height of dead vegetation (Buxton and Benson, 2016).

Sedge Wrens commonly use planted grasslands during the breeding season, especially those that provide tall, dense vegetation. In Alberta, Sedge Wrens were present in low numbers in 3- to 4-year old tame DNC grasslands (Prescott and Murphy, 1999). In Saskatchewan, Sedge Wrens preferred DNC grasslands (tame or native not specified) to idle native grasslands or wheat (*Triticum* spp.) fields (Hartley, 1994). In Manitoba, Sedge Wren abundance was higher in native and tame DNC grasslands than in idle native grasslands; productivity was higher in native DNC grasslands than in idle grasslands, but not significantly higher than in tame DNC grasslands (Dhol and others, 1994; Jones, 1994). In North Dakota, Sedge Wren density was significantly higher in DNC grasslands than in either idle or grazed native prairies (Renken and Dinsmore, 1987). DNC habitat was characterized by high grass and litter coverage, moderate forb coverage, low shrub coverage, and little bare ground (Renken, 1983). In CRP grasslands in Minnesota, Montana, North Dakota, and South Dakota, Sedge Wren density was positively associated with grass coverage (Johnson and Schwartz, 1993a, 1993b). In Minnesota, Sedge Wrens nested in former wastewater treatment ponds that were converted to grasslands seeded to native grass and forb species (Mundahl and Borsari, 2016). In Nebraska CRP fields, Sedge Wren abundance was positively associated with vertical density, percentage of grass cover, and litter depth and was negatively associated with percentages of litter cover and bare ground (Delisle and Savidge, 1997). In eastern Nebraska and western Iowa, Sedge Wrens were detected exclusively in conservation grasslands (that is, National Wildlife Refuges, CRP grasslands, and restored and remnant prairies) and were not detected in unmanaged marginal grasslands (that is, field borders and terraces) (Cox and others, 2014). In Iowa tallgrass prairies and grasslands restored to tallgrass species, Sedge Wren densities were positively correlated with the percentage of total vegetation cover (Fletcher and Koford, 2002). In Iowa restored grasslands, Sedge Wren densities were positively associated with vegetation height-density and litter depth (Vogel, 2011). In Wisconsin, Sedge Wrens nested in CRP fields planted to switchgrass, which provided tall, dense vegetation (Roth and others, 2005).

Sedge Wrens tolerate a limited amount of short-statured woody vegetation (Niemi and Hanowski, 1984; Grant and others, 2004; Panci and others, 2017; Morissette and others,

2013). In North Dakota mixed-grass prairies, Sedge Wren occurrence at the territory level (within 100-m radius of study plots) was not related to the percentage cover of shrubs ≤ 1 m tall but was negatively related to the percentage cover of shrubs greater than ($>$) 1 m tall and to percentage cover of quaking aspen (*Populus tremuloides*) woodland (Grant and others, 2004). In tallgrass prairies in southeastern North Dakota, occurrence of Sedge Wrens was positively associated with wetland cover and negatively associated with woodland cover at the 50-m scale (Cunningham and Johnson, 2006). In southwestern Minnesota grasslands, Elliott and Johnson (2017) reported that Sedge Wren density was highest at sites with no shrub cover but was unaffected by distance to trees and trees within 100 m. In northeastern Minnesota lowland brush ecosystems including swamp, fen, and wet-meadow communities, Sedge Wren abundance was negatively related to stem height, stem density, and woody species count (Hawkinson 2019). In northern Minnesota peatlands, Niemi and Hanowski (1984) characterized the habitat in which Sedge Wrens were most abundant (>15 pairs per 10 ha) as having low (1–2 m high), patchily distributed shrubs intermixed with sedges and in which median shrub densities were between 11 and 32 stems per 0.0025 ha. Where Sedge Wren abundance was lower (<5 pairs per 10 ha), shrubs were dense (>100 stems per 0.0025 hectare [ha]) and not as patchily distributed. Nevers and others (1981) reported high densities of Sedge Wrens in shrub-swamp peatland communities, characterized by shrub heights ranging from 0.3 to 4 m, but the authors also reported that the species occurred in open bogs and fens with shrub heights ranging from 0.3 to 2.3 m. Panci and others (2017) explained that the shrub-swamp community often was classified as emergent herbaceous wetland in land-cover databases and reported that Sedge Wren occurrence along Great Lakes coastal wetlands was positively related to the presence of shrub-swamp communities. In southern Wisconsin grassland habitats, Sedge Wrens tolerated woody vegetation (<2 percent of total vegetation cover) but avoided dense stands of woody vegetation (Sample, 1989).

Climatic factors may affect the abundance, distribution, and nesting success of Sedge Wrens. In southeastern Saskatchewan and southwestern Manitoba, Sedge Wrens were less common in dry years than in wet years and used wet meadows during the latter (Knapton, 1979). Niemuth and others (2008) reported that Sedge Wren abundance in northern North Dakota was positively associated with the number of wetland basins containing water in May of the same year and in May of the previous year. Sedge Wren dispersion also was positively associated with the number of May ponds of the same year. In a 6-year study in North Dakota, Grant and others (2010) reported that Sedge Wren abundance was greatest in the year after precipitation reached its maximum. In east-central North Dakota, Sedge Wrens used upland mixed-grass prairies when long-term precipitation patterns resulted in lush herbaceous growth (Johnson, 1997). Sedge Wrens typically were found in sedge meadows in Wisconsin and Minnesota, but during dry years they used hayfields, grasslands, and oldfields (idle

or neglected arable lands that have naturally reverted back to perennial cover) (Faanes, 1981). From an analysis of BBS data from Illinois, Iowa, Michigan, Minnesota, and Wisconsin, Thogmartin and others (2006) reported that mean temperature in January was an important factor affecting Sedge Wren abundance during the breeding season. Panci and others (2017) reported that average monthly spring (March–June) temperature or precipitation did not yield useful information in models predicting Sedge Wren occurrence in Great Lakes coastal wetlands. In some years, presence of breeding Sedge Wrens in Nebraska and Kansas coincides with years of high precipitation (Tordoff and Young, 1951; Cink, 1973; Bedell, 1987). During such years, Sedge Wren nests have been found in short (30 cm) grass with standing water (2 cm), wetlands, shortgrass prairies, and along dry hillsides. In Kansas, Sedge Wrens were not present during drought years (Zimmerman, 1993).

Wilsey and others (2019) compiled avian occurrence data from 40 datasets to project climate vulnerability scores under scenarios in which global mean temperature increases 1.5, 2, or 3 degrees Celsius ($^{\circ}\text{C}$). Sedge Wrens ranked moderate in vulnerability during the breeding season at all three levels. Steen and others (2014) forecasted a 66 percent decline in Sedge Wren occurrence within the PPR of the north-central United States by the 2040s, relative to baseline land cover and climate data from 1981 to 2000. Sedge Wren probability of occurrence was negatively related to variability in precipitation. In another modeling exercise, Steen and others (2016) reported that the Sedge Wren was estimated to lose 44 percent of its current range under the projected climate scenario for 2041–70. Under projected greenhouse gas emission scenarios described by the Intergovernmental Panel on Climate Change (2000), Langham and others (2015) categorized the Sedge Wren as a climate-threatened species, indicating that the species would lose more than 50 percent of its current distribution by 2080 across all Intergovernmental Panel on Climate Change scenarios, with net gain from potential range expansion.

Area Requirements and Landscape Associations

There is little information in the literature on the territory size of male Sedge Wrens. In a Minnesota sedge meadow, average territory size of 12 male Sedge Wrens was 0.2 ha (Burns, 1982). In an Illinois burned prairie, Sedge Wren pairs required 3.4 ha to establish territories (Schramm and others, 1986).

In southern Manitoba, Sedge Wren abundance was positively related to area of tallgrass prairie patches, increasing percentage of nonnative grasslands and agricultural fields within 500 m of tallgrass prairie patches, and local-scale vegetation density; abundance was negatively related to percentage cover of water (Bruinsma, 2012). From a study of

CRP fields in nine counties in North Dakota, South Dakota, Minnesota, and Montana, Sedge Wrens exhibited area sensitivity in one county (Johnson and Igl, 2001). In eastern South Dakota, Sedge Wren occurrence was positively related to grassland patch area in tallgrass and mixed-grass prairies, and Sedge Wren density was positively related to grassland patch area in tallgrass prairies (Bakker and others, 2002). In Minnesota, Wisconsin, and Michigan, Thogmartin and others (2006) did not find Sedge Wrens to be sensitive to grassland patch area. In southwestern Wisconsin, Sedge Wren densities were not related to pasture size (Renfrew and Ribic, 2002). In native and restored prairies and tame grasslands in Illinois, grassland area was not as important as vegetation structure in predicting Sedge Wren occurrence; Sedge Wrens were present on tallgrass prairies <10 ha (Herkert, 1991b, 1994b). However, when restricting analyses to tallgrass prairie fragments, Sedge Wren density was positively correlated to area (Herkert, 1994a).

Sedge Wrens may be affected by the composition of the surrounding landscape. Within the PPR of Canada, Fedy and others (2018) examined the effect of grassland, cropland, wetland, and woodland habitats at four scales (within 400; 800; 1,600; and 3,200 m of BBS stops) on the relative probability of occurrence of Sedge Wrens. The best model for predicting Sedge Wren occurrence indicated that the species' selected landscapes that consisted of native grasslands and an abundance of wetland basins within 3,200 m; the model indicated avoidance of shrubland within 3,200 m (Fedy and others, 2018). In southwestern Manitoba, Sedge Wren abundance was unaffected by grassland amount relative to grassland configuration; the relative abundance of grassland-obligate species, including the Sedge Wren, showed a strong negative response to a landscape shape index, which quantified the amount of edge for a given land-cover class relative to that of a maximally compact and simple shape (that is, a circle) of the same area (Lockhart and Koper, 2018). In North Dakota mixed-grass prairies, Sedge Wrens were present in grasslands characterized by a lower percentage cover of quaking aspen woodland within 500 m than in unoccupied grasslands, and the species was categorized as woodland-sensitive (Grant and others, 2004). In tallgrass prairies in southeastern North Dakota, occurrence of Sedge Wrens was negatively associated with tree cover at the 1,600-m scale (Cunningham and Johnson, 2006). In tallgrass prairies in eastern South Dakota, Sedge Wren occurrence was positively related to the proportion of grass within a 1,600-m buffer (Bakker and others, 2002). In mixed-grass prairies, occurrence was positively related to the proportion of grass within a 1,600-m buffer and negatively related to the proportion of patch edge that was woody. In restored grasslands in North Dakota and South Dakota, Sedge Wrens avoided edges within 170 m of woodlands (Tack and others, 2017). In fragmented grasslands of either native or tame grasses in Minnesota, Sedge Wren density was positively related to the proportion of grassland cover within 100 m of point counts and negatively related to the proportion of tree cover within 100, 500, and 1,000 m (Thompson and others,

2014). Sedge Wrens were predicted to increase from 0.44 to 0.53 bird per ha as the proportion of grassland cover increased from the 10th to the 90th percentile and predicted to decrease from 0.79 to 0.23 bird per ha as the proportion of tree cover increased. In North Dakota and South Dakota, Sedge Wrens were associated with 127 wetlands that averaged 7 ha in size (Igl and others, 2017). Landscape composition within 800 m of these wetlands was 55 percent grassland, 22 percent agricultural, and 17 percent wetland; the average number of wetlands within 800 m of these wetlands was 25. In tallgrass and mixed-grass prairie fragments in eastern North Dakota and South Dakota and western Minnesota, Sedge Wren occupancy was high in prairie remnants characterized by few wetlands and little open water, and embedded in landscapes with high total edge density, high wetland patch density, and high density of dispersed patches of hayland (Shahan and others, 2017). In the Upper Midwest, Sedge Wren abundance was negatively associated with the proportion of landscape in forest (Thogmartin and others, 2006). In Wisconsin landscapes composed of pasture, hayland, CRP fields, and deciduous forests, Sedge Wren abundance was not related to the amount of forest or grassland in the landscape (Murray and others, 2008).

In restored tallgrass prairies in Iowa, Sedge Wren density was positively associated with the percentage of wetlands in the surrounding landscape (Fletcher and Koford, 2002). In another Iowa study, occurrence was positively related to the percentage of wetland area that was wet-meadow vegetation, to the percentage of wetland area within a wetland complex that was wet-meadow vegetation, and to the area of temporary wetlands within a 3-kilometer (km) buffer around each wetland complex (Fairbairn and Dinsmore, 2001a, 2001b). Wetland complexes were defined as tracts of land containing 4–15 wetlands ranging in size from 44 to 144 ha. In restored wetlands in Iowa, occurrence of Sedge Wrens was negatively associated with the total area of seasonal wetlands within 1,500 m of the wetland center (Dault, 2001). In the Upper Midwest, Sedge Wren abundance was associated with grasslands, mucky soils (a correlate of moist grasslands), and the median area of wetlands >100 m from patch edge, indicating a preference for landscapes in which the number and size of wetlands are high (Thogmartin and others, 2006). From avian surveys conducted throughout Iowa, Harms and others (2017) reported that Sedge Wren occupancy and colonization of the landscape were positively correlated to the interaction between the percentage of the landscape in wetland and grassland within 500 m. In Iowa and Missouri tallgrass prairies, Sedge Wren density was positively associated with percentage grass cover at the 300–1,000-m scale and negatively associated with percentage grass cover at the 0–300-m scale and with the density of wooded edge within 300 m (Pillsbury, 2010). In Iowa CRP filter strips, Sedge Wren abundance was significantly higher in strips adjacent to corn or soybean fields than in strips adjacent to woody vegetation (Henningesen and Best, 2005). In patches of tallgrass prairie of varying sizes in Illinois, Sedge Wren density was positively related to the amount of grassland within 1.6 km of point counts (Buxton and Benson, 2016). In

coastal wet meadows along the northern Lake Huron shoreline of Michigan, Riffell and others (2003) reported that Sedge Wrens were most likely to be observed in wet meadows surrounded by other types of emergent, coastal wetlands. Along coastal wetlands throughout the Great Lakes region, Panci and others (2017) reported that Sedge Wren occurrence was positively related to woody wetlands, shrub-swamp communities within 500 m, and woody wetlands within 2,000 m and negatively related to grassland/pasture habitats within 2,000 m. Panci and others (2017) predicted that Sedge Wrens were 4.1 times more likely to occur at survey points with >9 percent coverage of woody wetlands within 2,000 m.

Brood Parasitism by Cowbirds and Other Species

No known records of brood parasitism by Brown-headed Cowbirds (*Molothrus ater*) exist for the Sedge Wren (Shaffer and others, 2019), probably because the entrance to their sphere-shaped nest is too small for a female cowbird to enter (Herkert and others, 2020). There was a single observation of an adult Sedge Wren feeding a Brown-headed Cowbirds fledgling on June 30, 1996, at Lonetree Wildlife Management Area in Wells County, North Dakota (D.E. Kroodsmas, pers. commun. [n.d.], in Herkert and others, 2020), but foster-parentage of this fledgling cowbird was not confirmed.

Breeding-Season Phenology and Site Fidelity

In spring, Sedge Wrens begin migration in early April, and the earliest spring migrants typically arrive in the southern portion of the species' breeding range during the first week of April (Herkert and others, 2020). In the northern Great Plains (North Dakota, Minnesota, and Manitoba), the breeding season of the Sedge Wren extends from late April to early October (Mousley, 1934; Walkinshaw, 1935; Bent, 1964; Stewart, 1975; Knapton, 1979; Faanes, 1981), making it one of the latest-nesting grassland birds in this region. In North Dakota, the peak breeding season is mid-June to early August (Stewart, 1975). In the central and southern Great Plains (Illinois, Iowa, Kansas, Missouri, and Nebraska), Sedge Wrens may not initiate breeding until July or August (Schwilling, 1982; Skinner and others, 1984; Schramm and others, 1986; Bedell, 1987; Lingle and Bedell, 1989; Zimmerman, 1993; Kent and Dinsmore, 1996). One possible explanation for late breeding attempts is that Sedge Wrens from northern breeding areas may move to southern areas and raise a second brood because of the longer breeding season (Bedell, 1996), but evidence of this is lacking (Hobson and Robbins, 2009). Sedge Wrens migrate northward through Kansas during late April and early May, only to return in July to breed during years of normal

precipitation levels (Zimmerman, 1993). In Minnesota, Sedge Wrens were double-brooded (Burns, 1982). Walkinshaw (1935) suggested that female Sedge Wrens may have re-nested after producing young in a Michigan population, but Crawford (1977) reported that none of the females in a northwestern Iowa population re-nested or were double-brooded. Sedge Wrens exhibit low site fidelity, although their natural history has not been well studied (Herkert and others, 2020).

Species' Response to Management

Spring burning in mixed-grass and tallgrass prairies can improve habitat quality by increasing vegetation height and density and by decreasing litter (Eddleman, 1974; Schramm and others, 1986), although Sedge Wren abundance may decrease immediately after a burn. In northern North Dakota mixed-grass prairies, Sedge Wren abundance was lowest the first year postburn, with the number of pairs peaking 2–3 years postburn in a 6-year study (Grant and others, 2010). In central North Dakota mixed-grass prairies, Sedge Wren occurrence seemed to be unrelated to the number of years since last burn, although there was a reduction in numbers of Sedge Wrens 1 year postburn (Johnson, 1997). In former crop fields planted to native grass species near Johnson's (1997) study areas, Sedge Wrens were present in July on grasslands burned in the spring of the same year (Higgins and others, 1984). Likewise, in Missouri, Nebraska, and Wisconsin, Sedge Wrens were present by July or August on tallgrass prairies burned in the spring of the same year (Skinner and others, 1984; King, 1991; Volkert, 1992). In Nebraska, Sedge Wrens avoided recently burned CRP fields (Delisle and Savidge, 1997). During years of normal precipitation in Kansas, Sedge Wrens may breed in unburned prairies as well as in prairies that had been burned earlier in the breeding season; during drought years, they may not breed regardless of burn treatment (Zimmerman, 1993). In a Kansas study of spring-burned and unburned CRP fields, abundance of Sedge Wrens was similar between unburned and spring-burned fields (Robel and others, 1998). In western Minnesota and northwestern Iowa, Ahlring and others (2019) examined the effect of grassland type (remnant prairie or restored grassland), land ownership (publicly or privately owned), and management history (time since fire or grazing) on Sedge Wren abundance after habitat and landscape variables had been considered. Fire and grazing history best explained additional variation in the abundance of Sedge Wrens. Sedge Wrens were more abundant on private than public lands, in the year of a burn than any of the postburning years, and in grazed grasslands not grazed 2 years previously. In west-central Illinois, Sedge Wrens preferred nesting and foraging in spring-burned areas but relied on unburned areas as a source of litter for nest building (Schramm and others, 1986). In northeastern and east-central Illinois, Sedge Wrens showed no significant response to prescribed burning, although they did not use a

650-ha spring-burned prairie 1 year postburn and were absent in small (1.4–32 ha) prairie fragments 1–3 years postburn (Herkert, 1991a, 1994a). However, climatic factors may have affected these results; the first 2 years of the study were abnormally dry, and the third year was abnormally wet. In Greater Prairie-Chicken (*Tympanuchus cupido*) sanctuaries in Illinois, Sedge Wrens preferred burned areas 3 years postburn over hayed and idle areas (Westemeier and Buhnerkempe, 1983).

Haying may negatively affect Sedge Wren use of grasslands (Herkert and others, 2020). In North Dakota, Sedge Wrens preferred hayfields with dense coverage of forbs and grasses, such as sweetclover, alfalfa, brome (*Bromus* spp.), Kentucky bluegrass, and wheatgrass (*Agropyron* spp.) (Stewart, 1975). In Iowa, Missouri, and Wisconsin, Sedge Wrens preferred hayfields that were dense, lush, and unmowed (Skinner, 1975; Sample, 1989; Frawley and Best, 1991). Several studies have found that Sedge Wrens did not use hayfields after they were mowed (Skinner, 1975; Messmer, 1990; Frawley and Best, 1991; Herkert, 1991a; Delisle and Savidge, 1997). Sedge Wrens may be killed or their nests may be destroyed by mowing during the breeding season (Herkert and others, 2020). Igl and Johnson (2016) assessed the effects of haying on grassland breeding birds in 483 CRP grasslands in nine counties in four States in the northern Great Plains between 1993 and 2008. Compared to densities in CRP grasslands that had been idled for at least 5 years, Sedge Wren densities were lower in the first year after haying but generally increased above idle densities in the second through fourth years after haying. During a 2-year study in North Dakota, Sedge Wrens were significantly more abundant in idled portions of CRP fields than in hayed portions that had been mowed the previous year (Horn and Koford, 2000). In Iowa and Wisconsin CRP fields planted to switchgrass, Sedge Wrens were more abundant in unharvested plots than in harvested plots (Murray and Best, 2003; Roth and others, 2005). In Iowa, Sedge Wrens nested in grassed waterways in crop fields that were not mowed the previous year (Bryan and Best, 1994).

Throughout their breeding range, Sedge Wrens avoid areas where vegetation is <10 cm in height or where vegetation density has been reduced by moderate-to-heavy grazing (Skinner, 1974, 1975; Kantrud, 1981; Messmer, 1985; Lingle and Bedell, 1989). In North Dakota, Sedge Wrens were found on idled pastures and not on grazed mixed-grass pastures (Messmer, 1985). In another North Dakota study, Sedge Wrens were more abundant in idle areas than in pastures under season-long (leaving a herd on the same pasture all growing season) or twice-over (grazing twice per season, with about a 2-month rest in between grazing periods) grazing systems (Messmer, 1990). In a study in southwestern Wisconsin, Sedge Wrens were present in lightly grazed fields under either continuous or rotational grazing regimes (neither regime was defined in the study) that were near riparian areas (Renfrew and Ribic, 2001). In southwestern Wisconsin, Sedge Wrens were more abundant in rotationally grazed

(stocked with 40–60 head of cattle per ha and grazed for 1–2 days, then left undisturbed for 10–15 days before being grazed again) pastures than in continuously grazed pastures (grazed throughout the summer at levels of 2.5–4 head of cattle per ha) or in ungrazed pastures (neither mowed nor grazed from May 15 to July 1) (Temple and others, 1999). Pastures in that study averaged 5 ha, and sites were composed of 50–75 percent cool-season grasses, 7–27 percent legumes, and 8–23 percent forbs. In Missouri, Sedge Wrens preferred lightly grazed areas where vegetation height was >30 cm, followed by idle grasslands and moderately grazed fields where vegetation height was 20–30 cm (Skinner, 1975; Skinner and others, 1984). The species avoided heavily grazed fields where vegetation height was <20 cm.

Several researchers have compared the effects of different management treatments on Sedge Wren density, including comparisons between burning and haying (Davis and others, 2017) and interactions between burning and grazing (Pillsbury, 2010; Duchardt and others, 2016). In Saskatchewan and Manitoba, Davis and others (2017) investigated the effects of burning and haying on Sedge Wren densities in grasslands converted from cropland to native or tame grass-forb mixtures at least 4 years prior to the 2-year study. In Manitoba, Sedge Wrens reached their highest densities 4–5 years postmanagement and their lowest densities in the first and eighth years postmanagement; the treatment effect was stronger in 1 of the 2 years of the study. However, vegetation structure was a better predictor of Sedge Wren densities or occurrence than management treatment (burning or haying) or years postmanagement (Davis and others, 2017). In the Grand River Grasslands of Iowa and Missouri, Pillsbury (2010) and Duchardt and others (2016) evaluated the effect of burning and grazing and their interaction on Sedge Wren abundance by comparing grasslands assigned to treatments of patch-burn grazing (that is, applying prescribed burns in a spatially and temporally variable mosaic and allowing livestock to select among burned and unburned patches in the landscape), grazing and burning of the entire fields, or burn-only every third year. Sedge Wren density was highest on the burn-only fields and lowest on the grazed and burned pastures; Sedge Wrens responded favorably to the change in vegetation structure induced by burning.

Sedge Wrens generally respond positively to the habitat provided in planted grasslands and restored prairies, although vegetation composition and structure vary based on the characteristics of the plant species used in seeding mixtures. In a multi-State assessment examining the effect of CRP establishment on population trends of grassland birds from BBS data, the abundance of Sedge Wrens in the Midwest decreased after the broad-scale establishment of CRP fields in the region (Herkert, 2009). Johnson and Igl (1995) predicted that statewide populations of Sedge Wrens in North Dakota would decline by 25.8 percent if all CRP lands in the State were returned to cropland production. In South Dakota, Sedge Wrens were attracted to rank, dense growth of green needlegrass in restored fields (formerly corn [*Zea mays*] or

soybean [*Glycine* spp.] fields) 2–4 years after being seeded to prairie grasses (Blankespoor, 1980). Uden (2012) modeled changes in Sedge Wren abundance within Nebraska's Rainwater Basin under three scenarios of climate change and irrigation limitation in which rowcrops would be converted to switchgrass or CRP fields. The models predicted that Sedge Wren abundance would increase 34–213 percent under conversion to switchgrass and increase 4–5 percent under conversion to CRP fields. At a landscape scale, Uden and others (2015) evaluated four scenarios of land-use change on Sedge Wren abundance in Nebraska. The first scenario was a baseline condition in which some rowcrops were converted to switchgrass under current conditions of climate, irrigation limitations, commodity prices, ethanol demand, and continuation of the CRP. The second scenario converted more rowcrops to switchgrass. The third scenario converted all CRP fields to switchgrass, and the final scenario converted all CRP fields to rowcrops. Sedge Wren abundance increased 34–124 percent under the first two scenarios and decreased <5 percent under the third and fourth scenarios, indicating that replacing rowcrops with switchgrass was more beneficial to Sedge Wrens than replacing CRP with switchgrass or rowcrops. In another Nebraska study, Negus and others (2010) reported that the abundance of Sedge Wrens did not differ between CRP fields managed with disking and interseeding and idle CRP fields. In Minnesota, Sedge Wrens were more abundant in grasslands restored 11 years previously to native grasses and forbs than in grasslands restored 1 year previously (Mundahl and Borsari, 2016). In east-central Wisconsin, Sedge Wren abundance gradually increased in the years following the restoration of a tallgrass prairie (Volkert, 1992). Sedge Wrens also were found on restored tallgrass prairies in Illinois and Kansas (Westemeier and Buhnerkempe, 1983; Schramm and others, 1986; Cink and Lowther, 1989). In Illinois, Osborne and Sparling (2013) found no difference in Sedge Wren densities among idle CRP fields and fields that were either disked, sprayed, or sprayed and interseeded with legumes.

In studies of bird use of cropland in the Midwest and Great Plains (Illinois, Iowa, Kansas, Manitoba, Minnesota, Missouri, Montana, Nebraska, North Dakota, Saskatchewan, and South Dakota), Sedge Wrens were not found in cropland (Johnson and Schwartz, 1993a; Hartley, 1994; Jones, 1994; Johnson and Igl, 1995; Patterson and Best, 1996; Best and others, 1997; Igl and others, 2008; Mozel, 2010). In a Saskatchewan study comparing bird use of uplands and wetlands in conventional, minimum-tillage, and organic farmland and DNC grasslands, Sedge Wrens were present only in organic farmland and DNC grasslands in uplands (Shutler and others, 2000). The species was more abundant in DNC grasslands than in organic farmland. In Arkansas, Sedge Wrens nested in flooded rice (*Oryza* spp.) fields when plant height reached 50 cm (Meanley, 1952).

In Minnesota grasslands, Thompson and others (2014, 2016) evaluated the impact of tree and shrub removal on Sedge Wrens and other birds in grasslands encroached by

woody vegetation. Initial efforts to remove woody vegetation via cutting and shearing were ineffective at controlling woody regrowth; burning and herbicide applications also were necessary. On the untreated sites, Sedge Wren abundance declined from the year of the treatment (0.41 bird per point count) to the sixth year after the treatment (0.05 bird per point count). On the treated sites, abundance declined from 0.46 bird per point count in the year of the treatment to 0.12 bird per point count in the second year after the treatment; Sedge Wrens responded positively in the fourth and fifth years after the treatment. Removal of woody vegetation via burning caused a loss of litter layer that may have negatively affected Sedge Wren numbers (Thompson and others, 2014, 2016).

Wetlands that have been modified or managed for waterfowl production are commonly used by nesting Sedge Wrens (Brady, 1983). In eastern South Dakota, Sedge Wrens were found on dug-brood complexes (that is, a system of channels, ponds, and created islands constructed in wetlands to provide deep, open water as well as upland nesting areas for waterfowl). Sedge Wren frequencies and densities were higher in the dug-brood complexes than in unmodified wetlands in both years of the study; however, the author's results were based on qualitative differences rather than statistical comparisons (Brady, 1983). In northwestern Nebraska, Sedge Wrens nested in natural seasonal and semipermanent wetlands and in wetlands that were restored 4–12 years previously (Dault, 2001). In restored wetlands in northwestern Iowa, the occurrence of Sedge Wrens was positively associated with the number of dominant plant species in the wet meadow and emergent vegetation zones and negatively associated with the proportion of the emergent vegetation zone composed of robust-stemmed vegetation (Dault, 2001). The probability of detecting Sedge Wrens increased with the evenness of the distribution of the various wetland zones (that is, a measure of habitat diversity evaluating the homogeneity of individual zones). In Minnesota, Sedge Wrens were more abundant in managed wetlands that were treated with burning and shearing to create open areas than in unmanaged wetlands (Hanowski and others, 1999). In shallow wetlands in northwestern Minnesota in which hybrid cattail was controlled by treatments of mowing, burning, or a combination of burning and spraying with chemicals, Sedge Wren abundance increased 22 percent 1 year after the wetlands were burned and 96 percent 2 years after burning; Sedge Wren abundance decreased with spraying alone and with the combination of burning and spraying 1 year after burning, with a slight increase in wren abundance by the second year (Bruggman, 2017). In Minnesota wetlands managed for hybrid cattail control, Sedge Wren abundance decreased as cattail biomass increased (Anderson and others, 2019).

In patches of tallgrass prairie of varying sizes in Illinois, Sedge Wren densities were negatively related to the amount of urban development within 1.6 km of point counts (Buxton and Benson, 2016). The amount of grassland in the landscape, however, was a much better predictor of wren

densities than urban development. In coastal wetlands in the Great Lakes region, Howe and others (2007) developed an ecological condition index, a probabilistic indicator approach to assess the occurrences of species in the context of a standard environmental stress gradient based on the intensity of human activities; Sedge Wrens showed a strong negative relationship with human environmental disturbances (that is, industrial, residential, and cultivated land uses and road area and length). In another study of Great Lakes coastal wetlands, Panci and others (2017) predicted that Sedge Wren occurrence was 25 times more likely at survey points with <11 km of roads within 1,000 m. In restored wetlands in Iowa, occurrence of Sedge Wrens was negatively associated with the total length of roads within a 1500-m radius buffer (Dault, 2001).

Energy development may negatively impact Sedge Wren distribution and abundance. 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. At a score of 4.14, the Sedge Wren was among 40 species (of 428 species evaluated) with an average priority score of at least a four or above out of nine. Beston and others (2016) estimated that 9.26 percent of the Sedge Wren breeding population in the United States are exposed to wind facilities. Loss and others (2013) reviewed published and unpublished reports on collision mortality at monopole wind turbines (that is, with a solid tower rather than a lattice tower) in the contiguous United States; two Sedge Wren mortalities were reported at one wind facility. In northern Minnesota peatlands, Niemi and Hanowski (1984) concluded that habitat differences between treatment and control areas hindered a conclusive determination of whether a 500-kilovolt transmission line affected Sedge Wren density.

Management Recommendations from the Literature

Protecting or restoring large tracts of grassland habitat, especially native grasslands, and protecting mesic grasslands, wet meadows, peatlands, and coastal wetlands will maintain habitat required for Sedge Wrens (Mozel, 2010; Gnass Giese and others, 2018; Herkert and others, 2020). In tallgrass prairies, stands of big bluestem or Indiangrass provide vegetation of adequate heights for nesting Sedge Wrens (Skinner and others, 1984). Areas of tall, dense planted cover, such as CRP or DNC grasslands, provide nesting cover for Sedge Wrens (Renken and Dinsmore, 1987; Johnson and Schwartz, 1993a, 1993b; Johnson and Igl, 1995; Patterson and Best, 1996; Igl, 2009; Uden and others, 2015). Suitable habitat also may be provided by areas dominated by reed canary grass and switchgrass if wet prairies or sedge meadows are not available (Sample, 1989).

Fairbairn and Dinsmore (2001b) suggested that effective management of Sedge Wrens will require attention to the landscape within which grasslands and wetlands are embedded. Protection or restoration of the natural gradient of wetland conditions inherent to coastal wetlands and of the wetland complexes inherent to grassland ecosystems will benefit the Sedge Wren during times of wet and dry water conditions (Dault, 2001; Fairbairn and Dinsmore, 2001b; Gnass Giese and others, 2018). The identification of landscapes within the Great Plains comprised of high amounts of grassland and wetland habitats and low amounts of woodland will enhance managers' ability to prioritize habitat management actions and define areas that may provide successful conservation outcomes (Fedy and others, 2018). Near the Great Lakes, Riffell and others (2003) and Panci and others (2017) recommended protection of landscapes consisting of wet meadows and other forms of emergent, coastal wetlands including woody wetlands, shrub-swamp communities, and streams.

Minimizing disturbances, such as mowing or herbicide spraying, during the breeding season can reduce avian mortality or nest destruction (Sample, 1989; Frawley and Best, 1991; Herkert, 1994b; Patterson and Best, 1996; Delisle and Savidge, 1997; Roth and others, 2005; Igl and Johnson, 2016; Davis and others, 2017). Because the species has a long nesting season, Patterson and Best (1996) recommended that mowing be delayed beyond the date generally recommended for other passerines (that is, July 15). Fields designed for maximum hay production, such as alfalfa fields, may be incompatible with bird conservation, as fields are mowed during the peak of the breeding season and periodically thereafter; unmowed CRP fields would be a better alternative for bird conservation (Frawley and Best, 1991). Delisle and Savidge (1997) recommended controlling noxious weeds in CRP grasslands by spot spraying rather than by spraying or mowing the entire field.

Although disturbances such as burning, mowing, grazing, or shrub removal during the breeding season are generally detrimental to nesting Sedge Wrens, periodic management treatments may be necessary to maintain long-term habitat quality for Sedge Wrens and to provide habitat for other species with differing habitat needs (Robert and others, 2009; Davis and others, 2017). Davis and others (2017) recommended that some form of management (for example, burning or haying) of planted grasslands occur at least once every 4–6 years to maintain habitat for Sedge Wrens. Frequency of management should depend upon local environmental conditions; for example, in the drier western portion of the northern prairies, frequent management may be unnecessary, but in mesic environments, more frequent management may be beneficial. Davis and others (2017) suggested that natural resource managers should seek to establish a mosaic of planted cover sites that vary from 1–6 years since they were last managed in a given year. In CRP grasslands 2–4 years after haying, improved habitat quality led to long-term increases in densities of Sedge Wrens that compensated

for short-term declines in Sedge Wren densities 1 year after haying (Igl, 2009; Igl and Johnson, 2016). For degraded idle CRP grasslands that have experienced litter accumulation and encroachment of trees, shrubs, and noxious weeds, Igl and Johnson (2016) recommended periodic management (for example, haying or other disturbances every 3–5 years) to maintain the conservation benefits of CRP for grassland nesting birds. In tallgrass prairies, a mosaic of burned and unburned areas provides for both nesting and foraging needs of the Sedge Wren (Schramm and others, 1986; Volkert, 1992). In Missouri, Skinner (1975) found that a rotational grazing system consisting of two or more grazing units provided distinct stands of grasses of various heights, but he recommended that warm-season grasses should not be grazed to <25 cm.

Grasslands and wetlands may require periodic disturbance to prevent encroachment of woody vegetation or to remove existing woody vegetation (Sample, 1989; Herkert, 1994b; Hanowski and others, 1999). In grasslands heavily encroached by woody vegetation, Grant and others (2004) suggested that managers focus initial restoration efforts on grasslands with <20 percent woodland encroachment because these grasslands would have the most immediate and lasting conservation benefits for grassland birds. Cunningham and Johnson (2006) discouraged the promotion of programs that encourage the planting of trees and tall shrubs within grasslands. Tack and others (2017) promoted shelter-belt removal to reduce woody edges in and near grasslands. Thompson and others (2014) recommended focusing tree removal on linear features, because they create more edge than a woodlot, and to target woody features that are isolated from other wooded habitats to maximize the percent reduction in woodland for a grassland patch. Robert and others (2009) and Thompson and others (2016) cautioned that once woody vegetation in grasslands and wetlands is established, successful, long-term removal is expensive and challenging and may require management treatments that are not immediately beneficial to Sedge Wrens. Robert and others (2009) recommended removing woody vegetation within wetlands where such vegetation is deemed unsuitable for Sedge Wrens (such as in fens) by using shearing or burning techniques but coupling management with bird and habitat monitoring programs to gauge the effectiveness of habitat management. Hanowski and others (1999) cautioned that maintaining some woody vegetation in wetlands around the Great Lakes is essential for maintaining bird diversity.

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Table V1. Measured values of vegetation structure and composition in Sedge Wren (*Cistothorus stellaris*) breeding habitat by study. The parenthetical descriptors following authorship and year in the “Study” column indicate that the vegetation measurements were taken in locations or under conditions specified in the descriptor; no descriptor implies that measurements were taken within the general study area.

[cm, centimeter; %, percent; --, no data; ≥, greater than or equal to; >, greater than; CRP, Conservation Reserve Program; <, less than; DNC, dense nesting cover]

Study	State or province	Habitat	Management practice or treatment	Vegetation height (cm)	Vegetation height-density (cm)	Grass cover (%)	Forb cover (%)	Shrub cover (%)	Bare ground cover (%)	Litter cover (%)	Litter depth (cm)
Bakker and Higgins, 2009	Minnesota, South Dakota	Tallgrass prairie	Native	96 ^a	20 ^b	--	--	--	--	--	2.6
Bakker and Higgins, 2009	Minnesota, South Dakota	Tame grassland	Seeded to intermediate wheatgrass (<i>Thinopyrum intermedium</i>)	135 ^a	36 ^b	--	--	--	--	--	3.1
Bakker and Higgins, 2009	Minnesota, South Dakota	Tame grassland	Seeded to switchgrass (<i>Panicum virgatum</i>)	107 ^a	37 ^b	--	--	--	--	--	1.6
Bakker and Higgins, 2009	Minnesota, South Dakota	Tame grassland	Cool-season seeding mixture	124 ^a	36 ^b	--	--	--	--	--	3.4
Bakker and Higgins, 2009	Minnesota, South Dakota	Tame grassland	Warm-season seeding mixture	166 ^a	27 ^b	--	--	--	--	--	4.1
Bedell, 1996	Nebraska	Multiple	--	≥50	--	--	--	--	--	--	--
Begley and others, 2012	Saskatchewan	Natural wetland	--	44.7	--	--	--	--	--	--	--
Begley and others, 2012	Saskatchewan	Restored wetland	--	39	--	--	--	--	--	--	--
Fletcher and Koford, 2002	Iowa	Tallgrass prairie	--	91.7	--	45.6	33.4	--	0.9	9.9	3.4
Fletcher and Koford, 2002	Iowa	Restored grassland	Cool- and warm-season seeding mixture	91.6	--	51.8	20.6	--	3.6	13.7	2.5
Frawley, 1989 (territories)	Iowa	Tame grassland	Hayed	48	--	15	78	--	8	--	--
Grant and others, 2004	North Dakota	Mixed-grass prairie	--	66	--	--	--	15.1	--	--	5.3
Meanley, 1952	Arkansas	Rice field	--	>50	--	--	--	--	--	--	--
McCoy and others, 2001 ^c	Missouri	Tame grassland (CRP)	Cool-season seeding mixture	--	51 ^b	46	33	1	12	75	2.6
McCoy and others, 2001 ^c	Missouri	Tame grassland (CRP)	Warm-season seeding mixture	--	80 ^b	54	27	<1	11	74	2.2
Murray and Best, 2003	Iowa	Tame grassland (CRP)	Total-harvested switchgrass	80.9	71 ^b	51.6	19.6	0.4	5	23.2	1.9

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[cm, centimeter; %, percent; --, no data; ≥, greater than or equal to; >, greater than; CRP, Conservation Reserve Program; <, less than; DNC, dense nesting cover]

Study	State or province	Habitat	Management practice or treatment	Vegetation height (cm)	Vegetation height-density (cm)	Grass cover (%)	Forb cover (%)	Shrub cover (%)	Bare ground cover (%)	Litter cover (%)	Litter depth (cm)
Murray and Best, 2003	Iowa	Tame grassland (CRP)	Strip-harvested switchgrass	81.7	75 ^b	53.3	17.5	0.1	2.8	29.6	3.5
Murray and Best, 2003	Iowa	Tame grassland (CRP)	Unharvested switchgrass	78.1	71 ^b	32.9	25.4	2.1	2.9	22.9	5.5
Negus and others, 2010 ^c	Nebraska	Tame grassland (CRP)	Disked and interseeded	65.7	35.8 ^b	41.8	23.8	--	14.5	25.2	1.8
Negus and others, 2010 ^c	Nebraska	Tame grassland (CRP)	Idle	55.9	29.4 ^b	63.9	1.4	--	1.4	39.3	3.1
Niemi, 1985	Minnesota	Mixed-grass prairie	Burned	110	--	--	--	--	--	--	--
Osborne and Sparling, 2013 ^c	Illinois	Tame grassland (CRP)	Idle	--	56.5 ^b	47.4	23.3	--	8.5	--	6
Osborne and Sparling, 2013 ^c	Illinois	Tame grassland (CRP)	Disked	--	52 ^b	47.7	22.5	--	16.1	--	5.4
Osborne and Sparling, 2013 ^c	Illinois	Tame grassland (CRP)	Glyphosate-sprayed	--	56.7 ^b	23.8	37.5	--	12.9	--	4.1
Osborne and Sparling, 2013 ^c	Illinois	Tame grassland (CRP)	Glyphosate-sprayed and seeded	--	53.7 ^a	29.3	31.3	--	15.5	--	3.6
Pillsbury, 2010 ^c	Iowa, Missouri	Restored native grassland	Multiple	--	44.6 ^b	21.7	24.8	2.3	--	32.1	--
Renfrew and Ribic, 2002	Wisconsin	Tame lowland grassland	Grazed	--	8.4 ^b	--	--	--	34.9	--	1
Renfrew and Ribic, 2002	Wisconsin	Tame upland grassland	Grazed	--	9.9 ^b	--	--	--	26.1	--	1.1
Renken, 1983 ^d	North Dakota	Tame grassland (DNC)	Idle, grazed	--	23 ^b	74	34	3	--	99	3.5
Roth and others, 2005	Wisconsin	Tame grassland (CRP)	Unharvested switchgrass	--	50 ^b	--	34.4	--	--	--	5.3
Sample, 1989	Wisconsin	Multiple	--	101.9	54.2 ^b	--	81.7 ^c	<2	0.2	10.2	--
Skinner, 1974	Missouri	Tallgrass prairie	Multiple	>30.4	--	--	--	--	--	--	--
Skinner and others, 1984	Missouri	Tallgrass prairie	Multiple	--	--	--	20–65	--	--	--	--

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[cm, centimeter; %, percent; --, no data; ≥, greater than or equal to; >, greater than; CRP, Conservation Reserve Program; <, less than; DNC, dense nesting cover]

Study	State or province	Habitat	Management practice or treatment	Vegetation height (cm)	Vegetation height-density (cm)	Grass cover (%)	Forb cover (%)	Shrub cover (%)	Bare ground cover (%)	Litter cover (%)	Litter depth (cm)
Temple and others, 1999 ^f	Wisconsin	Tame grassland	Multiple	--	--	50–75	8–23	--	--	--	--
Vogel, 2011	Iowa	Tame grassland	Cool-season grassland	--	34.9 ^b	60.3	2.7	0.03	2.7	30.3	2.2
Vogel, 2011	Iowa	Tame grassland	Younger warm-season grassland	--	22 ^b	42.8	15	0	24.6	15.9	0.4
Vogel, 2011	Iowa	Tame grassland	Older warm-season grassland	--	44.3 ^b	50	13.3	0.2	5.5	28.3	2.4
Vogel, 2011	Iowa	Tame grassland	High-diversity grassland	--	42.7 ^b	32.1	33.4	0.1	18.5	13.8	1

^aMean grass height.

^bVisual obstruction reading (Robel and others, 1970).

^cThe sum of the percentages is >100%, based on methods described by the author(s).

^dThe sum of the percentages is >100%, based on the modified point-quadrat technique of Weins (1969).

^eHerbaceous vegetation cover.

^fRanges represent values across grazing regime.

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