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Changes in Breeding Bird Populations with Habitat Restoration in Northern Iowa

ROBERT J. FLETCHER, JR. [1]
Iowa Cooperative Fish and Wildlife Research Unit, Department of Natural Resource Ecology and Management, Science Hall II, Iowa State University, Ames 50011

AND

ROLF R. KOFORD
USGS, Iowa Cooperative Fish and Wildlife Research Unit, Science Hall II, Iowa State University, Ames 50011

ABSTRACT.—Native tallgrass prairie and wetland habitat in the Prairie Pothole Region of the United States have declined over the past two centuries. Bird communities using these habitats have also experienced widespread declines that are often attributed to severe habitat loss and fragmentation. We estimated the change, or turnover, in bird populations in the Eagle Lake Wetland Complex, Iowa, with ongoing grassland and wetland restoration by linking geographic information system data and bird surveys in different land cover types (hayland, pasture, restored grassland, restored wetland and rowcrop agriculture) during the 1999–2001 breeding seasons. Habitat restoration efforts primarily converted rowcrop agriculture and pastures into grassland and wetland habitat. Based on land conversion, abundances of most species have likely increased in the area, including many species of management concern. Yet a few species, such as killdeer (*Charadrius vociferus*), have probably decreased in abundance. This estimation approach and these estimates provided a critical first step for evaluating restoration efforts; however, information on demographic parameters, such as nesting success, in restored areas is needed for understanding how restoration ultimately affects bird populations.

INTRODUCTION

Both native tallgrass prairie and wetlands in the Prairie Pothole Region of the United States have declined over the past two centuries (Dahl, 1990; Samson and Knopf, 1994). In Iowa, for example, 99% of native prairie and 89% of native wetlands have been lost (Bishop *et al.*, 1998; Smith, 1998). Based on the Breeding Bird Survey (BBS), bird populations using grassland habitats have also experienced consistent widespread declines throughout the continental United States (Herkert, 1995; Peterjohn and Sauer, 1999; *see* also Igl and Johnson, 1997) that have been attributed to severe habitat loss and fragmentation (Herkert *et al.*, 1996). Wetland birds tend to be under sampled by the BBS (Herkert, 1995), but other evidence suggests that many wetland species have also experienced population declines (Herkert, 1995; Igl and Johnson, 1997). To conserve bird communities, restoration must occur and provide adequate resources needed by avian communities. Recently, state and federal agencies have responded by restoring some of the grassland and wetland habitats in the Midwest (*e.g.*, Bishop *et al.*, 1998).

Effects of grassland and wetland restoration on bird populations are often evaluated by either: (1) comparing bird populations in native habitat to those on restored habitat

[1] Corresponding author: Present address: Division of Biological Sciences, University of Montana, Missoula, Montana 59812; telephone (406) 243-2035; e-mail: robertjfletcher@yahoo.com

(Blankespoor, 1980; Delphey and Dinsmore, 1993; Brown and Smith, 1998; Ratti *et al.*, 2001; Fletcher and Koford, 2002) or (2) comparing bird populations in restored habitat to populations on rowcrop agriculture lands (Johnson and Igl, 1995; Best *et al.*, 1997; Prescott and Murphy, 1999), which is the predominant land use in the Midwest. Bird populations are often compared between native and restored habitat to determine if restored areas are providing habitat that is similar in suitability to historical native habitat. Bird populations are often compared on rowcrop agriculture land and restored areas to determine how populations might have changed with land conversion because habitat is generally reconstructed from rowcrop lands. Here we present a more unified approach that links geographic information systems (GIS) and recent bird surveys in different land cover types to determine the contributions of habitat restoration to local bird populations.

Our objectives were to: (1) quantify changes in land cover with habitat restoration, (2) estimate bird densities in common land cover types in the region and (3) estimate changes in bird populations with habitat restoration. We expected grassland and wetland breeding birds would show positive changes in populations, whereas other breeding birds would either exhibit negative changes or no significant changes with habitat restoration. Potential scenarios of future land acquisition and restoration can be evaluated by using bird densities in common land cover types and predicting what types of land conversion will provide the greatest changes in bird populations. Estimating changes in bird populations with restoration will not only help evaluate the efficacy of past restoration efforts but will also provide a framework for evaluating future restoration efforts and restoration efforts elsewhere.

METHODS

Study area.—We quantified effects of habitat restoration within the Eagle Lake Wetland Complex, located in Hancock and Winnebago counties, north-central Iowa (43°N, 94°W). The Eagle Lake Wetland Complex encompasses approximately 162 km^2 and contains a complex of federal waterfowl production areas (WPAs) and state wildlife management areas (WMAs) in an agricultural landscape. Most areas were restored by state and federal agencies during the past 15 y, and restoration is ongoing in the complex. To estimate change, or turnover, in bird populations with restoration, we focused on the nine restored WPAs and WMAs (total area = 817.5 ha, $\bar{x}$ = 90.8 ha, SD = 59.7 ha; range = 31.4–196.7 ha) within the complex that had been restored since 1984. All contained restored grassland and wetland habitats.

Grasslands were restored using several techniques and plantings. Grasslands contained both warm-season and cool-season grass plantings. Warm-season plantings were typically switchgrass (*Panicum virgatum*), big bluestem (*Andropogon gerardii*) or mixtures of both, and cool-season plantings were typically smooth brome (*Bromus inermis*) or brome/alfalfa (*Medicago sativa*) mixtures. Other common plants in restored areas included orchard grass (*Dactylis glomerata*), reed canary grass (*Phalaris arundinacea*), red clover (*Trifolium pratense*) and milkweed (*Asclepias* spp.).

Wetlands were restored by removing drainage tile lines or plugging tile lines and/or drainage ditches (sensu LaGrange and Dinsmore, 1989; Delphey and Dinsmore, 1993). Some wetland basins were also excavated to increase wetland depth. Wetlands were not replanted with vegetation, but plant establishment in these areas occurred primarily from the seed bank (Galatowitsch and van der Valk, 1996). Propagules in the seed bank from drained wetlands may be viable for many years, although seed density and species richness decline over time (Wienhold and van der Valk, 1989). Dominant wetland vegetation included cattails (*Typha* spp.), bulrush (*Scirpus* spp.) and reed canary grass.

Estimating land conversion.—We calculated changes in land cover using aerial photographs

TABLE 1.—Land cover (ha) before (1983) and after (1999) habitat restoration in the Eagle Lake Wetland Complex, Iowa

Land cover	Prerestoration (1983)	Postrestoration (1999)	% change
Hayland	8.2	0.0	−1.0
Open water	0.0	74.6	9.1
Pasture	67.0	0.0	−8.2
Restored grassland	0.0	530.3	64.9
Rowcrop agriculture	687.9	98.9	−72.1
Wetland vegetation	5.1	81.8	9.4
Woodland	22.3	21.7	−0.1
Other*	27.0	10.2	−2.1
Total	817.5	817.5	

* Includes all land cover types that were each <1% of the total land cover area

of the WPAs and WMAs taken in 1983 (prerestoration) and 1999 (postrestoration). We chose 1983 as a prerestoration reference year because the earliest restoration we considered occurred in 1984 and this year also preceded the first sign-up for the Conservation Reserve Program (Young and Osborn, 1990). We chose 1999 as a postrestoration reference year because we initiated bird surveys during that year. Photographs were geo-referenced and digitized using a GIS. Land-cover categories included hayland (primarily alfalfa), homesteads, linear grassland (*e.g.*, terraces, grassed waterways, roadside ditches), open water (*e.g.*, lakes, open portions of some wetlands), pasture, restored grassland (both warm-season and cool-season plantings), rowcrop agriculture (corn and soybeans), wetland vegetation and woodland. Warm-season and cool-season plantings were not differentiated because aerial photographs did not provide sufficient resolution. Based on these photographs, land acquisition and restoration converted primarily rowcrop agriculture to restored grassland, wetland vegetation and open water land cover (Table 1).

Upland bird surveys.—Surveys were conducted during the 1999–2001 breeding seasons. Each site was surveyed once in each of three periods during the breeding season: 20 May–5 June, 6 June–22 June and 23 June–7 July. We used 10-min, 50-m fixed-radius point counts for surveying breeding birds (Ralph *et al.*, 1995), but only present data from the first 8 min to minimize differences in techniques between upland and wetland bird surveys (*see* below). Point count locations were ≥150 m apart. Surveys were conducted between sunrise and 4 h after sunrise. Surveys were not conducted during high winds (≥20 km/h) or precipitation. Each year two observers conducted surveys, and each observer surveyed each site at least once. One of these observers surveyed birds during every year of the study, but the other observer was different each year. Observers were trained for consistency before the commencement of sampling each year. During surveys, observers recorded all birds seen or heard, including how individuals were detected (song, visual or call), sex of individuals and distances of birds from the center point. We did not include birds flying over points in our analyses. Distances (m) to birds seen were estimated using a rangefinder.

Point count locations were determined using a GIS. A grid was laid over aerial photographs of each site, with each grid cell measuring 150 × 150 m. Each cell was considered a potential sampling unit (SU), with a potential point count location at the center of each cell. All sites had at least three SUs. We stratified potential sampling units into geographic sections of similar area (*e.g.*, northwest, northeast, southwest and southeast areas of the field). Sites with 12 or more SUs were stratified into four sections, sites with 9–11 SUs were stratified into three sections, sites with 6–8 SUs were stratified into two sections and sites with less than six SUs were not stratified. During each sampling period we randomly selected one SU in each stratum to sample. We did not repeat any individual SUs. This method provided a random sampling design yet ensured that the entire range of variability was sampled within each site. When sites were surveyed in more than one year, the same point count locations were sampled across years.

We surveyed birds in four upland land cover types: hayland (primarily alfalfa; n = 5 sites), pasture (n = 7), restored grassland (n = 8) and rowcrop agriculture (corn and soybeans; n = 7). Restored grasslands were surveyed every year (1999–2001; n = 90 points/y). In 1999 we surveyed four pastures (n = 30 points) and four rowcrop agriculture sites (n = 36 points). However, in 2000 and 2001 we were not granted permission onto four sites surveyed in 1999 (two rowcrop and two pasture sites). We added three rowcrop agriculture sites (n = 33 points/y), three pasture sites (n = 18 points/y) and five hayland sites (n = 30 points/y) to our sampling in 2000 and 2001. Our criteria for selecting hayland, pasture and rowcrop agriculture sites were: (1) sites needed to be <2 km of restored sites (to minimize potential landscape effects) and (2) sites needed to be >7 ha to accommodate our sampling design.

Wetland bird surveys.—We used a slightly different protocol for surveying wetland birds than our upland survey protocol, similar to other wetland bird studies (*e.g.*, Brown and Dinsmore, 1986; Delphey and Dinsmore, 1993; Naugle *et al.*, 1999). We defined wetland complexes as the total number of seasonal, semipermanent and permanent wetlands (Cowardin *et al.*, 1979) within a WPA or WMA (sensu Fairbairn and Dinsmore, 2001). We considered wetland complexes within WPAs and WMAs as independent units. Wetland surveys were conducted during the 1999–2001 breeding seasons. Each restored wetland complex was surveyed three times during similar time periods as for upland surveys: 15 May–5 June, 6–22 June and 23 June–5 July. We conducted wetland bird surveys using 8-min, 20-m fixed-radius point counts (Delphey and Dinsmore, 1993). Count radius was smaller than in upland counts to minimize habitat heterogeneity within count circles (*see* also Brown and Dinsmore, 1986; Hemesath and Dinsmore, 1993; Delphey and Dinsmore, 1993; Naugle *et al.*, 1999). Point count locations were ≥75 m apart. We played taped calls to detect secretive species during minutes 3–5 of each survey. We used 30-s taped calls to detect Virginia rail (*see* Appendix for scientific names of common species detected), sora, least bittern (*Ixobrychus exilis*) and American bittern (*Botaurus lentiginosus*). However, we had few observations of least and American bitterns, so these species were not considered in analyses. Surveys were conducted between sunrise and 4 h after sunrise and were not conducted during high winds (≥20 km/h) or precipitation.

We delineated wetland boundaries within WPAs and WMAs using aerial photographs taken in 1999 and count locations were selected using a GIS. We combined the perimeters of wetlands within each complex (*i.e.*, each WPA/WMA) into one overall length, divided the length into three equal segments and selected one random point along each segment. Based on 1999 photos, points were centered in the emergent vegetation zone, or at the water's edge where no emergent vegetation was present (Delphey and Dinsmore, 1993). Three point count locations were surveyed in each wetland complex (n = 7), and each point was repeated during each time period (n = 63 points/y). Although wetland conditions varied among years (*see* Results), the same count locations were repeated each year. Therefore, a count location could be along the water's edge in one year but not in another year, if water levels changed across years. After each point count survey, we also measured water depth (cm) at four locations within the point count area: one at the center of the point and at three locations 0°, 120° and 240° from the center, at distances of 10 m.

Statistical analyses.—Because point counts within sites were not independent, we estimated bird densities (birds/ha) per site for each land cover type surveyed, averaged across years and estimated 95% confidence intervals for these density estimates. We weighted estimates based on the number of point counts conducted per site to incorporate increased precision with our estimates as the number of counts within sites increased. We did not correct for detectability because of few observations of species in some land cover types (*see* Appendix). Elsewhere we documented that most species have high detectability up to 50 m from observers and that uncorrected density estimates are generally similar to corrected estimates (Fletcher and Koford, 2002; *see* also Rotella *et al.*, 1999). Lower confidence limits for density estimates were truncated to zero because negative density cannot occur. We estimated the change in abundance with habitat restoration by linking density estimates and changes in land cover types to determine the population change for each species:

$$Estimated\ change = \sum_{i=1}^{n} d_i \times (A_{i,postrestoration} - A_{i,prerestoration})$$

where d_i is the density of the species (birds/ha) in land cover i, A is the total area of the land cover and n is the number of land cover types. We estimated change using both mean density estimates and lower and upper confidence limits of density estimates. Using confidence limits is critical for incorporating precision and site variability in density estimates. This measure of change does not incorporate temporal or spatial trends in bird densities (*see* Discussion), but quantitative measures of temporal and spatial patterns of bird densities are not well-documented for the species that we considered. This measure only requires estimating bird densities in land cover types that have changed with restoration efforts. We surveyed the primary land cover types that changed with restoration; the only land cover type that we did not survey for birds that changed substantially was open water (Table 1). For this land cover, we assumed bird density was zero, which is reasonable for all species that we considered. This assumption is conservative for evaluating restoration, because relaxing it would lead to increases in estimated changes for common bird species.

RESULTS

Between 1999–2001 we recorded 3322 bird observations during point counts: 1630 in restored grasslands, 740 in restored wetlands, 531 in pastures, 253 in haylands and 168 in rowcrop fields. We observed 54 species: 29 in restored grasslands, 31 in restored wetlands, 14 in pastures, 11 in haylands and 8 in rowcrop fields. Most species had lower densities in rowcrop agriculture than other land cover types (Appendix).

We estimated changes for 20 bird species known to breed in at least one land cover type: 6 species that typically nested in grasslands, 6 that typically nested in wetlands and 8 other species, which included species that were not grassland/wetland obligate breeders (Table 2). Based on mean estimates of change, 16 species increased with restoration and 4 decreased. However, by inspecting confidence limits, 9 species exhibited significant increases, 10 showed no change and 2 decreased. Only killdeer and brown-headed cowbirds significantly decreased with habitat restoration. Eleven species have exhibited declines in the region (Table 2), based on BBS data from 1983–1999 for USFWS Region Three, which includes Iowa (route-regression analysis; Sauer *et al.*, 2001). Five of these 11 species increased with restoration.

Bird density in wetlands can vary depending on wetland conditions (Weller and Fredrickson, 1974; Igl and Johnson, 1997), which differed among years of our study. Based on water depth measurements taken at each point count location, 2000 was significantly drier than 1999 or 2001 (1999: 21.94 ± 2.20 cm; 2000: 7.08 ± 4.03 cm; 2001: 27.28 ± 6.20 cm;

TABLE 2.—Estimated change in abundance (mean number of birds, lower [LCL] and upper [UCL] confidence limits) of common bird species based on land conversion from 1983–1999 in the Eagle Lake Wetland Complex, Iowa and the Breeding Bird Survey trend (BBS) during this time period for USFWS Region Three (which includes Iowa). Estimated change in abundance was calculated using density estimates (means and confidence limits) averaged across years (1999–2001), for a dry year (2000) and for a wet year (2001)

	Estimated change									
	1999–2001			2000			2001			
Species	x̄	LCL	UCL	x̄	LCL	UCL	x̄	LCL	UCL	BBS[a]
Grassland-breeding birds:										
Sedge wren	360	197	522	382	161	615	187	59	315	0.4
Savannah sparrow	237	−13	548	280	0	654	92	44	18	−0.9[b]
Grasshopper sparrow	234	91	374	183	16	327	130	−11	330	−3.1[b]
Dickcissel	220	87	349	190	30	311	234	97	365	−1.9[b]
Bobolink	1070	881	1266	1217	866	1607	1290	938	1656	−3.3[b]
Western meadowlark	4	0	12	−4	−6	0	11	0	23	−1.7[b]
Wetland-breeding birds:										
Virginia rail	19	0	45	0	0	0	19	0	50	−25.6[b]
Sora	55	13	97	10	0	33	78	0	169	5.6
American coot	23	0	47	0	0	0	48	0	108	−12.3[b]
Marsh wren	100	0	222	165	0	376	29	0	63	−3.9
Swamp sparrow	171	18	323	274	15	559	109	0	270	1.2
Yellow-headed blackbird	368	0	703	19	0	67	452	0	592	−9.9[b]
Other breeding birds[c]:										
Killdeer	−173	−298	−40	−157	−311	0	−126	−272	0	2.6[b]
Horned lark	−36	−75	0	−33	−110	0	−50	−122	0	−1.4[b]
Common yellowthroat	544	266	815	557	101	1006	547	230	816	−0.9[b]
Vesper sparrow	−77	−166	0	−83	−275	0	−133	−297	0	−0.8
Song sparrow	121	2	248	89	0	196	124	17	250	0.9[b]
Red-winged blackbird	1474	1229	1694	1543	916	2120	1432	1054	1686	−1.0[b]
Brown-headed cowbird	−8	−9	−3	−64	−167	0	3	−7	31	−0.4
American goldfinch	44	0	89	52	0	137	18	0	43	0.8[b]

[a] Route-regression analysis (Sauer *et al.*, 2001)
[b] $P < 0.05$
[c] Includes species that tend to breed in more than one land cover type or are non-obligate grassland/ wetland breeders

$F = 8.05$, $df = 2, 12$, $P = 0.006$). In 2000 most wetlands were relatively dry during spring migration and few wetland-nesting species settled in the restored wetlands relative to other years, whereas grassland-nesting species were more commonly observed in the relatively dry wetlands (Table 3). To incorporate this variability into our modeling approach, we also estimated changes in bird populations separately for a dry year (2000) and a wet year (2001). In general, estimates were similar between years (Table 2).

DISCUSSION

Grassland and wetland restoration inevitably provide breeding habitat for declining grassland and wetland-nesting birds. Nonetheless, estimating how restoration efforts have

TABLE 3.—Density of common bird species [mean birds/ha, standard error (SE)] observed in restored wetlands within the Eagle Lake Wetland Complex, Iowa, 1999–2001. 2000 was a relatively dry year, whereas 1999 and 2001 were relatively wet

	1999		2000		2001	
Species	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Grassland-breeding birds:						
Sedge wren	0.13	0.13	0.63	0.37	0.00	0.00
Savannah sparrow	0.00	0.00	0.13	0.13	0.00	0.00
Grasshopper sparrow	0.38	0.38	0.38	0.26	0.00	0.00
Dickcissel	0.00	0.00	0.13	0.13	0.00	0.00
Bobolink	0.00	0.00	0.38	0.38	0.13	0.13
Western meadowlark	0.00	0.00	0.00	0.00	0.00	0.00
Wetland-breeding birds:						
Virginia rail	0.51	0.33	0.00	0.00	0.25	0.16
Sora	1.01	0.41	0.13	0.13	1.01	0.49
American coot	0.25	0.16	0.00	0.00	0.63	0.32
Marsh wren	1.39	0.84	2.15	1.12	0.38	0.18
Swamp sparrow	1.01	0.41	2.53	0.95	0.63	0.32
Yellow-headed blackbird	8.34	4.08	0.25	0.25	8.72	3.94
Other breeding birds[a]:						
Killdeer	0.00	0.00	0.13	0.13	0.00	0.00
Horned lark	0.00	0.00	0.00	0.00	0.00	0.00
Common yellowthroat	1.26	0.38	2.65	1.04	2.53	0.85
Vesper sparrow	0.00	0.00	0.00	0.00	0.00	0.00
Song sparrow	1.01	0.76	0.25	0.16	0.38	0.26
Red-winged blackbird	11.63	2.78	12.76	2.49	12.13	2.02
Brown-headed cowbird	0.00	0.00	0.13	0.13	0.00	0.00
American goldfinch	0.00	0.00	0.38	0.26	0.13	0.13

[a] Includes species that tend to breed in more than one land cover type or are non-obligate grassland/wetland breeders

contributed to bird populations and communities in fragmented landscapes is not necessarily straightforward. Experimental or time-series approaches would provide strong inference for understanding temporal effects of restoration on bird populations, yet these approaches may be difficult to implement. Our approach provided quantitative estimates for evaluating potential changes in bird communities based on land conversion, which could be fruitful in future restoration efforts when different scenarios are being considered. Others have used qualitative measures to evaluate landscape change (*e.g.*, species lists; White *et al.*, 1997) or have measured bird communities in different land cover types without linking bird estimates with measures of landscape change (Pidgeon *et al.*, 2001; but *see* Herkert, 1997). However, integrating standardized quantitative estimates of avian populations that incorporate measures of precision and other information on landscape change provide stronger inference in understanding how habitat restoration or landscape change may affect bird populations.

We estimated that many species of management concern have increased with habitat restoration. Four of 6 grassland-nesting species increased, but grasshopper sparrows and western meadowlarks showed no significant change, possibly because of their high densities in pastures and high variability among sites. Grasshopper sparrows and meadowlarks both prefer relatively open habitats for breeding, like those found in pastures (Herkert, 1994; Temple *et al.*, 1999; Ribic and Sample, 2001; Fletcher and Koford, 2002). Only 2 of 6 wetland-nesting species increased significantly with restoration, possibly owing to high variability among both sites and years, or lag time in recolonization (but *see* Hemesath and Dinsmore, 1993). With continued establishment of wetland vegetation in restored wetlands, other wetland-nesting species may also increase in the area.

Even though some species exhibited an apparent increase with restoration, both killdeer and brown-headed cowbirds decreased. Killdeer tend to nest in open areas devoid of ground vegetation, such as rowcrop fields in early summer (Best *et al.*, 1997). Densities of killdeer were higher in rowcrop agriculture than other land cover types, and killdeer had higher densities in rowcrop fields than other species. Because brown-headed cowbirds had higher densities in pasture than in other land cover types, cowbirds likely decreased with restoration because of the conversion of pasture to restored grassland.

Our approach did not incorporate spatial processes that could be important in determining habitat use by birds in agricultural landscapes. For example, many species of grassland and wetland birds tend to be area sensitive, or less likely to occur or less dense in small patches of grassland or small wetland potholes (Brown and Dinsmore, 1986; Herkert, 1994; Naugle *et al.*, 1999; Winter and Faaborg, 1999; Johnson and Igl, 2001; but *see* Horn *et al.*, 2000). In addition, some grassland and wetland birds may be less abundant or less likely to occur in landscapes with low amounts of grassland or wetland composition, or high amounts of edge (Hughes *et al.*, 1999; Naugle *et al.*, 1999; Bajema and Lima, 2001; Ribic and Sample, 2001; Fletcher and Koford, 2002). Incorporating metrics that reflect these processes could be difficult because patterns could be conditional on regional density of the species of interest (Horn *et al.*, 2000). However, the importance of regional density as a covariate has not been quantified (but *see* Johnson and Igl, 2001). In prerestoration land cover, what little grassland and wetland habitat that did occur was composed of very small patches with little to no other habitat in the surrounding areas. Therefore, fragmentation-sensitive species may have been less likely to occur in these areas than we estimated using density estimates from larger patches.

Temporal dynamics in bird populations can potentially affect estimates of population change for two reasons: (1) bird populations can change among years based on habitat conditions, such as water depth in wetlands (Weller and Fredrickson, 1974; Igl and Johnson, 1997) and (2) some populations may be exhibiting either population increases or declines at regional scales (Herkert, 1995). We incorporated yearly variability into our estimates by calculating densities for relatively wet and dry years. However, our estimates did not incorporate temporal trends in bird populations, even though most of the species we investigated have exhibited declines between prerestoration and postrestoration periods, based on BBS trends (*see* also Herkert, 1995; Peterjohn and Sauer, 1999). We did not include potential temporal factors because it is unclear if temporal trends, from data such as BBS, reflect similar changes in within-patch bird density.

Our bird density estimates for different land cover types revealed that relatively few species used rowcrop agriculture land in this landscape, and those species observed in agriculture generally had lower densities than in other land cover types. In contrast, some species had relatively high densities in both pastures and haylands (*see* also Ribic and Sample, 2001). This suggests that future restoration efforts that restore grasslands from haylands and pasture will likely provide less change in avian populations than would restoring grasslands from rowcrop agriculture. Although restoring grassland from either haylands or pastures will likely provide less change in bird populations, these types of restoration efforts will ultimately be valuable because both grazing in pastures and mowing of haylands can decrease breeding success of birds (Bollinger *et al.*, 1990; Dale *et al.*, 1997; Temple *et al.*, 1999).

Understanding how abundances of bird populations change with habitat restoration is important for managing and conserving these species, but ultimately understanding how demographic parameters may change with restoration is needed. Fragmented landscapes in the Midwest may be acting as either habitat sources or sinks for grassland birds (McCoy *et al.*, 1999). Because bird density may not be correlated with nesting success (Hughes *et al.*, 1999; Winter and Faaborg, 1999) and nesting success can be low for species breeding in midwestern landscapes (*e.g.*, Hughes *et al.*, 1999), understanding how habitat and landscape structure affects nest success of breeding birds will be critical for evaluating habitat restoration and conserving declining bird populations.

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APPENDIX.—Density estimates [mean birds/ha, standard error (SE)] for five land cover types used to estimate changes in common bird species with habitat restoration in the Eagle Lake Wetland Complex, Iowa, 1999–2001

	Hayland		Pasture		Restored Grassland		Restored Wetland		Rowcrop agriculture	
Species	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Grassland-breeding birds:										
Sedge wren (*Cistothorus platensis*)	0.17	0.10	0.16	0.09	0.66	0.12	0.25	0.12	0.00	0.00
Savannah sparrow (*Passerculus sandwichensis*)	1.17	0.33	2.33	0.54	0.81	0.21	0.17	0.17	0.06	0.04
Grasshopper sparrow (*Ammodramus savannarum*)	0.08	0.07	0.61	0.20	0.52	0.26	0.13	0.09	0.01	0.01
Dickcissel (*Spiza americana*)	0.74	0.32	0.13	0.07	0.45	0.12	0.04	0.04	0.01	0.01
Bobolink (*Dolichonyx oryzivorus*)	1.02	0.37	1.23	0.48	2.15	0.20	0.17	0.17	0.02	0.02
Western meadowlark (*Sturnella neglecta*)	0.00	0.00	0.21	0.10	0.04	0.02	0.00	0.00	0.00	0.00
Wetland-breeding birds:										
Virginia rail (*Rallus limocola*)	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.14	0.00	0.00
Sora (*Porzana carolina*)	0.00	0.00	0.00	0.00	0.00	0.00	0.72	0.22	0.00	0.00
American coot (*Fulica americana*)	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.13	0.00	0.00
Marsh wren (*Cistothorus palustris*)	0.00	0.00	0.00	0.00	0.00	0.00	1.31	0.65	0.00	0.00
Swamp sparrow (*Melospiza geogiana*)	0.00	0.00	0.04	0.03	0.13	0.05	1.39	0.47	0.00	0.00
Yellow-headed blackbird (*Xanthocephalus xanthocephalus*)	0.00	0.00	0.00	0.00	0.00	0.00	5.77	2.54	0.08	0.08
Other breeding birds[a]:										
Killdeer (*Charadrius vociferus*)	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.35	0.11
Horned lark (*Eremophila alpestris*)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.03
Common yellowthroat (*Geothlypis trichas*)	0.28	0.08	0.08	0.05	0.76	0.16	2.15	0.52	0.02	0.01
Vesper sparrow (*Pooecetes gramineus*)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.06
Song sparrow (*Melospiza melodia*)	0.02	0.02	0.03	0.02	0.17	0.07	0.55	0.34	0.02	0.02
Red-winged blackbird (*Agelaius phoeniceus*)	1.78	0.49	1.57	0.71	1.63	0.25	12.17	1.37	0.27	0.13
Brown-headed cowbird (*Molothrus ater*)	0.00	0.00	0.19	0.12	0.09	0.05	0.04	0.04	0.06	0.03
American goldfinch (*Carduelis tristis*)	0.00	0.00	0.09	0.08	0.07	0.03	0.17	0.09	0.00	0.00

[a] Includes species that tend to breed in more than one land cover type or are non-obligate grassland/wetland breeders