GRASSLAND AND BREEDING BIRD USE OF MOIST-SOIL WETLANDS MANAGED FOR WATERFOWL

BY

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THESIS

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ABSTRACT

Many species of breeding birds are declining in the United States, and grassland birds are among those experiencing the steepest declines. One of the most widely accepted reasons for decreasing populations is habitat loss. For grassland birds in the midwestern United States during the spring and summer, a major concern is the loss of breeding habitat. Illinois has retained <1% of native prairie from the early 1800s due to the expansion of agriculture and urban development. Birds that historically relied on prairies for breeding must use alternate vegetative communities to fulfill their needs. Seasonally dewatered wetlands (e.g., moist-soil wetlands) provide vegetation structure similar to grasslands and may provide breeding habitat for birds during the summer when dewatered. I quantified avian use of dewatered moist-soil wetlands in the Illinois River Valley and used environmental variables to predict measures of avian density, avian conservation significance (ACS), nest density, and nest success. Nest densities were greater in grasslands (0.13 nests/ha, SE = 0.02) than in moist-soil wetlands (0.09 nests/ha, SE = 0.01), but habitat did not have a strong effect on avian density (grassland $\overline{x}$ = 13.5 birds/ha, SE = 3.5; moist-soil wetland $\overline{x}$ = 10.2 birds/ha, SE = 1.1) or ACS (grassland $\overline{x}$ = 218.6, SE = 27.8; moist-soil wetland $\overline{x}$ = 214.2, SE = 15.9). The percent cover of woody vegetation had a positive relationship with ACS, and the percent cover of forbs had a negative relationship with avian density. Sites that were disconnected from the river had greater avian conservation significance than partially connected sites. Wetland size and the proximity to the Illinois River were poor predictors of nest density. I observed many grassland birds using moist-soil wetlands, including nesting dickcissels (*Spiza americana*, a generalist-grassland nester) and grasshopper sparrows (*Ammodramus savannarum*, an obligate-grassland nester). I also observed the state endangered northern harrier (*Circus cyaneus*), common gallinule (*Gallinula galaeta*), and Forster’s tern (*Sterna forsteri*) in moist-soil wetlands. Dewatered moist-soil wetlands provide useful breeding

habitat for grassland birds, but wetlands that are partially connected to the Illinois River pose a risk to nesting birds if they are flooded during the breeding season. I recommend that moist-soil managers conduct a mid-season or late drawdown of wetlands that are at a high risk of flooding to avoid creating an ecological trap for breeding birds. In moist-soil wetlands that are disconnected from the Illinois River and less likely to flood, I recommend an early drawdown to allow moist-soil vegetation to grow and provide habitat for grassland birds.

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INTRODUCTION

Breeding bird populations have undergone widespread declines in the midwestern United States since the 1800s (Brennan and Kuvelsky 2005). In particular, grassland bird populations have declined due to the near complete loss of native prairie in this region. Illinois has lost > 99% of the prairie present in the 1800s (Fischer and Lindenmayer 2007, Walk et al. 2011). Most original prairie has been converted to row-crop agriculture, urban development, and other land types that are largely unsuitable for most avian use, especially during the breeding season (Herkert 1995). The remainder has been converted into other types of grasslands (e.g., pastures, hayfields), accounting for approximately 19% of current Illinois land cover. The remaining grasslands tend to be highly fragmented, disturbed, or otherwise not considered to be of high-quality although they may still provide useful habitat for breeding (Vickery et al. 1994, Best et al. 1995, Herkert et al. 1996). Grasslands that are dominated by exotic plants or are frequently disturbed tend to have lower levels of avian use than less-disturbed areas with native grasses (Warner 1994, Scheiman et al. 2003).

Grassland birds (e.g., grasshopper sparrows [*Ammodramus savannarum*] and dickcissels [*Spiza americana*]) used to be relatively common species in Illinois but are now identified as species in greatest need of conservation by the Illinois Comprehensive Wildlife Conservation Plan and Strategy due to the loss of breeding habitat (Illinois Department of Natural Resources 2005, U.S. Fish and Wildlife Service 2008). For example, the grasshopper sparrow has declined to an estimated 8.3% of their original Illinois breeding population since 1966 (Coppedge et al. 2008, Sauer et al. 2014). Furthermore, many of the birds listed as state threatened or endangered in Illinois such as the loggerhead shrike (*Lanius ludovicianus*), barn owl (*Tyto alba*), short-eared owl (*Asio flammeus*), upland sandpiper (*Bartramia longicauda*), Swainson's hawk (*Buteo* *swainsoni*), northern harrier (*Circus cyaneus*), and greater prairie-chicken (*Tympanuchus cupido*) all use grasslands for nesting or foraging during the breeding season (Illinois Endangered Species Protection Board 2015).

Alternate habitats with a similar vegetation structure to grasslands, such as dewatered moist-soil wetlands, can potentially support breeding birds during the breeding season. Moist-soil wetlands are often located in areas connected to a water source (e.g., the floodplain of rivers) and are inundated from autumn to spring during waterfowl migration and wintering periods. Moist-soil management is usually characterized by the use of water control structures (e.g., gas-fueled pumps, drop-board structures) to manipulate water levels (Strader and Stinson 2005). The goal of moist-soil management is to provide foraging habitat for migrating and wintering waterfowl by producing an abundance of seed-producing plants (Laubhan 1992, Kross et al. 2008). Typically, a moist-soil wetland is dewatered in late spring or summer to allow annual vegetation to grow and reach peak seed production by early autumn. The length of the growing season varies mainly based on latitude and elevation, but a growing season length suitable for most desirable moist-soil plants in the Midwest is 60 to 90 days (Bellrose et al. 1983, Fredrickson 1991)**.** Examples of desirable moist-soil plants include barnyard grasses (*Echinochloa* spp.), smartweeds (*Polygonum* spp.), rice cutgrass (*Leersia oryzoides*), and sedges (e.g., *Cyperus* spp.; Kaminski et al. 2003, Bowyer et al. 2005). In autumn and winter, moist-soil wetlands are shallowly flooded, which creates a nutrient-rich environment that is attractive as foraging habitat to migrating waterfowl (Low and Bellrose 1944, Stafford et al. 2011).

Moist-soil wetlands are assumed to provide useful habitat for other wildlife outside of the flooded period (Schultheis and Eichholz 2013). For example, mud-flats and shallow water often exist during drawdowns, providing foraging habitat for shorebirds, wading birds, and marsh birds (Galat et al. 1998, Smith et al. 2012, Russell et al. 2016, Wilson 2016). Evidence exists to suggest that seasonally dewatered wetlands may support species like songbirds during the growing season (Fleming 2010, Benson et al. 2011, Benson et al. 2013). Natural resource agencies and wetlands managers need information regarding the importance of moist-soil wetlands to wildlife other than waterfowl outside of the flooded period in order to maximize conservation efforts for a diverse suite of species (Illinois Department of Natural Resources 2005).

The nesting season of most grassland birds is similar to the date of drawdown and length of the growing season in dewatered moist-soil wetlands, and the desirable vegetation in dewatered seasonal wetlands may be able to provide suitable breeding habitat for grassland birds (Wittenberger 1980, Winter 1999, Fleming 2010)**.** Vegetation composition (e.g., woody vegetation cover, total vegetation cover) has been shown to have an effect on nest densities and success rates of grassland birds, but more data are needed, especially in alternate habitat types (Winter et al. 2005). Understanding the relationship between the vegetation in moist-soil wetlands and breeding birds that use them is critical, especially for the acutely threatened grassland birds in this region.

I quantified avian use in moist-soil wetlands and upland grasslands during late spring and summer of 2014 and 2015 and identified factors that influenced avian density, avian conservation significance, nest density, and nest success. I predicted that moist-soil wetlands would yield similar values of all measured avian variables to grasslands and provide comparable habitat function. I also predicted that moist-soil wetlands with management capabilities and those closer to a water source (e.g., the Illinois River) would yield greater avian densities and conservation scores. I expected some vegetative characteristics (e.g., percent cover of forbs, woody vegetation, ground litter) to be among top supported predictors for nest density and success in moist-soil wetlands and grasslands.

METHODS

Study Area

In 2014 and 2015, I collected data from sites located near or within the 100-year floodplain of the Illinois River Valley (IRV). The five counties in which I conducted surveys (DeWitt, Fulton, Mason, Woodford, and Tazewell) contain approximately 3.4% of the state's seasonal wetlands (Illinois Department of Natural Resources 1996). I collected data from land managed by private landowners, the Illinois Department of Natural Resources, Ducks Unlimited, and the U.S. Fish and Wildlife Service. The sites were located north to south from Woodford to Fulton County, and as far west as DeWitt County (Figure 1). Survey sites ranged from 2 to 170 ha ($\bar{x}$ = 38.7 ha, SE = 5.4). The average site area exceeds the minimum area requirement for most nesting grassland birds (5 – 55 ha; Herkert 1994), and individual sites less than the minimum required area were located within a larger matrix of similar habitat and could have likely supported nesting birds. I collected data from late June to September in 2014 and from May to August in 2015. I only surveyed wetlands that had been dewatered and where desirable moist-soil vegetation (e.g., a diverse community of annual grasses and forbs) was growing (Hagy and Kaminski 2012). I also surveyed grasslands in the same region but located outside of the 100-year floodplain of the river because none were available within the floodplain in the study area. Moist-soil wetlands (n = 25) ranged from 2 to 99 ha ($\bar{x}$ = 42.6, ha SE = 6.1) and grasslands (n = 5) ranged from 2 to 34 ha ($\bar{x}$ = 19 ha, SE = 5.9). I selected grasslands within the study area based on their lack of flooding and the vegetation composition being primarily grasses with the allowance of smaller portions of woody (< 10%) and forb (< 50%) cover.

The average precipitation for the central portion of the IRV is approximately 89 – 114 cm per year. The main channel of the Illinois River generally occupies only 3 – 6% of the total width of the river's floodplain, which spans 2.5 – 5 km along the middle Illinois River (Sparks 1995). During periods of high rainfall that results in flooding, the river expands its reach to fill more of the floodplain and begins to fill partially-connected wetlands that are protected by low-elevation levees during normal flow and mild flood events but that are overtopped during moderate and severe floods (Fredrickson and Taylor 1982). Flooding can inundate shallow backwater lakes that, as flooding recedes, produce moist-soil vegetation (Bellrose et al. 1983). Changes in the hydrology in this region of Illinois have resulted in the elimination of most obligate emergent aquatic plants but a 162% increase in cover of moist-soil vegetation since the 1930s (Stafford et al. 2010). Thus, moist-soil wetlands are very important for migrating waterfowl in the IRV (Havera 1999).

Experimental Design

Point counts.— Within each site, I conducted point counts at 2 to 10 randomly-generated locations, with the number of points relative to the size of the site. I generated random points using ArcMap 10.3 and then randomly selected final points based on the following criteria: points were 1) at least 100 m away from any other surrounding habitat (e.g., forests) and 2) at least 250 m away from one another to avoid overlapping of observations. I collected data in three survey periods that began when sites became dry enough to survey, and whose durations were influenced by the number of days with acceptable weather conditions: late-May through mid-July (period 1), mid-July through mid-August (period 2), and mid-August to September (period 3). I surveyed between 30 minutes before and approximately 3 hours after sunrise, but did not survey in instances of dense fog, moderate to heavy precipitation, or winds exceeding 28 kilometers per hour (Gutzwiller 1991). The duration of point counts were 10 minutes with no preceding waiting period (Ralph et al. 1995, Lee and Marsden 2008). I identified and recorded birds within a 100-m radius, and for each individual or cluster of birds I recorded the time of detection, sex, age (if possible), distance from the observer, habitat (e.g., moist-soil wetland, grassland, edge), behavior (e.g., flying, perched, territorial behavior), and number of individuals. I also recorded birds outside of the 100-m radius in this manner, but excluded them from subsequent analyses. At each point, I recorded a standardized description of the vegetation within the 100-m radius, the timing of the survey (time of day and date), and standardized measures of weather conditions and ambient noise level (Gutzwiller 1991, Alldredge et al. 2007).

Vegetation.— Following each point count, I measured vegetation structure and composition within 3 randomly-placed 2-m^2 plots nearby each point count location. These plots were placed at the end of three random azimuths of three random distances between 0 and 25 m using the point count location as a radial anchor. Within each vegetation survey plot, I visually estimated the percent cover of each vegetation type (e.g., woody, forb, grass, sedge [e.g., *Carex* spp., *Cyperus* spp.], and rush [e.g., *Juncaceae* spp.]) as well as each plant species present. I estimated vegetation height as the average of the tallest and shortest plants present. In 2015, I also recorded the total percent cover of vegetation in each plot, the percent ground cover of litter, and litter depth in cm. Additional site-wide characteristics included management intensity (recorded as 1 if actively managed, e.g., protected by levees with the presence of a water control structure, or if planting had occurred in the past year, 0 if not managed or passively managed), connectivity to the Illinois River (1: sites partially connected to the river were often protected by levees that would prevent inundation under mild flooding of the river [> 4.3 m], but may become inundated at higher flood levels; 0: sites that were disconnected from the river were not at risk for becoming inundated even during extreme flooding of the river), proximity to the Illinois River in meters, and the nearest proximity to any source of water in meters (e.g., rivers, lakes, ditches > 4 m wide with persistent water throughout the growing season. Bordering water was considered a proximity of 0; Table 1).

Nest searches.— I searched for nests at each point count location after the bird survey was complete. I systematically searched an 800-m^2 area to the east of each point using a transect approach (Figure 2). When I found a nest, I recorded the location, date, species (if possible), adult presence, nest contents, stage of development of eggs/nestlings, nest bowl composition (e.g., fine grasses, reeds and sticks), vegetation height, water depth, and a full vegetation survey as described above. I estimated embryo development using a field candler made of foam pipe insulation, and then revisited each nest at 3 to 4-day intervals until nestlings fledged or fate could be determined (Johnson and Temple 1990, Lokemoen and Koford 1996). I considered a nest to be successful if at least one bird fledged. I also searched 1 m on each side of my path between points to augment systematic surveys and recorded those as ancillary observations. I used nests discovered incidentally outside of the search areas (e.g., during vegetation surveys or outside of a site) in the calculation of success but not density, and otherwise treated them in the same manner as nests found during searches. Additionally, I used behavioral cues of birds to find additional nests for use in nest survival estimates. The behavioral cues included displaying male birds, agitated adults, and birds holding food or nest material (Vickery et al. 1992, Davis and Sealy 2000, Kosciuch et al. 2006). I did not estimate detection probability, but used similar nest searching methods in grasslands and wetlands and assumed my technique provided a reliable index of nest density.

Statistical Analyses

I generated estimates of avian density using program DISTANCE 6.2 (Thomas et al. 2010, Research Unit for Wildlife Population Assessment, St. Andrews, UK). I truncated observations at a radial distance of 100 m, and applied a filter to exclude observations classified as flyovers (i.e., birds not actively using the habitat within the 100-m radius of the point count). I ran each model with a conventional distance sampling (CDS) engine. I ran five models within each analysis using different key function and series expansions (i.e., uniform/cosine, uniform/simple polynomial, half-normal/cosine, half-normal/hermite polynomial, and hazard-rate/cosine) and selected the model with the lowest Akaike's Information Criterion corrected for small sample size (AIC_c; Burnham and Anderson 2002). I selected the number of intervals based on goodness of fit tests, appearance of the detection function, and biological plausibility of density estimates. To test for differences between grassland and moist-soil wetland densities, I post-stratified results by habitat type. For an index of avian density by habitat type and species, I separated avian observations by habitat type, summed observations for each species, and then divided that by the total number of points I surveyed for that habitat type.

I generated site level conservation scores using concern values as described by Twedt (2005). For land birds, I used Partners in Flight concern scores specific to area 22 (breeding regional concern score for Eastern Tallgrass Prairie), and for non-landbirds, I used preliminary scores from the Bird Conservancy of the Rockies for waterbirds (Partners in Flight Science Committee 2012; Bird Conservancy of the Rockies, unpublished data). The end result was a value for each site reflecting the site's conservation value, henceforth referred to as avian conservation significance (ACS). To compare the degree of influence on ACS that grassland birds had between habitat types, I calculated an ACS for grasslands and moist-soil wetlands separately only using birds considered obligate (entirely dependent on grasslands) or facultative grassland (commonly use grasslands) birds (Vickery et al. 1999; Appendix A). I calculated nest densities for each site by dividing total nests found during systematic searches by the total area searched at each site.

I used an information theoretic approach based on AIC_c to evaluate vegetation and site-specific characteristics as predictors of avian density, ACS, and nest density using a general linear mixed model in software SAS™ 9.4 (PROC MIXED; SAS Institute Inc., Cary, NC, Littell et al. 1996). I examined residual plots for each dependent variable to ensure that the assumptions for normality and homogeneity of variances were met. I applied a square root transformation to the values of nest density to meet the assumptions for the homogenous distribution of residuals. Site-specific characteristics included management intensity, connectivity to the Illinois River, average vegetation height, percent cover of forb, woody, grass, cocklebur (*Xanthium* spp., a common plant whose growth is generally discouraged by moist-soil managers), and smartweed (*Polygonum* spp.; a desirable moist-soil plant), the site's proximity to the Illinois River and to any source of water, habitat type (grassland or moist-soil wetland), the site's area, the total percent cover of vegetation, and the percent cover and depth of ground litter (Strader and Stinson 2005). Prior to data analysis, I developed biologically meaningful combinations of variables for inclusion in model sets. Using PROC CORR in SAS, I examined correlations among explanatory variables prior to analyses to avoid problems with multicollinearity, and considered variables with the absolute value of the Pearson correlation coefficient < 0.5 to be uncorrelated (Rodgers and Nicewander 1988). I included site and year as random effects. I ranked models in each set by the lowest AIC_c, retained those within 4 ΔAIC_c units of the top model, and then assigned model weights (w_i) to determine the relative support for each model (Burnham and Anderson 2002). If there was model uncertainty and variables occurred in more than one supported model, I model-averaged parameter estimates or predicted values and generated unconditional 85% confidence intervals (Burnham and Anderson 2002). I considered model-averaged variables whose confidence intervals did not include zero and predicted variables whose standard errors did not overlap to be strongly supported. Several predictors (i.e., total percent cover of vegetation, percent litter cover, and litter depth) were only measured during 2015 and could not be included in multi-year models, but post-hoc analyses using only data from 2015 revealed that none of those variables were important predictors for any dependent variables, and I omitted them from pooled analyses.

I calculated daily survival rates (DSR) for nests using the Mayfield method, and calculating nest success rates by raising the DSR to the power of the number of days in the nesting cycle (Mayfield 1975)**.** Since most nests were red-winged blackbirds and sample sizes were low across species, I used a 25-day nesting cycle to calculate overall success rates for all species, but those probabilities should be viewed with caution since they include multiple species (Dolbeer 1976, Johnson and Shaffer 1990, Confer and Pascoe 2003, Knutson et al. 2004, Novak et al. 2016). I used logistic exposure models (SAS PROC GENMOD) to identify site-wide, temporal, and environmental factors that influenced daily nest survival (Shaffer 2004). Using this approach, I examined the effects of the percent cover of woody vegetation, forbs, grass, cocklebur, smartweed, site area, habitat type, vegetation height, percent cover of total vegetation, litter cover and depth, and temporal characteristics including the year, date, and survey period in which the nest was checked. I selected the best-supported models using AIC_c, and I inferred significant differences between continuous variables based on the overlap of model-averaged coefficients with 85% confidence intervals, and model-averaged predicted means with standard errors for categorical variables when variables appeared in multiple top models.

RESULTS

In 2014, I surveyed 12 moist-soil wetlands totaling 561 ha during the 3 sample periods. I recorded a total of 2,498 bird observations within the 100-m radius of point counts. In 2015, I surveyed 18 sites at least once, however, due to flooding at 6 moist-soil wetlands as a result of record high levels of the Illinois River, I was only able to survey those in period 1. I surveyed the remaining 12 sites (7 moist-soil wetlands and 5 grasslands) in all 3 survey periods for a total area of 600 ha. Birds recorded within 100 m of point counts in 2015 totaled 1,005. Combining both years, I surveyed approximately 1,161 ha and recorded 3,503 individual bird observations.

I observed 78 species within the 100-m radius of survey points from both years. The most common species of birds recorded were tree swallows (*Tachycineta bicolor*; 1.1 birds/point in grasslands, 3.2 birds/point in moist-soil wetlands), red-winged blackbirds (*Agelaius phoeniceus*; 4.1 birds/point in grasslands, 3.2 birds/point in moist-soil wetlands), and dickcissels (0.7 birds/point in grasslands, 1.4 birds/point in moist-soil wetlands; Appendix A). These three species composed 67% of all observations for the 2014 and 2015 field seasons. I observed several state threatened or endangered birds during within the 100-m radius of counts, including the common gallinule (*Gallinula galaeta*) and Forster's tern (*Sterna forsteri*), and the northern harrier and peregrine falcon outside of the 100 m. The northern harrier and peregrine falcon were both observed using moist-soil wetlands for foraging in late summer. Other species of conservation concern observed during surveys included the Bell's vireo (*Vireo bellii*), bobolink (*Dolichonyx oryzivorous*), dickcissel, grasshopper sparrow, pied-billed grebe (*Podilymbus podiceps*), prothonotary warbler (*Protonotaria citrea*), red-headed woodpecker (*Melanerpes erythrocephalus*), sedge wren (*Cistothorus platensis*), and willow flycatcher (*Empidonax traillii*).

Avian Density

In 2014, density estimates ranged from 4.3 to 16.8 birds/ha ($\bar{x}$ = 10.0, SE = 1.2). In 2015, density estimates ranged from 4.6 to 18.3 birds/ha ($\bar{x}$ = 12.6, SE = 1.1). Avian density varied as a function of average forb cover, habitat type, and average vegetation height across top models (Table 2). Avian density declined 0.7 birds/ha (SE = 0.3) for every 10% increase in forb cover, but confidence intervals for average vegetation height included zero indicating no true effect (Table 3). Avian density was similar in grasslands ($\bar{x}$ = 13.5, SE = 3.5) and moist-soil wetlands ($\bar{x}$ = 10.2, SE = 1.1).

Avian Conservation Significance

Avian conservation significance for all sites ranged from 62.5 to 384.1 with a mean score of 214.9 (SE = 13.8). Mean ACS in grasslands ($\bar{x}$ = 218.6, SE = 27.8) and moist-soil wetlands ($\bar{x}$ = 214.2, SE = 15.9) was similar. Considering only the obligate and facultative grassland birds, ACS was 260.1 (n = 16 species) in grasslands and 179.2 (n = 24 species) in moist-soil wetlands, and in those sets, the mean species-level conservation scores were similar between grasslands ($\bar{x}$ = 13.8, SE = 0.7) and moist-soil wetlands ($\bar{x}$ = 13.0, SE = 0.6; Appendix A). ACS varied as a function of the connectivity to the Illinois River, management intensity, and percent cover of woody vegetation among top models (Table 2). ACS increased 7.5 (SE = 3.8) for every 1% increase in cover of woody vegetation (Table 3). ACS was less in sites partially connected to the Illinois River ($\bar{x}$ = 171.0, SE = 17.9) than those disconnected from the river ($\bar{x}$ = 247.6, SE = 16.6). Actively managed sites ($\bar{x}$ = 218.6, SE = 14.6) had similar ACS to unmanaged and passively managed sites ($\bar{x}$ = 198.1, SE = 20.1).

Nest Density and Abundances

I observed 17 nests in 2014. Of those nests, 3 (18%) successfully hatched chicks, and 2 (18%) were determined to have failed. One of these failures was believed to be due to predation, and the other due to flooding. The remaining 12 nests (70%) were either empty for each visit, or of an undetermined fate due to insufficient evidence for success or failure.

In 2015, I observed 26 nests of which 4 (15%) successfully fledged chicks, 16 (62%) failed, and 6 (23%) were empty for every visit. Sources of nest failure in 2015 were due to predation of 5 nests (31%), flooding of 4 (25%), and the cause of the remaining 7 failures could not be determined (44%). Eighteen of the nests from 2015 (69%) were found in moist-soil wetlands, and 8 (31%) were found in grasslands. In grasslands, 2 (25%) nests were successful, 5 (63%) failed, and 1 (13%) was empty for each visit. DSR in grasslands was 0.894 for an overall nest success of 6%. Three (60%) of nest failures in grasslands were due to predation, and 2 (40%) failed due to unknown causes.

Across habitats and years, nest failures with known causes were due to predation (35%) and flooding (29%). DSR across both years and habitats was 0.912 for a 10% overall nest success. In moist-soil wetlands across years, 5 (14%) nests were successful, 13 (37%) failed, the fates of 5 (14%) were unknown, and the remaining 12 (34%) were empty for each visit. Three nest failures in moist-soil wetlands were due to predation (23%), 5 to flooding (38%), and the remaining 5 (38%) failed due to unknown causes. DSR in moist-soil wetlands was 0.924 for an overall nest success of 14%. Apparent nest success was 11.1% and 25.0% in moist-soil wetlands and grasslands respectively, and apparent failure rates were 61.1% and 62.5%. The remaining nests were empty for each visit. Daily survival rates of nests varied by year with a greater DSR in 2014 than 2015 (Table 4). All other models had an AIC_c greater than the constant survival model, thus, I detected no environmental variables that explained variation in nest DSR.

Grasslands tended to have a greater number of species nesting than moist-soil wetlands. Out of eight nests found in grasslands, I confirmed five nesting species including red-winged blackbirds, grasshopper sparrows, brown thrashers (*Toxostoma rufum*; a species of concern in Illinois), indigo buntings (*Passerina cyanea*), and dickcissels. From the 29 nests observed in moist-soil wetlands, 27 were red-winged blackbirds, one dickcissel, and one grasshopper sparrow.

Nest densities were greater in grasslands (0.13 nests/ha, SE = 0.02) than in moist-soil wetlands (0.09 nests/ha, SE = 0.01; Table 2). Proximity to the Illinois River appeared in all 4 top models for nest density, but the model-averaged predicted values for sites 220 m (lower quartile) and 1,600 m (median distances) from the river were 0.06 nests/ha (SE = 0.02) and 0.07 nests/ha (SE = 0.02), respectively. The average proximity to the river of sites with nests (*n* = 17) was 8,378 m, and the average proximity to the river from sites with no nests (*n* = 13) was 3,197 m. Site area did not have a strong effect on nest density, with model-averaged predicted values for sites 20 ha (lower quartile; 0.03 nests/ha, SE = 0.01) similar to sites 26.85 ha (median; 0.04 nests/ha, SE = 0.00).

DISCUSSION

Moist-soil wetlands can provide nesting and foraging habitat for birds during the breeding season, including some grassland species. Moist-soil wetlands and grasslands had similar values of ACS and avian densities, indicating the conservation value of moist-soil wetlands to be comparable to that of grasslands in this system. However, grasslands tended to have slightly greater nest densities and a greater number of nesting species than moist-soil wetlands and were used by a greater number of obligate and facultative grassland birds. Moist-soil wetlands have the potential to become ecological traps for nesting birds due to an increased risk of flooding during early portions of the breeding season, but they still have the potential to provide important habitat for breeding birds when dewatered and in areas with adequate flood protection.

I recorded only one species exclusively in grassland sites, the northern mockingbird (*Mimus polyglottos*), which is not considered a grassland species or species of conservation concern in Illinois (See Appendix A for a full list of species observed, an index of abundance, and concern scores). Grasslands had a greater number of grassland birds of conservation concern than moist-soil wetlands, but the greater diversity of birds from different guilds that used moist-soil wetlands compensated for the difference in ACS. Some of the birds that I observed only in moist-soil sites were waterbirds and non-grassland songbirds with high regional concern scores (e.g., American goldfinch [*Spinus tristis*], American white pelican [*Pelecanus erythrorhynchos*], chimney swift [*Chaetura pelagica*], red-headed woodpecker), and those species contributed significantly to the greatest proportion of the difference in ACS between moist-soil wetlands and grasslands.

The two species I most commonly observed in both habitat types were the red-winged blackbird and tree swallow. Red-winged blackbirds were most abundant in grasslands, whereas tree swallows were most abundant in moist-soil wetlands. The tree swallows I observed in moist-soil wetlands were usually foraging. Tree swallows eat primarily flying insects that may be emerging from recently dewatered wetlands or nearby water (Quinney and Smith 1985, Anderson and Smith 2000). Although locally abundant, tree swallow populations are declining across North America along with other aerial insectivores (Nebel et al. 2010). Other aerial insectivores including cliff swallows, barn swallows, and chimney swifts, were relatively common in moist-soil wetlands (> 0.1 birds/point). Barn and cliff swallows were also relatively common in grasslands, but chimney swifts were not. Moist-soil management has been shown to increase aquatic invertebrate density, biomass, and diversity, and the production of invertebrates is a goal of moist-soil management for waterfowl (Anderson and Smith 2000). The positive relationship with moist-soil management and invertebrate communities may help explain why actively managed sites tended to have greater ACS, and why I observed more aerial insectivores foraging at those sites.

I observed grassland birds nesting in both grasslands and moist-soil wetlands, but the only important predictor for nest density was habitat type. Nest densities were likely greater than estimated here because of their extremely cryptic nature. In a study comparing nest search methods for grassland birds, Winter et al. (2003) reported that for the savannah sparrow that builds nests similar to grasshopper sparrow, systematic walking and behavioral observations resulted in detection probabilities of 16–52%. Although my estimates of nest density are likely conservative based on previous estimates of detection probability, I assume that detection probabilities were similar across habitats and provided a reliable index for comparing nesting between habitats. Although moist-soil wetlands provide slightly lower nest densities than grasslands, they still provide useful nesting habitat for grassland birds.

I found two grassland bird species nesting in moist-soil wetlands, dickcissels and grasshopper sparrows. The dickcissel is typically a grassland nesting species, but they are also known for being generalists that will nest in a variety of habitat that contain herbaceous vegetation (Winter 1999). In contrast, the grasshopper sparrow is generally described as an obligate-grassland species (Coppedge et al. 2008, Hovick et al. 2012). The fact that grasshopper sparrows were found nesting in a moist-soil wetland suggests that the vegetation structure, including the ground litter in which they nest, may mimic grasslands enough to provide suitable habitat for a variety of grassland bird species. Several of the nests I observed in moist-soil wetlands, including the grasshopper sparrow, failed due to flooding. The increase in frequency and magnitude of flooding in the floodplain of the IRV raises the concern that moist-soil wetlands may act as ecological traps for nesting birds, especially early in the breeding season (Sparks 1995, Sparks et al. 1998).

Since 2013, there have been 3 major floods that drove the Illinois River to record-high peaks. Three out of the four highest peaks in recorded history (since the 1800s) in Havana, Illinois have occurred since 2013 (National Weather Service, unpublished data). Human disturbance has resulted in drastic changes in hydrology, therefore making areas like moist-soil wetlands in river floodplains a risky area for nesting birds. The risk is greatest in sites that are partially connected to the Illinois River and flood at moderate flood stages. Moist-soil wetlands that are hydrologically disconnected from the river (e.g., outside of the 100-year floodplain of the river or isolated by a drainage and levee districts) provide more dependable habitat for breeding birds because they do not easily flood as a result of higher river levels. For example, the three sites with the greatest ACS were from a complex of managed moist-soil wetlands within the floodplain of the Illinois River that were protected by a large river levee and therefore protected from flooding due to high river levels. Conversely, some of the sites with the lowest ACS were from a managed moist-soil complex in the floodplain of the Illinois River that were likely to flood under moderate river levels. Sites with the greatest ACS scores tended to be actively managed and hydrologically disconnected from the Illinois River, and some of those sites also had the greatest nest densities (e.g., 3.5 and 0.5 nests/ha).

Interestingly, the sites with the least amount of forb cover and greatest amount of grass cover tended to have the greatest ACS scores. Across habitat types, forb cover had a negative relationship with avian density. The effect of forb cover on grassland bird densities has been shown to vary across species, and also that the relationship is not linear in that forb cover has a positive effect on avian density when cover is sparse but a negative effect if forbs predominate (Skinner 1975). In one study, a mean forb cover of 22% (range 3–53%) had a positive relationship with the abundance of two grassland bird species, but a negative relationship with a third grassland species (Patterson and Best 1996). Mean forb cover in both moist-soil wetlands and grasslands in this study exceeded 30% and may have been greater in many wetlands than preferred by grassland birds. It should also be noted that moist-soil wetlands had a greater percent cover of forbs than most grasslands but also a greater range in forb cover (Table 1). There may be an upper threshold in which forb cover begins to have a negative impact on avian density, and the sites from this study may have exceeded that since there is a linear decline in avian density as forb cover increases.

Although flooding during the growing season is typically avoided when possible, higher river levels do not necessarily have a negative impact on the environment. Brief, shallow floods can stimulate the growth of moist-soil vegetation, kill undesirable vegetation, and benefit other species. Some waterbirds may actually benefit from flooding during the breeding season as more habitat becomes inundated for them to use for foraging and possibly even nesting (Fredrickson and Taylor 1982). During a mild flood in 2014, I observed the state endangered Forster's tern foraging in a moist-soil wetland. Grassland birds are not the only guild of birds in need of conservation in this region. Illinois has experienced an extensive loss of wetlands since the 1800s, and the majority of the birds listed as state threatened or endangered in Illinois or as species of conservation concern by the U.S. Fish and Wildlife Service rely on wetlands in some capacity (U.S. Fish and Wildlife Service 2008, Illinois Endangered Species Protection Board 2015). So despite the detrimental effects of flooding for some wildlife, it may also benefit others as long as it is not prolonged or deep enough to kill moist-soil vegetation.

Across years and habitats, the success rate for nests observed in this study assuming a 25-day nesting cycle was 10%, which is lower than most values reported in other studies for grassland birds (Jehle et al. 2004, Winter et al. 2005, Morgan et al. 2010, Walk et al. 2010). Overall nest success was lower in grasslands (6%) than in moist-soil wetlands (13.7%) across years, but these results should be viewed with caution due to the relatively low sample sizes. In a review of 87 DSR estimates from 21 grassland nest studies in the Midwest, Benson et al. (2013) reported a mean DSR of approximately 0.935 which, assuming a 25-day nesting cycle like my data, results in a success rate of 18.6%. Others have reported difficulties in identifying environmental characteristics that impact nest success in grasslands and similar habitats (e.g., Winter et al. 2005, Benson et al. 2013). My results mirror those findings, in that no environmental explanatory variables explained significant variation in nest success. Nest predation is relatively high in grasslands and often the main source of nest failure, as was the case in grasslands in this study with 60% of grassland nest failures attributed to predation compared to the 23% in moist-soil wetlands, although it should be noted that nests in moist-soil wetlands are subjected to the additional risk of flooding. The high predation rate could mean that vegetative characteristics are less important as predictors of nest success than other variables, like those influencing predator abundance or activity (Nolan 1963, Vickery et al. 1992).

Woody vegetation cover had a positive effect on ACS; however, the growth of woody vegetation is typically discouraged in managed moist-soil wetlands (Strader and Stinson 2005). The presence of woody vegetation in an area with desirable moist-soil vegetation increases the diversity of the overall vegetation composition and structure, and it's a reasonable assumption that this would result in a greater diversity of avian species with different habitat preferences. I did not consider the distribution within the wetland or species composition of the woody vegetation in this project. A better understanding of those factors may help guide moist-soil management to provide breeding habitat for a broader range of conservation priority species during drawdown without having a detrimental effect on the productivity of the wetland for waterfowl (Stauffer and Best 1980).

Management recommendations for moist-soil wetlands involve drawing down water in spring or early summer and then maintaining soil moisture throughout the growing season before shallowly inundating vegetation in the fall (Fredrickson and Taylor 1982, Bowyer et al. 2005). The timing and speed of drawdown has an impact on the vegetation community in moist-soil wetlands. Slow, early-season drawdowns (before May 15th) usually encourage a greater production of seeds than fast and mid-season (May 15th–July 1st) or late (after July 1st) drawdowns. Fast and late drawdowns increase the chance that undesirable vegetation will grow due to the lower moisture retention of the soil. Early drawdowns usually produce the most productive vegetation, but there is a risk of the moist-soil wetland becoming too dry later in the season if the area does not get enough precipitation. In the case of an early drawdown and a dry season, wetland managers may induce a short mid-season flood to stimulate the growth of desirable plants (Fredrickson and Taylor 1982). If a flood does occur after drawdown and during the breeding season, as it did in 2015 in my study area, it is likely to cause nest failures. Nest attempts among grassland birds in this region have been reported to peak during June, but have also been shown to begin as early as mid-April and conclude in early July (Basore et al. 1986, Giocomo et al. 2008). The timing of typical drawdowns tends to occur after some birds have begun breeding, but most moist-soil wetlands are dewatered by peak breeding season (Strader and Stinson 2005). Additionally, re-nesting is common for grassland birds with such consistently high rates of nest failure, so even if moist-soil wetlands are not dry until later in the breeding season, they will likely still provide habitat for late-nesting and re-nesting birds.

In conclusion, I have shown that moist-soil wetlands can provide habitat for breeding birds, including grassland species, during the breeding season. However, the susceptibility of moist-soil wetlands in river floodplains to water-level fluctuations make them a potentially risky place for nesting, particularly for the grassland species that nest on or near the ground. This risk is exacerbated by the increase in occurrence and severity of floods due to the highly altered landscape in the midwestern United States. I found that vegetation structure and composition play a role in the dynamics of moist-soil avian communities, so to augment future moist-soil management recommendations for breeding birds, it would be beneficial to further explore the role of specific environmental variables. I recommend examining the distribution, species composition, and vegetation structure of woody plants on avian conservation significance, the role of invasive plants on measures of avian use, invertebrate communities as foraging opportunities for birds during the breeding season, and the timing and speed of drawdown in the beginning of the growing season and its impact on nest survival and success.

Management Implications

In order to manage moist-soil wetlands to provide productive habitat for grassland birds, wetland managers should consider the characteristics of each wetland when making management decisions. Moist-soil wetlands that will inundate under mild flood conditions and sites that are hydrologically connected to the Illinois River pose the greatest risk to nesting grassland birds. To minimize the risk of creating an ecological trap for breeding birds, I recommend that moist-soil managers conduct a mid-season or late drawdown (e.g., late-June through July) in connected and partially-connected wetlands within the IRV to discourage birds from nesting until the greatest risk of flooding has passed (Sparks et al. 1998). If nesting does occur after drawdown, I recommend keeping the site completely dewatered, if possible, until the end of the breeding season. In moist-soil wetlands that are disconnected from the Illinois River and where flooding is less likely, I recommend conducting an early drawdown (e.g., mid-May through mid-June) to allow moist-soil vegetation to grow and provide habitat for grassland birds during peak breeding season.

LITERATURE CITED

Alldredge, M. W., T. R. Simons, and K. H. Pollock. 2007. A field evaluation of distance measurement error in auditory avian point count surveys. Journal of Wildlife Management 71:2759–2766.

Anderson, J. T., and L. M. Smith. 2000. Invertebrate response to moist-soil management of playa wetlands. Ecological Applications 10:550–558.

Basore, N. S., L. B. Best, and J. B. Wooley. 1986. Bird Nesting in Iowa no-tillage and tilled cropland. Journal of Wildlife Management 50:19–28.

Bellrose, F. C., S. P. Havera, F. L. Paveglio Jr., and D. W. Steffeck. 1983. The fate of lakes in the Illinois River Valley. Illinois Natural History Survey Biological Notes 119. Champaign, Illinois, USA.

Benson, T. J., S. J. Chiavacci, and M. P. Ward. 2013. Patch size and edge proximity are useful predictors of brood parasitism but not nest survival of grassland birds. Ecological Applications 23:879–887.

Benson, T. J., J. J. Dinsmore, and W. L. Hohman. 2011. Short-term effects of burning and disking on songbird use of floodplain conservation easements. American Midland Naturalist 165:257–273.

Benson, T. J., J. J. Dinsmore, and W. L. Hohman. 2013. Soil disturbances increase songbird use of monotypic re-established grasslands. Wildlife Society Bulletin 37:725–732.

Best, L. B., K. E. Freemark, J. J. Dinsmore, and M. Camp. 1995. A review and synthesis of habitat use by breeding birds in agricultural landscapes of Iowa. American Midland Naturalist 134:1–29.

Bowyer, M. W., J. D. Stafford, A. P. Yetter, C. S. Hine, M. M. Horath, and S. P. Havera. 2005. Moist-soil plant seed production for waterfowl at Chautauqua National Wildlife Refuge, Illinois. American Midland Naturalist 154:331–341.

Brennan, L. A., and W. P. J. Kuvelsky. 2005. North American grassland birds: an unfolding conservation crisis? Journal of Wildlife Management 69:1–13.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and inference: a practical information-theoretic approach. Second edition. Springer-Verlag, New York, USA.

Confer, J. L., and S. M. Pascoe. 2003. Avian communities on utility rights-of-ways and other managed shrublands in the northeastern United States. Forest Ecology and Management 185:193–205.

Coppedge, B. R., S. D. Fuhlendorf, W. C. Harrell, and D. M. Engle. 2008. Avian community response to vegetation and structural features in grasslands managed with fire and grazing. Biological Conservation 141:1196–1203.

Davis, S. K., and S. G. Sealy. 2000. Cowbird parasitism and nest predation in fragmented grasslands of southwestern Manitoba. Pages 220–228 *in* J. N. M. Smith, T. L. Cook, S. I. Rothstein, S. K. Robinson, and S. G. Sealy, editors. Ecology and management of cowbirds and their hosts: studies in the conservation of nothern American passerine birds. University of Texas Press, Austin, USA.

Dolbeer, R. A. 1976. Reproductive rate and temporal spacing of nesting red-winged blackbirds in upland habitat. Auk 93:343–355.

Fischer, J., and D. B. Lindenmayer. 2007. Landscape modification and habitat fragmentation: a synthesis. Global Ecology and Biogeography 16:265–280.

Fleming, K. S. 2010. Effects of management and hydrology on vegetation, winter waterbird use, and water quality on Wetlands Reserve Program lands, Mississippi. Thesis, Mississippi State University, Starkville, USA.

Fredrickson, L. H. 1991. Strategies for water level manipulations in moist-soil systems. Waterfowl Management Handbook. Leaflet No. 13.4.6. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C., USA.

Fredrickson, L. H., and T. S. Taylor. 1982. Management of seasonally flooded impoundments for wildlife. U.S. Fish and Wildlife Service Resource Publication 148, Washington, D.C., USA.

Galat, D. L., L. H. Fredrickson, D. D. Humburg, K. J. Bataille, J. R. Bodie, J. Dohrenwend, G. T. Gelwicks, J. E. Havel, D. L. Helmers, J. B. Hooker, R. B. Renken, and R. D. Semlitsch. 1998. Flooding to restore connectivity of regulated, large-river wetlands. BioScience 47:721–733.

Giocomo, J. J., E. D. Moss, D. A. Buehler, and W. G. Minser. 2008. Nesting biology of grassland birds at Fort Campbell, Kentucky and Tennessee. Wilson Journal of Ornithology 120:111–119.

Gutzwiller, K. J. 1991. Estimating winter species richness with unlimited-distance point counts. Auk 108:853–862.

Hagy, H. M., and R. M. Kaminski. 2012. Winter waterbird and flood dynamics in autumn-managed moist-soil wetlands in the Mississippi Alluvial Valley. Wildlife Society Bulletin 36:512–523.

Havera, S. P. 1999. Waterfowl of Illinois: status and management. Illinois Natural History Survey Special Publication 21, Champaign, Illinois, USA.

Herkert, J. R. 1994. The effects of habitat fragmentation on midwestern grassland bird communities. Ecological Applications 4:461–471.

Herkert, J. R. 1995. An analysis of midwestern breeding bird population trends: 1966–1993. American Midland Naturalist 134:41–50.

Herkert, J. R., D. W. Sample, and R. E. Warner. 1996. Management of midwestern grassland landscapes for the conservation of migratory birds. Pages 89–116 *in* F. R. Thompson III, editor. Management of midwestern landscapes for the conservation of migratory birds. U.S. Forest Service General Technical Report NC-187.

Hovick, T. J., J. R. Miller, S. J. Dinsmore, D. M. Engle, D. M. Debinski, and S. D. Fuhlendorf. 2012. Effects of fire and grazing on grasshopper sparrow nest survival. Journal of Wildlife Management 76:19–27.

Illinois Department of Natural Resources. 1996. 1996 land cover atlas. <http://dnr.state.il.us/orep/ctap/map/land.htm>. Accessed 23 Jun 2016.

Illinois Department of Natural Resources. 2005. The Illinois comprehensive wildlife conservation plan and strategy. Version 1.0. State of Illinois, Department of Natural Resources, Springfield, Illinois, USA.

Illinois Endangered Species Protection Board. 2015. Checklist of endangered and threatened animals and plants of Illinois. Illinois Endangered Species Protection Board, Springfield, Illinois. <http://www.dnr.state.il.us/espb/index.htm>. Accessed 23 Jun 2016.

Jehle, G., A. A. Yackel Adams, J. A. Savidge, and S. K. Skagen. 2004. Nest survival estimation: a review of alternatives to the Mayfield estimator. Condor 106:472–484.

Johnson, D. H., and T. L. Shaffer. 1990. Estimating nest success: when Mayfield wins. Auk 107:595–600.

Johnson, R. G., and S. A. Temple. 1990. Nest predation and brood parasitism of tallgrass prairie birds. Journal of Wildlife Management 54:106–111.

Kaminski, R. M., B. J. David, W. H. Essig, P. D. Gerard, and K. J. Reinecke. 2003. True metabolizable energy for wood ducks from acorns compared to other waterfowl foods. Journal of Wildlife Management 67:542–550.

Knutson, M. G., G. J. Niemi, W. E. Newton, and M. A. Friberg. 2004. Avian nest success in midwestern forests fragmented by agriculture. Condor 106:116–130.

Kosciuch, K. L., T. H. Parker, and B. K. Sandercock. 2006. Nest desertion by a cowbird host: an antiparasite behavior or a response to egg loss? Behavioral Ecology 17:917–924.

Kross, J., R. M. Kaminski, K. J. Reinecke, E. J. Penny, and A. T. Pearse. 2008. Moist-soil seed abundance in managed wetlands in the Mississippi Alluvial Valley. Journal of Wildlife Management 72:707–714.

Laubhan, M. 1992. A technique for estimating seed production of common moist-soil plants. Waterfowl Management Handbook. Leaflet No. 13.4.5. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C., USA.

Lee, D. C., and S. J. Marsden. 2008. Adjusting count period strategies to improve the accuracy of forest bird abundance estimates from point transect distance sampling surveys. Ibis 150:315–325.

Littell, R. C., G. A. Milliken, W. W. Stroup, and R. D. Wolfinger. 1996. SAS system for mixed models. SAS Institute Inc., Cary, North Carolina, USA.

Lokemoen, J. T., and R. R. Koford. 1996. Using candlers to determine the incubation stage of passerine eggs. Journal of Field Ornithology 67:660–668.

Low, J. B., and F. C. Bellrose. 1944. The seed and vegetative yield of waterfowl food plants in the Illinois River Valley. Journal of Wildlife Management 8:7–22.

Mayfield, H. F. 1975. Suggestions for calculating nest success. Wilson Bulletin 87:456–466.

Morgan, M. R., C. Norment, and M. C. Runge. 2010. Evaluation of a reproductive index for estimating productivity of grassland breeding birds. Auk 127:86–93.

Nebel, S., A. Mills, J. D. McCracken, and P. D. Taylor. 2010. Declines of aerial insectivores in North America follow a geographic gradient. Avian Conservation and Ecology 5:1 doi: 10.5751/ACE-00391-050201.

Nolan, V. 1963. Reproductive success of birds in a deciduous scrub habitat. Ecology 44:305–313.

Novak, L. D., C. E. Comer, W. C. Conway, D. G. Scognamillo, and R. D. Gay. 2016. Nesting ecology of early-successional birds in restored longleaf and loblolly pine stands. Wilson Journal of Ornithology 128:314–327.

Partners in Flight Science Committee. 2012. Species Assessment Database <http://rmbo.org/pifassessment>. Accessed 6 Mar 2016.

Patterson, M. P., and L. B. Best. 1996. Bird abundance and nesting success in Iowa CRP fields: the importance of vegetation structure and composition. American Midland Naturalist 135:153–167.

Quinney, T. E., and L. M. Smith. 1985. Prey size selection by tree swallows. Auk 102:245–250.

Ralph, C. J., S. Droege, and J. R. Sauer. 1995. Managing and monitoring birds using point counts: standards and applications. Pages 161-168 *in* C. J. Ralph, J. R. Sauer, and S. Droege, editors. Monitoring bird populations by point counts. USDA Forest Service General Technical Report PSW-GTR-149, Albany, California, USA.

Rodgers, J. L., and W. A. Nicewander. 1988. Thirteen ways to look at the correlation coefficient. American Statistician 42:59–66.

Russell, R. P., K. E. Koch, and S. J. Lewis. 2016. Upper Mississippi Valley/Great Lakes Regional shorebird conservation plan. Version 2.0. U. S. Fish and Wildlife Service, Division of Migratory Birds, Bloomington, Minnesota, USA.

Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski Jr., and W. A. Link. 2014. The North American breeding bird survey, results and analysis 1966–2013. Version 01.30.2015. Volume 2015. USGS Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Scheiman, D. M., E. K. Bollinger, and D. H. Johnson. 2003. Effects of leafy spurge infestation on grassland birds. Journal of Wildlife Management 67:115–121.

Schultheis, R. D., and M. W. Eichholz. 2013. A multi-scale wetland conservation plan for Illinois. Report prepared for Illinois Department of Natural Resources, Springfield, Illinois, USA.

Shaffer, T. L. 2004. A unified approach to analyzing nest success. Auk 121:526–540.

Skinner, R. M. 1975. Grassland use patterns and prairie bird populations in Missouri. Pages 171–180 *in* M. K. Wali, editor. Prairie: a multiple view. University of North Dakota Press, Grand Forks, USA.

Smith, R. V., J. D. Stafford, A. P. Yetter, M. M. Horath, C. S. Hine, and J. P. Hoover. 2012. Foraging ecology of fall-migrating shorebirds in the Illinois River Valley. PLoS One 7:1–12.

Sparks, R. E. 1995. Need for ecosystem management of large rivers and their floodplains. BioScience 45:168–182.

Sparks, R. E., J. C. Nelson, and Y. Yin. 1998. Naturalization of the flood regime in regulated rivers. BioScience 48:706–720.

Stafford, J. D., M. M. Horath, A. P. Yetter, R. V. Smith, and C. S. Hine. 2010. Historical and contemporary characteristics and waterfowl use of Illinois River Valley wetlands. Wetlands 30:565–576.

Stafford, J. D., A. P. Yetter, C. S. Hine, R. V. Smith, and M. M. Horath. 2011. Seed abundance for waterfowl in wetlands managed by the Illinois Department of Natural Resources. Journal of Fish and Wildlife Management 2:3–11.

Stauffer, F., and L. B. Best. 1980. Habitat selection by birds of riparian communities: evaluating effects of habitat alterations. Journal of Wildlife Management 44:1–15.

Strader, R. W., and P. H. Stinson. 2005. Moist-soil management guidelines for U.S. Fish and Wildlife Southeast Region. U.S. Fish and Wildlife Service, Jackson, Mississippi, USA. <https://www.fws.gov/columbiawildlife/moistsoilreport.pdf>. Accessed 16 Jul 2016.

Twedt, D. J. 2005. An objective method to determine an area's relative significance for avian conservation. Pages 71–77 *in* C. J. Ralph and T. D. Rich, editors. Bird conservation implementation and integration in the Americas: Proceedings of the 3rd International Partners in Flight Conference, 20–24 March 2002. U.S. Forest Service, General Technical Report PSW-GTR-191, Asilomar, California, USA.

U.S. Fish and Wildlife Service. 2008. Birds of conservation concern 2008. United States Department of Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, Virginia, USA.

Vickery, P. D., M. L. Hunter Jr., and J. V. Wells. 1992. Evidence of incidental nest predation and its effects on nests of threatened grassland birds. Oikos 63:281–288.

Vickery, P. D., M. L. Hunter Jr., and S. M. Melvin. 1994. Effects of habitat area on the distribution of grassland birds in Maine. Conservation Biology 8:1087–1097.

Vickery, P. D., P. L. Tubaro, J. M. Cardoso da Silva, B. G. Peterjohn, J. R. Herkert, and R. B. Cavalcanti. 1999. Conservation of grassland birds in the western hemisphere. Studies in Avian Biology 19:2–26.

Walk, J. W., E. L. Kershner, T. J. Benson, and R. E. Warner. 2010. Nesting success of grassland birds in small patches in an agricultural landscape. Auk 127:328–334.

Walk, J. W., M. P. Ward, T. J. Benson, J. L. Deppe, S. A. Lischka, S. D. Bailey, and J. D. Brawn. 2011. Illinois birds: a century of change. Illinois Natural History Survey Special Publication 31, Champaign, Illinois, USA.

Warner, R. E. 1994. Agricultural land use and grassland habitat in Illinois: future shock for midwestern birds? Conservation Biology 8:147–156.

Wilson, E. D. 2016. Phenological assessment of marsh bird distribution within and among moist-soil managed wetlands in Kansas. Thesis, Emporia State University, Kansas, USA.

Winter, M. 1999. Nesting biology of dickcissels and Henslow’s sparrows in southwestern Missouri prairie fragments. Wilson Bulletin 111:515–526.

Winter, M., S. E. Hawks, J. A. Shaffer, and D. J. Johnson. 2003. Guidelines for finding nests of passerine birds in tallgrass prairie. Prairie Naturalist 35:197–212.

Winter, M., D. H. Johnson, and J. A. Shaffer. 2005. Variability in vegetation effects on density and nesting success of grassland birds. Journal of Wildlife Management 69:185–197.

Wittenberger, J. F. 1980. Vegetation structure, food supply, and polygyny in bobolinks (*Dolichonyx oryzivorous*). Ecology 61:140–150.

FIGURES AND TABLES

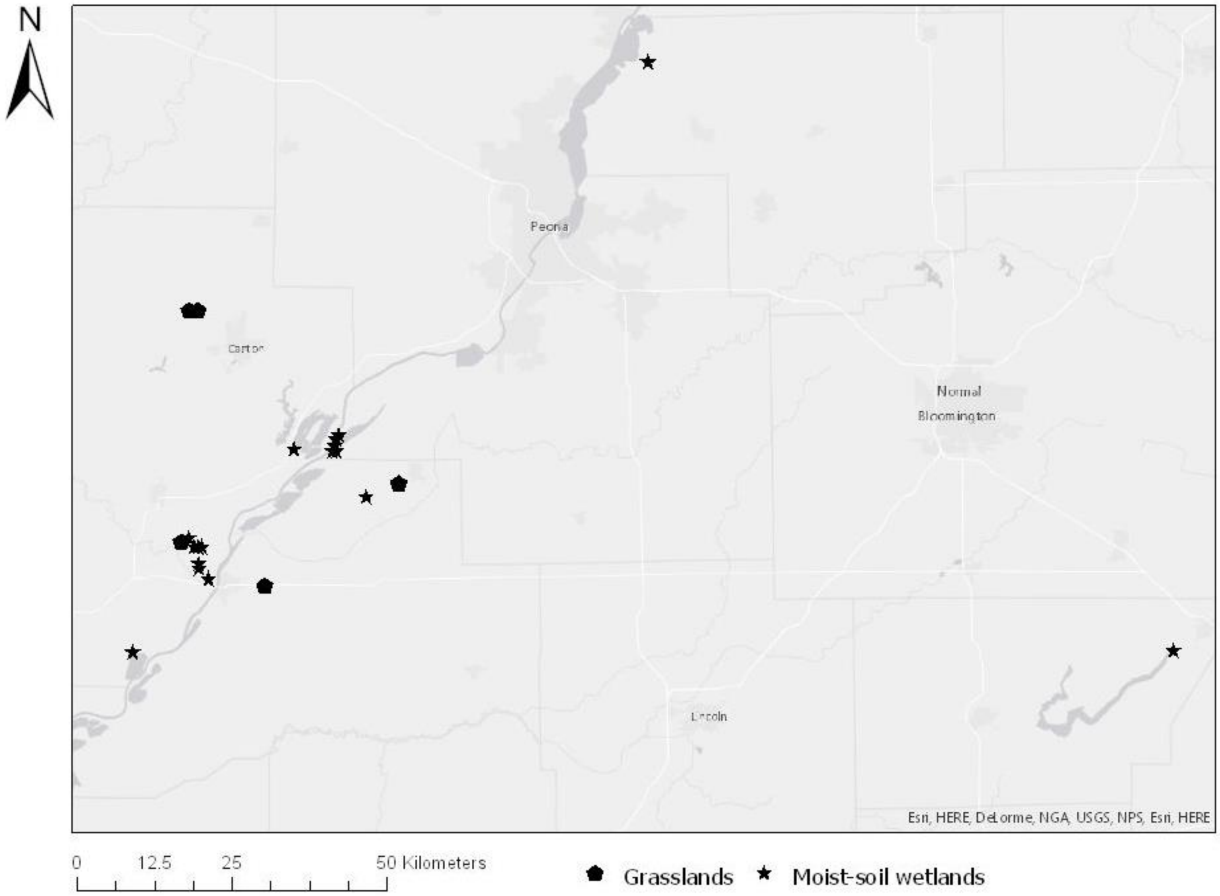

Figure 1. Locations of moist-soil wetlands and grasslands located in or near the floodplain of the Illinois River Valley near Havana, Illinois and studied for breeding bird use from May – September of 2014 and 2015.

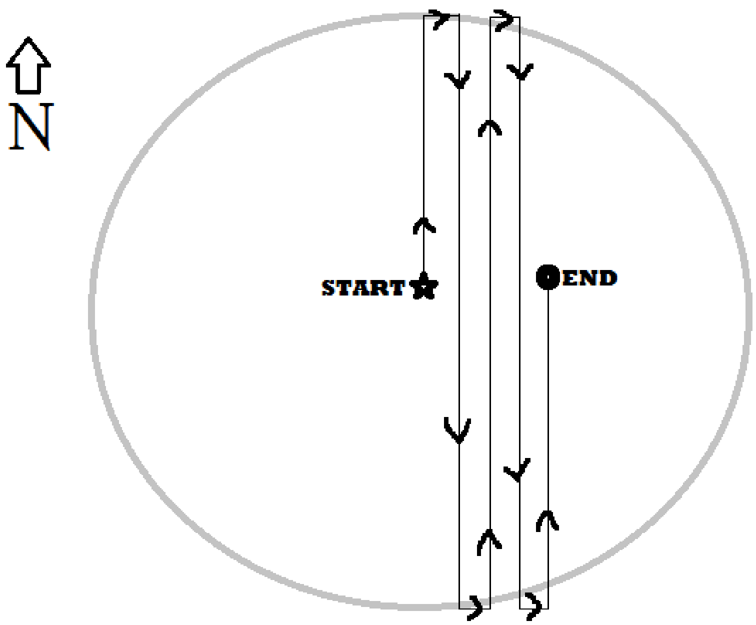

Figure 2. Systematic nest search pattern for obtaining estimates of nest density in moist-soil wetlands and grasslands in and near the floodplain of the Illinois River Valley from May – September in 2014 and 2015. The star represents the starting point of the search, which is also a point count location. I traveled a total of 400 m during a single nest search, checking one meter one each side of the path.

Table 1. Mean, standard error, and ranges for environmental variables and characteristics recorded at grasslands (*n* = 5) and moist-soil wetlands (*n* = 25) in and near the Illinois River Valley from May – September in 2014 and 2015.

	Grasslands			Moist-soil Wetlands		
Variables	$\bar{x}$	SE	Range	$\bar{x}$	SE	Range
Site Area (ha)	19	5.9	2.1 – 34	42.6	6.1	2.1 – 98.7
Proximity to River (km)	12.4	3.8	5.5 – 22.0	4.9	3.6	100 – 90.0
Proximity to Water (km)	2.7	1.7	0 – 7.8	0.2	0.2	0 – 4.0
Management Intensity[a]	0.2	0.2	0 – 1	0.8	0.1	0 – 1
Connectivity to River[b]	0	0	0 – 1	0.6	0.1	0 – 1
Average Veg Height (m)	73.3	14.3	46.5 – 125.9	72.8	7.2	17 – 143.5
% Woody	0.2	0.1	0 – 0.6	2.7	0.7	0 – 14.9
% Forb	35.6	2.1	32.1 – 43.2	50.3	4.9	6.8 – 87.8
% Grass	69.5	4.1	54 – 76.3	30.5	4.4	0 – 77.3
% Sedge	1.7	1.0	0 – 5.3	4.8	1.1	0 – 25.8
% Rush	2.6	2.3	0 – 11.9	2.6	1.2	0 – 21.4
% Total Cover	88.4	5.3	71.8 – 98.4	67.7	6.4	30.4 – 99
% Smartweed	0.1	0.1	0 – 0.3	15.7	4.4	0 – 72.0
% Cocklebur	0.2	0.2	0 – 1.1	9.8	2.7	0 – 49.9
% Litter Cover	45.2	21.8	0 – 100	47.5	8.9	4.8 – 99.4
Litter Depth (cm)	6.4	3.4	0 – 18.3	3.9	1.0	0.5 – 11.4

[a] Sites that were actively managed (e.g., water control, planting) were recorded as 1, and sites that were not managed were recorded as 0. The mean reflects the proportion of actively managed sites.

[b] Sites that were partially connected to the Illinois River were recorded as 1, and sites that were completely disconnected from the Illinois River were recorded as 0. The mean represents the proportion of partially connected sites.

Table 2. Results of the best-fitting linear mixed models predicting the effects of vegetation and site-wide environmental factors on dependent variables avian density, avian conservation significance, and nest density. Model results include the number of model parameters (K), Akaike's Information Criterion adjusted for a small sample size (AIC_c), the difference between AIC_c from each model compared to the top model (ΔAIC_c), the -2 Log Likelihood (-2Log*L*), and model weights (w_i). Data were collected from sites in moist-soil wetlands and grasslands in and near the Illinois River Valley from May – September in 2014 and 2015.

Models	K	AIC_c	ΔAIC_c[a]	-2Log*L*	w_i
Avian density					
% Forb cover	4	166.0	0.0	156.3	0.34
Habitat type	4	167.6	1.6	158.0	0.15
Average vegetation height + % forb cover	5	168.2	2.2	155.6	0.11
Average vegetation height	4	168.4	2.4	158.8	0.10
Avian conservation significance					
Connectivity to river	4	344.1	0.0	334.5	0.49
Management intensity + connectivity to river	5	346.4	2.3	333.9	0.16
% Woody cover	4	348.1	4.0	338.5	0.07
Nest density					
Proximity to river	4	13.3	0.0	3.7	0.38
Site area + proximity to river	5	13.5	0.2	1.0	0.34
Proximity to river + habitat type	5	16.2	2.9	3.7	0.09
Site area*proximity to river	6	16.6	3.3	1.0	0.07

[a] Models reported here are limited to those ≤ 4 ΔAIC_c from the top model.

Table 3. Model-averaged coefficients (β; 85% confidence limits) and support ($\sum w_i$) from top models with continuous variables (≤ 4 ΔAIC_c from the model with the lowest AIC_c) in a set of linear mixed models for dependent variables avian density and avian conservation significance. Data were collected in moist-soil wetlands and grasslands located in and near the Illinois River Valley from May – September in 2014 and 2015.

Variable	β (85% CI)	$\sum w_i$
Avian Density		
% Forb cover	-0.07 (-0.10, -0.03)	0.45
Average vegetation height	-0.03 (-0.06, 0.00)	0.21
Avian Conservation Significance		
% Woody cover	7.45 (1.93, 12.97)	0.07

Table 4. Results from the top models in a logistic-exposure model set predicting the daily survival rates for nests observed in moist-soil wetlands and grasslands located in and near the Illinois River Valley from May – September in 2014 and 2015.

Models	AIC_c	ΔAIC_c[a]	w_i
Year	61.1	0.0	0.34
Constant survival[b]	63.2	2.1	0.12
% Cocklebur cover across site	63.3	2.3	0.11
Ordinal date	64.3	3.3	0.07
% Woody cover at nest	64.5	3.4	0.06
% Grass cover at nest	64.7	3.7	0.05
% Smartweed cover across site	65.0	4.0	0.05

[a] Models reported here are limited to those ≤ 4 ΔAIC_c from the top model.
[b] Intercept only.

SUMMARY

The loss of breeding habitat for birds in the midwestern United States has resulted in the decline of many avian populations, and the decline of grassland birds are among the most drastic due to the loss of high-quality prairie (Brennan and Kuvelsky 2005, Walk et al. 2011). Illinois has lost > 99% of prairie present in the 1800s, and most of the remaining grasslands in the state, although still potentially useful for grassland birds, are highly fragmented and not considered to be of high quality (e.g., pastures, hayfields, row-crop agriculture; Vickery and Hunter 1994, Best et al. 1995, Herkert et al. 1996). Moist-soil wetlands are emergent wetlands with seasonal hydrology managed to produce food for migrating and wintering waterfowl (e.g., seeds, plant parts, invertebrates). The vegetation in moist-soil wetlands during the growing season may provide similar structure to grasslands, and the timing and duration of drawdown is similar to the breeding season for grassland birds in Illinois suggesting that moist-soil wetlands may support grassland birds during the breeding season (Wittenberger 1980, Winter 1999, Fleming 2010). Conservation planners assume that the management of water levels in moist-soil wetlands for waterfowl will benefit other wildlife, but natural resource agencies acknowledge the need to test these assumptions (Illinois Department of Natural Resources 2005, Schultheis and Eichholz 2013, Russell et al. 2016). Here, I quantified avian use of moist-soil wetlands and upland grasslands in and near the floodplain of the Illinois River and sought to identify environmental variables that influence avian use during the breeding season.

I found that moist-soil wetlands can provide habitat for birds during the breeding season, including grassland birds. Grasslands had greater nest densities than moist-soil wetlands, but moist-soil wetlands and grasslands had comparable measures of avian density and avian conservation significance, but composition of the avian community differed slightly between the habitats. For instance, obligate and facultative grassland birds had a greater impact on the scores for grasslands than moist-soil wetlands. Non-grassland birds of high conservation concern in moist-soil wetlands (e.g., American goldfinch, American white pelican, chimney swift, and red-headed woodpecker) contributed a greater proportion of ACS than obligate and facultative grassland birds. I observed grassland birds nesting in both grasslands and moist-soil wetlands (e.g., dickcissel and grasshopper sparrow). The grasshopper sparrow is considered an obligate-grassland species, suggesting that moist-soil wetlands can provide similar habitat function for grassland birds when dewatered. However, moist-soil wetlands that tend to be susceptible to flooding are risky places for ground nesting species and can act as ecological traps.

I recommend that moist-soil managers take the characteristics of each individual moist-soil unit into consideration when making management decisions. Dewatered moist-soil wetlands attract breeding birds during the growing season, and among them are some of Illinois' conservation priority birds. Grassland birds usually nest on or near the ground, so they are highly susceptible to flooding. Moist-soil wetlands that will inundate under mild flood conditions and wetlands that are hydrologically connected to the river may become ecological traps for nesting grassland birds. For moist-soil wetlands that are likely to flood during the breeding season, I recommend conducting a mid-season or late drawdown to discourage birds from nesting until the greatest risk of flooding due to high river levels has passed (Sparks et al. 1998). If nesting does occur after drawdown, I recommend keeping the site completely dewatered, if possible, until the end of the breeding season.

In moist-soil wetlands that are disconnected from the Illinois River and where flooding is less likely, I recommend conducting an early drawdown to allow moist-soil vegetation to grow and provide habitat for grassland birds during peak breeding season. Future research should examine the relationship between woody vegetation in and near moist-soil wetlands and avian communities in order to maximize the benefits for breeding birds.

APPENDIX A: ALL BIRDS OBSERVED WITH CONSERVATION SCORES

Table 5. A list of all avian species observed during the study period presented in this thesis separated by grassland and moist-soil wetland including common name, number of birds observed, an index of avian abundance, and regional concern score (breeding; RCS-b). The regional concern scores for species marked with a (*) were obtained from Bird Conservancy of the Rockies as preliminary data, species marked with a (†) were only observed in grasslands, and species marked with a (‡) were considered obligate or facultative grassland birds.

Moist-soil wetlands			
Species	No. Observed	No./point	RCS-b
Tree swallow	1156	4.78	8
Red-winged blackbird‡	762	3.15	13
Dickcissel‡	342	1.41	17
American white pelican*	186	0.77	11
Indigo bunting	133	0.55	10
Common yellowthroat‡	89	0.37	13
American goldfinch	77	0.32	13
Cliff swallow‡	63	0.26	9
Song sparrow	59	0.24	10
Killdeer*‡	56	0.23	12
Barn swallow‡	50	0.21	13
Chimney swift	32	0.13	15
Lesser yellowlegs*‡	32	0.13	13
Red-headed woodpecker	29	0.12	18
Field sparrow‡	28	0.12	17
Gray catbird	28	0.12	10
American robin	27	0.11	9
Eastern meadowlark‡	27	0.11	17
Common grackle	26	0.11	10
Mourning dove‡	21	0.09	10
Northern cardinal	20	0.08	9
House wren	19	0.08	9
Warbling vireo	19	0.08	9
Yellow-billed cuckoo	19	0.08	15
Cedar waxwing	18	0.07	9
Northern flicker	14	0.06	16
Northern bobwhite‡	13	0.05	16
Bell's vireo	12	0.05	14
Grasshopper sparrow‡	12	0.05	16
Ruby-throated hummingbird	10	0.04	11

Table 5 (cont.) Moist-soil wetlands			
Species	No. Observed	No./point	RCS-b
Mallard*‡	9	0.04	8
Sedge wren‡	9	0.04	12
Canada goose*‡	8	0.03	9
Eastern wood-pewee	8	0.03	14
Green heron*	8	0.03	11
Great crested flycatcher	7	0.03	10
White-breasted nuthatch	7	0.03	10
Bald eagle	6	0.02	12
Eastern kingbird‡	6	0.02	15
Great blue heron*	6	0.02	11
Brown-headed cowbird‡	5	0.02	10
Chipping sparrow	5	0.02	9
Great egret*	5	0.02	9
Red-tailed hawk	5	0.02	10
Rose-breasted grosbeak	5	0.02	12
Sora*	5	0.02	11
Willow flycatcher	5	0.02	13
Black-capped chickadee	4	0.02	11
Blue jay	4	0.02	12
Caspian tern	4	0.02	8
Short-billed dowitcher*‡	4	0.02	14
American crow	3	0.01	10
Baltimore oriole	3	0.01	12
Eastern bluebird‡	3	0.01	11
Red-bellied woodpecker	3	0.01	11
Scarlet tanager	3	0.01	10
American kestrel‡	2	0.01	13
Belted kingfisher	2	0.01	14
Brown thrasher	2	0.01	16
Downy woodpecker	2	0.01	11
Hairy woodpecker	2	0.01	12
Pied-billed grebe*	2	0.01	10
Prothonotary warbler	2	0.01	13
Black-billed cuckoo	1	0.00	15
Blue-gray gnatcatcher	1	0.00	10
Bobolink‡	1	0.00	16
Carolina wren	1	0.00	9
Common gallinule*	1	0.00	10

Table 5 (cont.) Moist-soil wetlands			
Species	No. Observed	No./point	RCS-b
Eastern towhee	1	0.00	11
Horned lark‡	1	0.00	12
House finch	1	0.00	7
Least flycatcher	1	0.00	9
Pileated woodpecker	1	0.00	9
Ring-necked pheasant‡	1	0.00	13
Spotted sandpiper*	1	0.00	12
Tree sparrow	1	0.00	11
Tufted titmouse	1	0.00	12
Turkey vulture‡	1	0.00	8
Winter wren	1	0.00	10
Wood duck*	1	0.00	12
Yellow warbler	1	0.00	9
Yellow-rumped warbler	1	0.00	7

Table 5 (cont.) Grasslands			
Species	No. Observed	No./point	RCS-b
Red-winged blackbird‡	143	4.09	13
Tree swallow	39	1.11	8
Cliff swallow	27	0.77	9
Common yellowthroat‡	25	0.71	13
Dickcissel‡	25	0.71	17
Field sparrow‡	18	0.51	17
Grasshopper sparrow‡	17	0.49	16
Indigo bunting	17	0.49	10
American goldfinch	15	0.43	13
Bobolink‡	14	0.40	16
Barn swallow‡	12	0.34	13
Sedge wren‡	12	0.34	12
Northern cardinal	10	0.29	9
Eastern towhee	9	0.26	11
Mourning dove‡	7	0.20	10
Song sparrow	7	0.20	10
House wren	6	0.17	9
Mallard*‡	6	0.17	8
American robin	5	0.14	9
Blue jay	5	0.14	12
Eastern meadowlark‡	5	0.14	17
Northern bobwhite‡	5	0.14	16
Northern mockingbird†	5	0.14	10
Willow flycatcher	4	0.11	13
American crow	2	0.06	10
Bell's vireo	2	0.06	14
Chipping sparrow	2	0.06	9
Eastern kingbird‡	2	0.06	15
Gray catbird	2	0.06	10
Killdeer*‡	2	0.06	12
Ring-necked pheasant‡	2	0.06	13
Black-capped chickadee	1	0.03	11
Cedar waxwing	1	0.03	9
Chimney swift	1	0.03	15
Common gallinule*	1	0.03	10
Downy woodpecker	1	0.03	11
Eastern wood-pewee	1	0.03	14

Table 5 (cont.) Grasslands			
Species	No. Observed	No./point	RCS-b
European starling†	1	0.03	10
House finch	1	0.03	7
Horned lark‡	1	0.03	12
Pileated woodpecker	1	0.03	9
Warbling vireo	1	0.03	9
Wood duck*	1	0.03	12