2016

05. Bird Communities Within a Prairie/Wetland Complex: Restoration of Former Wastewater Treatment Ponds in Southeastern Minnesota

Neal Mundahl
Winona State University, nmundahl@winona.edu

Bruno Borsari
Winona State University

Bird Communities Within a Prairie/Wetland Complex: Restoration of Former Wastewater Treatment Ponds in Southeastern Minnesota

NEAL MUNDAHL[1] AND BRUNO BORSARI

Program in Ecology & Environmental Science, Department of Biology, Winona State University, Winona, MN 55987, USA (NM, BB)

ABSTRACT Our 12-mo study examined the bird communities associated with three habitat types at differing stages of restoration within a prairie/wetland complex in southeastern Minnesota. The 25-ha site previously consisted of three municipal wastewater treatment ponds that were taken off-line in 2002. One pond was retained as a shallow wetland; the others were reconfigured and restored by planting with prairie vegetation (one pond in 2003 and the other pond in 2013) to provide habitat for both wetland and grassland birds. Timed walking surveys of birds in each habitat were made monthly from June 2014 through May 2015. We observed 48 bird species at the study site during the year, with red-winged blackbird, song sparrow, American tree sparrow, dickcissel, and American goldfinch accounting for 83% of total individuals. Bird abundance varied seasonally in all habitats (0–22 birds/min), peaking in April in prairies and in September in the wetland. The wetland held more bird species (39) than either old (22) or new (24) prairies, but prairies had much higher Simpson diversity (0.799–0.809) than the wetland (0.428). Bird communities of old and new prairies were more similar to each other (Bray–Curtis similarity = 0.517) than either was to the wetland community (0.297, 0.301). Bobolink, dickcissel, sedge wren, western meadowlark, and ring-necked pheasant were found in both old and new prairies, but these species were significantly more abundant (2.7 times more individuals) in the old prairie. Management of this site (plantings, control of invasives, prescribed burns) for improved bird diversity is continuing.

KEY WORDS birds, community, diversity, Minnesota, prairie, restoration, wetlands

Prairie restorations can help to slow or reverse the loss of prairie habitats in many regions of North America (Samson and Knopf 1994, Van Dyke et al. 2004). Throughout the Midwest, >95% of native prairies have been lost, largely to agriculture (Samson and Knopf 1994, Johnson et al. 2011). Both large- and small-scale prairie restorations have been undertaken successfully (Schwartz and van Mantgem 1997, Ruiz-Jaen and Aide 2005), recreating conditions necessary for survival of many species of grassland fauna (Fletcher and Koford 2003).

Grassland-obligate birds are extremely vulnerable to prairie loss (Igl and Johnson 1997), with abundances of many species declining at rates of 2–8% per year within the Midwest (Herkert et al. 1996, Askins et al. 2007, Thogmartin et al. 2006). However, despite these negative trends, many grassland birds respond readily and rapidly to restored grasslands (Fletcher and Koford 2003, Andrews 2013). Colonization of restored grasslands by ground-nesting passerines can be nearly immediate, with some species establishing territories and nesting even within the first 1 or 2 yr after restoration (Andrews 2013). Although grassland birds on smaller restored grasslands may experience higher mortality due to nest depredation (Herkert et al. 2003), even small, isolated restoration sites can be extremely important to grassland birds in agricultural areas (Schwartz and van Mantgem 1997, Van Dyke et al. 2004, Askins et al. 2007), especially when nesting success is compared with that in surrounding agricultural fields (VanBeek, Brawn, and Ward 2013).

When the small, rural community of Lewiston, Minnesota, removed a 25-ha complex of wastewater treatment ponds from service in 2002 after earlier pond failure (Jannik et al. 1992), local officials worried that draining the ponds may have an unexpected economic effect on the city. While active, the treatment ponds had attracted a wide variety of mostly wetland bird species not easily viewed elsewhere in the region that, in turn, had attracted large numbers of bird watchers to the community. Visiting birdwatchers contributed to the local economy, and the loss of those dollars was of concern to the community.

Local officials, in consultation with regional natural resource conservation groups, devised a plan that would allow the treatment pond site to continue to attract both birds and people. Two of the three ponds on the site were drained and restored to upland habitat, specifically prairie habitat with mixed grasses and forbs. The third pond was partially drained and retained as a wetland. Together, these habitats were expected to continue to attract many of the wetland bird species that had used the site previously, while providing new and very rare prairie habitat (in an area dominated by row-crop agriculture) to attract grassland bird species.

The objective of this study was to document use of the restored habitats by birds throughout an entire calendar year. It was anticipated that wetland species would continue to

[1] Corresponding author email address: nmundahl@winona.edu

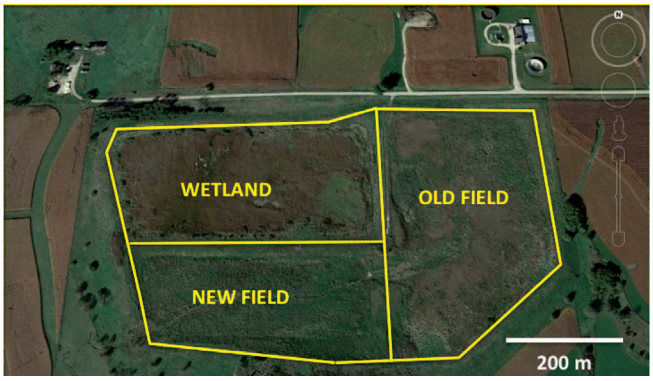

Figure 1. Aerial view of the 25-ha Lewiston Nature Preserve, with wetland and old prairie restoration (2003) and recent prairie restoration (2013) fields designated.

use the partially drained wetland during spring, summer, and fall, whereas the newly restored prairie habitat would attract obligate grassland species. Ultimately, the city of Lewiston will produce a brochure listing species' abundances by month and habitat, as a guide for bird watchers.

MATERIALS AND METHODS

The study was conducted from June 2014 through May 2015 at the site of former wastewater treatment settling ponds for the city of Lewiston, Minnesota (43°58′N, 91°53′W). The 25-ha site, now designated as the Lewiston Nature Preserve, is completely surrounded by agricultural lands (row crops, hay lands). The nature preserve consisted of three basins (18.1 ha combined) that were taken out of service in 2002 (Figure 1) and associated roadways, berms, and embankments (6.9 ha combined). One basin (6.9 ha) was partially drained and changing from a pond that was >2 m deep to a shallow wetland with a mixture of open, standing water; cattail (*Typha latifolia*) marsh; and mudflats. This basin was intended to attract the same species of water birds (i.e., waterfowl, shorebirds, gulls, wading birds) that had been using the site for decades.

Complete draining and habitat restoration of the other two basins was begun in 2003 as a partnership between the Lewiston Sportsmen's Club, Pheasants Forever, the Minnesota Department of Natural Resources, the city of Lewiston, the Winona County Soil and Water Conservation District, and Walmart. The restoration was intended to provide year-round habitat for ring-necked pheasant (*Phasianus colchicus*) and nesting habitat for grassland songbirds. One of the drained basins (7.0 ha) was planted with a seed mix of native forbs and grasses in 2003, and the other basin (4.3 ha) was planted with a similar mix in 2013. After plantings, basins were mowed completely twice each year (early summer, late summer/early fall) for the first 2 yr and then patch-mowed as needed to control invasive plants. Tree saplings and shrubs were removed as they seemed to eliminate potential perches for predatory birds (to protect ring-necked pheasant chicks).

Beginning in June 2014, walking surveys were used to assess bird abundances monthly within each of the three basins. Time of day varied among surveys depending on season, but most surveys were conducted during morning (0700–1100 hours). Separate assessments were conducted for each basin, to allow for comparisons among habitats. A single line transect was used to cover each habitat during each survey (most detections within 20 m of transect), with transect pathways changing each month to better cover all habitats. However, basins were surveyed in the same order (first, the 2003 restored prairie [hereafter referred to as old field]; second, the 2013 restored prairie [new field]; and third, the wetland) during each visit. A stopwatch was started at the beginning of each habitat, and all birds observed or heard along the transect were recorded. No attempt was made to determine bird density along transects. At the end of a transect, the time elapsed was recorded and the process was then repeated for each successive habitat.

Survey abundance data were standardized for each habitat/date by dividing bird counts by the duration of each survey. Standardized abundances were compared among the three habitats with a two-factor analysis of variance (ANOVA) (site and month as factors) to assess whether habitats differed in overall bird abundance. In addition, standardized abundances were compared between old and new prairie restoration habitats for a subset of grassland birds only with a paired *t*-test to determine whether age of habitat restoration (11 yr vs. 1 yr) affected grassland bird abundance.

Bird diversities and community similarities were calculated for each of the three habitats surveyed. Simpson diversities (Brower, Zar, and von Ende 1998) were calculated for each monthly habitat survey and compared among habitats with a two-factor ANOVA (site and month as factors) after diversities were transformed (log [X + 1]) to meet ANOVA normality assumptions (Zar 1974). Monthly surveys were combined for each site to produce a yearly community total, and these community totals were compared between site pairs (old vs. new, old vs. wetland, new vs. wetland) with a Bray–Curtis community similarity index (Brower et al. 1998).

RESULTS

We observed 1,656 birds representing 48 species at the study site during the year (Table 1), with red-winged blackbird (60.5%), song sparrow (9.2%), American tree sparrow (7.7%), dickcissel (3.4%), and American goldfinch (2.4%) accounting for 83% of total individuals. Five additional species (ring-necked pheasant, common yellowthroat, sedge wren, western meadowlark, and American robin) each accounted for >1% of all birds observed.

Nineteen species (40% of the species observed) were represented by only one or two individuals. No species were observed in every month; ring-necked pheasant and song sparrow were recorded during nine months and red-winged blackbird during eight months.

Bird abundance varied seasonally in all habitats (0–22 birds/min), peaking in April in old and new fields and in September in the wetland (Figure 2). April and September peaks were the result of large numbers of red-winged blackbirds in all habitats. An additional peak in February in the new field resulted from flocks of American tree sparrow. Although total yearly bird abundance in the wetland was 3.5 times greater than that in either old or new fields, and standardized bird abundance averaged more than twice as much in the wetland (3.65 ± 6.13 birds/min) as in the restored prairies (old field = 1.22 ± 1.43 birds/min, new field = 1.74 ± 1.80 birds/min), there was no statistically significant difference (ANOVA: $F_{2,22} = 1.39$; $P = 0.27$) in standardized bird abundance among the three habitats.

Five species of grassland birds that the restoration was intended to attract—ring-necked pheasant, bobolink, dickcissel, western meadowlark, and sedge wren—were observed in all three habitats during the year of surveys. In particular, fledglings or chicks of these five grassland bird species were observed during summer surveys in the restored prairies, indicating that all species had reproduced successfully within these habitats. In addition, a single individual of a sixth grassland species, field sparrow (*Spizella pusilla*), was observed in the new field. The 140 individual grassland birds tallied during surveys represented 8.5% of all birds observed. The majority of grassland birds were found in the old field, where they represented >25% of all birds counted (Figure 3). The new field and wetland held smaller, but similar, numbers of grassland birds, where they represented 11 and 2% of birds sighted within those habitats, respectively. Although both old and new fields attracted all five species of grassland birds, these species were significantly (paired $t_{11} = 2.47$, $P = 0.015$) more abundant in the old field (0.30 ± 0.12 [mean ± SE] birds/min) than in the new field (0.16 ± 0.08 birds/min).

The wetland held 1.6 times more bird species (39) than either old (22) or new (24) fields. Sixteen species were found in all three habitats, but no habitat had more than 18 species in common with any other habitat. Restored fields had much higher Simpson diversity (0.799–0.809) than the wetland (0.428) when yearly totals were examined. However, average monthly Simpson diversities for the wetland (0.490 ± 0.093) were not significantly different (ANOVA: $F_{2,22} = 0.16$; $P = 0.85$) from those for old (0.444 ± 0.106) or new (0.503 ± 0.103) fields. Bird communities of old and new fields were much more similar to each other (Bray–Curtis similarity = 0.517) than either was to the wetland community (Bray–Curtis similarity = 0.297, 0.301).

DISCUSSION

This study documented three important features of the Lewiston Nature Preserve habitat restoration project. First, wetland species continued to use the partially drained wetland from spring through fall. Second, the restored prairies were successful in attracting grassland songbirds and pheasants, with evidence of successful reproduction by both groups. Third, the age of the two prairie restorations affected the abundance, but not the diversity, of grassland birds using the sites.

When they were still in use as wastewater treatment basins, the three ponds attracted a wide diversity of wetland bird species, including waterfowl, shorebirds, gulls, and songbirds (A. Nyhus, Hiawatha Valley Audubon Society, personal communication). Anecdotal evidence suggests that up to 300 species of birds have been sighted at the study site. However, eBird (2016) lists only 114 species in its records (most dated between March 2012 and April 2015, after or during the habitat restoration). The Minnesota Ornithologist's Union (2016) sightings database lists 124 species for the study site (dated 1981–2015). Combined, these lists include 25 species of ducks, geese, and swans; 24 species of shorebirds; 3 species of gulls; 3 species of blackbirds; 3 species of wading birds; and 6 species of grassland birds. Although the total number of wetland birds using the study site has declined since the ponds were taken out of service (D. Benz, Hiawatha Valley Audubon Society, personal communication), they are still attracted to the partially drained pond, with a wide diversity of species still using it. Most of the waterfowl and shorebird species listed for this site (eBird 2016, Minnesota Ornithologist's Union 2016) were not observed in the present study. Sightings records indicate that most of these species were observed only during spring migrations in April. The single April sample date in the present study would have a high probability of missing most of these species, given their likely transitory presence at the site during migration. Multiple survey dates each month would be needed to more completely document the true number of species using the study site, especially during migration periods.

The restored prairies at the Lewiston Nature Preserve were successful in attracting several species of grassland-dependent birds, and some of these birds successfully reproduced. Although the total number of grassland species in restored prairies at the study site was low (eight species; present study, eBird 2016), such low grassland bird species richness seems to be typical of small prairies (Marzluff and Ewing 2001, Van Dyke et al. 2004). For example, similar-sized (~8-ha) prairie patches in Iowa that had been restored and intensively managed for 15–30+ yr had 9 to 10 species of grassland birds (Van Dyke et al. 2004). Because some species of grassland birds have a very low frequency of occurrence (<10%) on prairie patches under 10 ha (Fletcher

Table 1. Numbers of birds observed during surveys of three habitats in the Lewiston Nature Preserve, June 2014–May 2015.

Order/Common Name	Scientific Name	Old Field	New Field	Wetland	Totals	% of Total
Anseriformes						
Blue-winged teal	*Anas discors*	0	0	2	2	0.1
Canada goose	*Branta canadensis*	0	0	1	1	0.1
Mallard	*Anas platyrhynchos*	0	0	4	4	0.2
Galliformes						
Ring-necked pheasant	*Phasianus colchicus*	19	2	9	30	1.8
Cathartiformes						
Turkey vulture	*Carthartes aura*	0	4	0	4	0.2
Accipitriformes						
Bald eagle	*Haliaeetus leucocephalus*	0	1	0	1	0.1
Cooper's hawk	*Accipiter cooperii*	0	0	1	1	0.1
Red-tailed hawk	*Buteo jamaicensis*	0	0	1	1	0.1
Falconiformes						
American kestrel	*Falco sparverius*	1	1	0	2	0.1
Gruiformes						
Sora	*Porzana carolina*	0	0	2	2	0.1
Charadriiformes						
Greater yellowlegs	*Tringa melanoleuca*	0	0	2	2	0.1
Killdeer	*Charadrius vociferus*	1	1	3	5	0.3
Lesser yellowlegs	*Tringa flavipes*	0	0	3	3	0.2
Snipe	*Gallinago gallinago*	2	1	0	3	0.2
Solitary sandpiper	*Tringa solitaria*	0	0	4	4	0.2
Columbiformes						
Mourning dove	*Zenaida macroura*	2	0	6	8	0.5
Caprimulgiformes						
Ruby-throated hummingbird	*Archilochus colubris*	0	0	1	1	0.1
Piciformes						
Downy woodpecker	*Picoides pubescens*	0	0	1	1	0.1
Northern flicker	*Colaptes auratus*	1	0	0	1	0.1
Passeriformes						
American crow	*Corvus brachyrhynchos*	1	1	2	4	0.2
American goldfinch	*Spinus tristis*	21	7	11	39	2.4
American robin	*Turdus migratorius*	4	3	12	19	1.1
American tree sparrow	*Spizella arborea*	0	89	39	128	7.7
Barn swallow	*Hirundo rustica*	3	3	7	13	0.8
Black-capped chickadee	*Poecile atricapillus*	3	4	3	10	0.6
Blue jay	*Cyanocitta cristata*	3	2	2	7	0.4
Bobolink	*Dolichonyx oryzivorus*	10	1	1	12	0.7
Brown-headed cowbird	*Molothrus ater*	0	0	2	2	0.1
Cliff swallow	*Petrochelidon pyrrhonota*	8	0	5	13	0.8
Common grackle	*Quiscalus quiscula*	5	2	3	10	0.6
Common yellowthroat	*Geothlypis trichas*	11	6	5	22	1.3
Dark-eyed junco	*Junco hyemalis*	0	0	8	8	0.5

Table 1. Continued.

Order/Common Name	Scientific Name	Old Field	New Field	Wetland	Totals	% of Total
Dickcissel	*Spiza americana*	30	15	11	56	3.4
European starling	*Sturnus vulgaris*	0	2	0	2	0.1
Field sparrow	*Spizella pusilla*	0	1	0	1	0.1
Fox sparrow	*Passerella iliaca*	0	0	4	4	0.2
Horned lark	*Eremophila alpestris*	9	0	0	9	0.5
Indigo bunting	*Passerina cyanea*	0	0	1	1	0.1
Marsh wren	*Cistothorus palustris*	0	0	2	2	0.1
Northern cardinal	*Cardinalis cardinalis*	0	0	1	1	0.1
Red-eyed vireo	*Vireo olivaceus*	0	0	1	1	0.1
Red-winged blackbird	*Agelaius phoeniceus*	120	74	808	1,002	60.5
Sedge wren	*Cistothorus platensis*	18	1	1	20	1.2
Song sparrow	*Melospiza melodia*	20	47	86	153	9.2
Swamp sparrow	*Melospiza georgiana*	0	0	12	12	0.7
Tree swallow	*Tachycineta bicolor*	0	1	0	1	0.1
Western meadowlark	*Sturnella neglecta*	7	12	2	21	1.3
White-throated sparrow	*Zonotrichia albicollis*	0	0	7	7	0.4
Total		299	281	1,076	1,656	100.0
No. of species		22	24	39		

2006, Askins et al. 2007), the small restored prairies at the Lewiston Nature Preserve, even if intensively managed for grassland birds, may only be capable of attracting a small number of species (Schwartz and van Mantgem 1997, Marzluff and Ewing 2001).

Although the two restored prairies at the study site differed in the time since restoration (1 versus 11 years), both held similar numbers of species (both total and grassland) during the monthly surveys and also exhibited similar bird community diversity. The two restoration sites differed only in the total numbers of grassland birds (but not total numbers of all birds) using the habitats, with the old field having 2.7 times as many as the new field. The old field contained five grassland species, whereas the new field had six species.

As restored prairies develop and mature, their plant communities pass through a series of changes that may favor

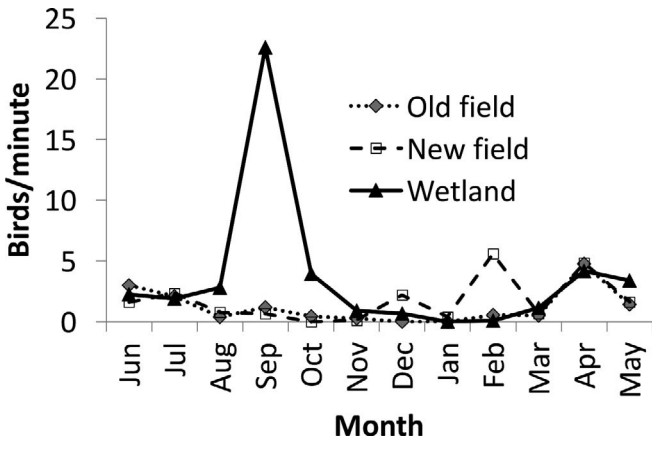

Figure 2. Standardized total bird abundance (birds/minute) in three habitats at Lewiston Nature Preserve, based on monthly transect surveys, June 2014–May 2015.

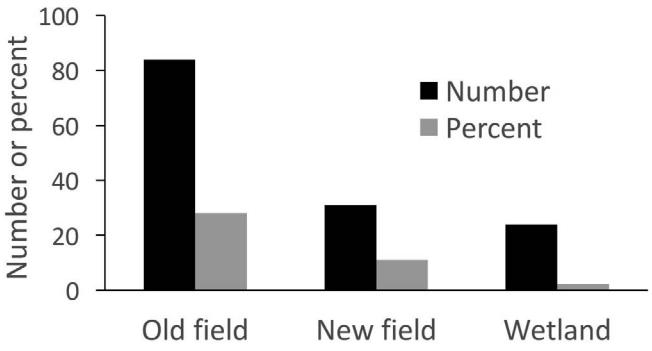

Figure 3. Total numeric and percentage abundances of grassland-obligate birds (ring-necked pheasant, bobolink, dickcissel, western meadowlark, sedge wren) in three habitats at Lewiston Nature Preserve, based on monthly transect surveys, June 2014–May 2015.

or disfavor various grassland birds (Fletcher and Koford 2003, Andrews 2013). For example, bobolink, dickcissel, sedge wren, savannah sparrow (*Passerculus sandwichensis*), and grasshopper sparrow (*Ammodramus savannarum*) all increased in abundance after prairie patch restorations in northern Iowa, whereas killdeer and brown-headed cowbird numbers declined as plant physical structure increased and bare ground decreased (Fletcher and Koford 2003). Savannah sparrows are pioneer species (Whitmore 1981, Vickery 1996) that will colonize newly restored grasslands immediately after restoration, during the first year of plant growth (Andrews 2013), likely because they exhibit low site fidelity from year to year and regularly seek out new potential nesting sites (Jones et al. 2007). Invasion of restored sites by non-native plants may not affect their use by grassland birds, as long as the physical structure of invading plants does not differ markedly from that of the native prairie forbs and grasses (Kennedy et al. 2009).

At 11 yr postrestoration, the old field grassland bird community had likely stabilized when this study was undertaken, whereas the new field, 1 yr after restoration began and still in its initial mowing regimen, had a grassland bird community that was just developing. Grassland birds represented >25% of the total bird community in the old field, but only 11% of that in the new field. Four of the six grassland species were represented by only one or two individuals, whereas four of the five grassland species in the old field were represented by 10 or more individuals. In the new field, the seasonal mowings reduced the physical structure of plants and exposed more area of bare soil compared to that present in the old field. These conditions seemed to be suitable for the short-grass-loving western meadowlark and the more grassland generalist dickcissel (both species represented by >10 individuals), yet was not attractive for the other species such as bobolink that prefer denser and taller vegetation (Ehrlich et al. 1988). As the new field restoration matures and plant species diversity increases, we suspect that the number of grassland birds will increase to levels matching those in the old field restoration. At that stage, with a combined area >11 ha, the restored prairies may be able to attract additional grassland birds beyond those observed to date (eBird 2016, this study).

The Lewiston Nature Preserve, with its wetland and restored prairie habitats, now attracts a wide diversity of bird species for birdwatchers to enjoy. Both wetlands and prairies provide important habitat for specialist birds in a region otherwise dominated by agriculture and deciduous forest remnants. The prairie restorations in particular have added small, but extremely important, tallgrass prairie habitat to aid the conservation of several imperiled species of birds that have experienced severe population declines in recent years. Future prairie management practices (prescribed burns, invasive plant control, periodic mowing, additional plantings, or overseeding) at this site will need to focus on maintaining maximum diversity of grassland birds while still facilitating use by a wide diversity of wetland and edge species. The city of Lewiston is dedicated to maintaining this valuable resource for the enjoyment of birdwatchers, not only the regional residents but also the many visitors who come to Winona County every year to experience the richness and diversity of our bioregion.

ACKNOWLEDGMENTS

We thank the city of Lewiston for requesting that this project be undertaken and for providing access to the study site. Mark Reisetter (Lewiston Sportsmen's Club) provided information on site history and management.

LITERATURE CITED

Andrews, J. E. 2013. Habitat selection in restored grasslands: the role of social cues in the settlement of Grasshopper Sparrows. Master's thesis. University of Illinois at Urbana-Champaign, USA.

Askins, R. A., F. Chávez-Ramírez, B. C. Dale, C. A. Haas, J. R. Herkert, F. L. Knopf, and P. D. Vickery. 2007. Conservation of grassland birds in North America: understanding ecological processes in different regions. Ornithological Monographs 64:1–46.

Brower, J. E., J. H. Zar, and C. von Ende. 1998. Field and laboratory methods for general ecology. Fourth edition. WCB McGraw-Hill, Boston, Massachusetts, USA.

eBird. 2016. Lewiston WTP, Winona County, Minnesota. eBird hotspots. Cornell Lab of Ornithology, Cornell University, Ithaca, New York, USA. http://ebird.org/ebird/hotspot/L1333672?yr=all&m=&rank=mrec. Accessed 4 August 2016.

Ehrlich, P. R., D. S. Dobkin, and D. Wheye. 1988. The birder's handbook: a field guide to the natural history of North American birds. Simon & Schuster Inc., New York, USA.

Fletcher, R. J., Jr. 2006. Emergent properties of conspecific attraction in fragmented landscapes. American Naturalist 168:207–219.

Fletcher, R. J., Jr., and R. R. Koford. 2003. Changes in breeding bird populations with habitat restoration in northern Iowa. American Midland Naturalist 150:83–94.

Herkert, J. R., D. L. Reinking, D. A. Wiedenfield, M. Winter, J. L. Zimmerman, W. E. Jensen, E. J. Finck, R. R. Koford, D. H. Wolfe, S. K. Sherrod, M. A. Jenkins, J. Faaborg, and S. K. Robinson. 2003. Effects of prairie fragmentation on the nest success of breeding birds in the midcontinental United States. Conservation Biology 17:587–594.

Herkert, J. R., D. W. Sample, and R. E. Warner. 1996. Managing Midwest landscapes for the conservation of Neotropical migratory birds. Pages 89-116 *in* General

Technical Report NC-187. U.S. Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota, USA.

Igl, L., and D. H. Johnson. 1997. Changes in breeding bird populations in North Dakota: 1967 to 1992-93. Auk 114:74–92.

Jannik, N. O., E. C. Alexander, Jr., and L. J. Landherr. 1992. The sinkhole collapse of the Lewiston, Minnesota waste water treatment facility lagoon. Pages 715–724 *in* J. Quinlan and A. Stanley, editors. Proceedings of the Third Conference on Hydrogeology, Ecology, and Monitoring of Ground Water in Karst Terranes. National Ground Water Association, Nashville, Tennessee, USA.

Johnson, R. J., J. A. Jedlicka, J. E. Quinn, and J. R. Brandle. 2011. Global perspectives on birds in agricultural landscapes. Pages 55–140 *in* W. B. Campbell and L. O. Silva, editors. Integrating agriculture, conservation and ecotourism: examples from the field. Springer-Verlag, Berlin, Germany.

Jones, S. L., J. S. Dieni, M. T. Green, and P. J. Gouse. 2007. Annual return rates of breeding grassland songbirds. Wilson Journal of Ornithology 119:89–94.

Kennedy, P. L., S. J. DeBano, A. M. Bartuszevige, and A. S. Lueders. 2009. Effects of native and non-native grassland plant communities on breeding passerine birds: implications for restoration of Northwest bunchgrass prairie. Restoration Ecology 17:515–525.

Marzluff, J. M., and K. Ewing. 2001. Restoration of fragmented landscapes for the conservation of birds: a general framework and specific recommendations for urbanizing landscapes. Restoration Ecology 9:280–292.

Minnesota Ornithologist's Union. 2016. Sightings database: query Lewiston, Winona County. Minnesota Ornithologist's Union, J. F. Bell Museum of Natural History, University of Minnesota, Minneapolis, Minnesota, USA. http://moumn.org/avian/query.php. Accessed 6 August 2016.

Ruiz-Jaen, M. C., and T. M. Aide. 2005. Restoration success: how is it being measured? Restoration Ecology 13:569–577.

Samson, F., and F. Knopf. 1994. Prairie conservation in North America. Bioscience 44:418–421.

Schwartz, M. W., and P. J. van Mantgem. 1997. The value of small preserves. Pages 213–218 *in* C. Warwick, editors. Proceedings of the 15th North American Prairie Conference. The Natural Areas Association, Bend, Oregon, USA.

Thogmartin, W. E., M. G. Knutson, and J. R. Sauer. 2006. Predicting regional abundance of rare grassland birds with a hierarchical spatial count model. Condor 108:25–46.

VanBeek, K. R., J. D. Brawn, and M. P. Ward. 2013. Does no-till soybean farming provide any benefits for birds? Agriculture, Ecosystems and Environment 185:59–64.

Van Dyke, F., S. E. Van Kley, C. E. Page, and J. G. Van Beek. 2004. Restoration efforts for plant and animal communities in tallgrass prairies using prescribed burning and mowing. Restoration Ecology 12:575–585.

Vickery, P. 1996. Grasshopper sparrow (*Ammodramus savannarum*). Species 239 *in* A. Poole, editor. The birds of North America online. Cornell Lab of Ornithology, Cornell University, Ithaca, New York, USA. http://bna.birds.cornell.edu/bna/species/239/articles/breeding. Accessed 5 August 2016.

Whitmore, R. 1981. Structural characteristics of grasshopper sparrow habitat. Journal of Wildlife Management 45:811–814.

Zar, J. H. 1974. Biostatistical analysis. Prentice-Hall, Inc., Englewood Cliffs, New jersey, USA.