Patch-and landscape-scale effects on area sensitivity of grassland birds in Iowa

by

Abel Jose Robles

A thesis submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Major: Wildlife Ecology

Program of Study Committee:
Rolf R. Koford, Major Professor
Stephen J. Dinsmore
William R. Clark

Iowa State University

Ames, Iowa

2010

TABLE OF CONTENTS

CHAPTER 1. GENERAL INTRODUCTION

Grassland birds of North America have significantly declined in recent decades (Sauer et al. 2008). The tremendous transformation of the landscape due to anthropogenic practices has undoubtedly contributed to these declines. The eastern tall-grass prairie, for example, has been nearly completely replaced by intensive agriculture (Samson and Knopf 1994). In Iowa less than 0.1% of the pre-settlement prairie remains (Smith 1998). The remaining habitats in Iowa are generally fragmented or embedded within a matrix of row-crop agriculture. Habitat loss and fragmentation, which results in smaller habitat patches, has been shown to be a major cause of grassland bird decline (Herkert et al. 1994). Of more concern are bird species that are considered to be area-sensitive. Area-sensitive species show a pattern of greater occurrence or density with increased patch area (Robbins et al. 1989). Grassland bird decline has prompted many studies (e.g., Herkert 1994, Askins et al. 2007, Ribic et al. 2009) and initiatives to help increase grassland bird populations. Landscape has also been shown to affect occurrence of area-sensitive bird species (Vickery et al. 1994, Cunningham and Johnson 2006, Ribic et al. 2009). Knowing how landscape composition, such as the amount of grassland or woodland habitat surrounding a patch, affects area-sensitive birds could also help increase grassland bird populations through management. With restoration efforts ongoing in the Midwest, it is important to understand how current restoration practices impact grassland-associated wildlife, especially when managing habitat for area-sensitive species. Area sensitivity seems to vary among species, perhaps for many reasons such as variability in study design, region, or landscape in which the studies were done. More information is needed on the effect of local and landscape features on area-sensitive birds. The state of Iowa can provide a good landscape to look at the issue of area-sensitivity in grassland birds.

I studied the impact of local and landscape factors on grassland birds in Iowa by examining two questions. First, I compared patch size variables as predictors of grassland bird occurrence in Iowa State Preserves, with a specific focus on area-sensitive bird species. State Preserves provide a compilation of restored and native prairies that can help in the preservation and conservation of avian species. I examined the effect that additions of adjacent habitat to the preserves as a management practice has on grassland bird species found in the preserves, focusing on area-sensitive species. Second, I investigated the effect of landscape variables (amount of forest and amount of grassland) on five area-sensitive species. Evidence is accumulating that grassland birds respond to features surrounding their focal patch (Ribic et al. 2009). Little information is known about how area-sensitive birds react to patches embedded in landscapes with a large percentage of grassland habitats (Renfrew and Ribic 2008). Southern Iowa was suitable to study this question, by providing a landscape with a large percentage of grassland habitat compared to other regions in Iowa. This is one of the few studies that examine the impact of local and landscape variables on the occurrence of area-sensitive birds in Iowa.

This study provides insight on the issues of area sensitivity along with information on the status of Iowa State Preserves. Results from this study might help elucidate the issue of area sensitivity on grassland birds and provide future guidance to management and restoration efforts to develop high-quality habitat for area-sensitive grassland birds.

Thesis Organization

This thesis is composed of two papers written for publication in peer-reviewed journals. Chapter 1 provides a general introduction to my thesis research. Chapter 2 examines the potential and realized habitat for area-sensitive species on Iowa State Reserves. Chapter 3 looks at the effect of landscape on five area-sensitive grassland bird species in southern Iowa. Chapter 4 contains a general conclusion from my thesis research. Data acquisition, statistical analysis and preparation of this text were the responsibility of the candidate; Dr. Rolf R. Koford provided guidance and editorial advice.

Literature Cited

Askins, R. A., F. Chavez-Ramírez, B. C. Dale, C. A. Haas, J. R. Herkert, F. L. Knopf, and P. D. Vickery. 2007. Conservation of grassland birds in North America: Understanding ecological processes in different regions. Ornithological Monographs, no. 64.

Cunningham, M. A., and D. H. Johnson. 2006. Proximate and landscape factors influence landscape factors influence grassland bird distributions. Ecological Applications 16:1062–1075.

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

Renfrew, R. B., and C. A. Ribic. 2008. Multi-scale models of grassland passerine abundance in a fragmented system in Wisconsin. Landscape Ecology 23:181–193.

Ribic, C. A. and D. W. Sample. 2001. Associations of grassland birds with landscape factors in southern Wisconsin. American Midland Naturalist 146:105–121.

Ribic, C. A., R. R. Koford, J. R. Herkert, D. H. Johnson, N. D. Niemuth, D. E. Naugle, K. K. Bakker, D. W. Sample, and R. B. Renfrew. 2009. Area sensitivity in North American grassland birds: patterns and processes. Auk 126:233-244.

Robbins, C. S., D. K. Dawson, and B. A. Dowell. 1989. Habitat area requirements of breeding forest birds of the middle Atlantic states. Wildlife Monograph No. 103.

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

Sauer, J. R., J. E. Hines, and J. Fallon. 2008. The North American Breeding Bird Survey, Results and Analysis 1966–2007, version 5.15.2008. U.S. Geological Survey Patuxent Wildlife Research Center, Laurel, Maryland.

Smith, D.D. 1998. Iowa Prairie: Original extent and loss, preservation and recovery attempts. Journal of the Iowa Academy of Science 105: 94-108.

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.

CHAPTER 2. POTENTIAL AND REALIZED HABITAT FOR AREA-SENSITIVE BIRD SPECIES ON IOWA STATE PRESERVES

Abel Robles and Rolf R. Koford

Abstract. The Iowa landscape has been drastically transformed due to agricultural practices, causing population declines in many grassland bird species. Of greatest concern are bird species that are considered to be area sensitive. The Iowa State Preserve System is composed of tracts of prairies, wetlands, and woodlands that can provide habitat for many grassland bird species. This study provides an inventory of the bird species found in 15 Iowa State Preserves that have a prairie component, focusing on area-sensitive grassland bird species. We examined the hypothesis that area and a combination of area and shape are good predictors of the use of the state preserves by grassland birds. We compared whether area or perimeter-to-area ratio was a better predictor of both individual species presence and overall species richness. Preserve area and perimeter-to-area ratio were not an important predictor for the total number of species found in the preserves ($P > 0.05$). Area was a better predictor than perimeter-to-area ratio for total number of area-sensitive species. As area increased, the total number of grassland area-sensitive species also increased ($R^2 = 0.25$, $P = 0.04$). Both area and perimeter-to-area ratio models, when plotted against number of grassland area-sensitive species, were significant. The data supported the hypothesis that perimeter-to-area ratio, which reflects both area and shape of the preserves, is a better predictor of the number of area-sensitive grassland bird species found in the preserves ($R^2 = 0.32$), than just area ($R^2 = 0.28$). As perimeter-to-area ratio decreases, the number of grassland area-sensitive species

found in the preserves increases (P=0.02). We concluded that species are missing in some measure because they are area-sensitive and that it may be possible to bring some of these species back by restoring habitat adjacent to preserves, thus allowing the preserves to function as larger habitat blocks.

Introduction

Agricultural and urban development has severely transformed and fragmented native habitats throughout the midwestern United States (Herkert 1994). The greatest change has been in Iowa, where less than 0.1% of the original 12 million hectares of prairie remains (Smith 1992). Associated with this massive conversion of prairie has been a concomitant change in communities of birds and other animals that rely on grassland habitats (Johnson and Igl 2001). Bird species that nest in prairies or other grasslands have experienced greater population declines since the 1960s, from regional to continental scales, than any other group of bird species (Knopf 1994, Sauer et al. 2003). Much of the decline appears to be associated with habitat loss, fragmentation, and degradation of grassland and shrub-steppe habitats, more specifically native prairies and most recently agricultural grasslands (Herkert et al. 1996, Erickson et al. 2005). These declines have prompted research aimed at understanding their causes, and conservation programs attempting to reverse the declines. Although breeding birds use various types of altered or surrogate grassland (pasture/hay land), native prairies form the conservation backbone of management efforts (Samson and Knopf 1994).

The Iowa State Preserve System is composed of tracts of prairies, wetlands, and woodlands that provide habitat for many species of plants and animals (Fleckenstein 1992).

The State Preserve System was set up in 1965 with the intention of creating conservation areas that promote and preserve wildlife that cultivate good citizenship. It also provides opportunities for programs of public recreation and historical features of scientific and educational values. Since their establishment these preserves have benefited many species of plants and animals. By 1992 a total of 84 sites, encompassing about 3,601 ha, were dedicated as preserves and about 2,000 species of plants and 600 species of vertebrate animals were part of these natural communities (Fleckenstein 1992).

As part of functioning ecosystems, the preserves provide living laboratories where ecosystem processes and functions can be examined. Those processes and functions may have been altered by habitat fragmentation. For example, the timing and intensity of fires may be different now than it once was. Habitat fragmentation is also expected to lead to reductions in the number of species occupying habitat remnants (MacArthur and Wilson 1967). Because some processes and functions may depend on individual species, it is important to know which species may have been lost. In addition to possibly altering ecological processes, species that are lost may be of conservation concern because of their declining populations. Of greatest conservation concern are specialist species that cannot readily adapt to surrogate grasslands and species that are found only on larger blocks of habitat.

Many grassland birds are area sensitive in at least some parts of their breeding ranges (Vickery et al. 1994, Herkert 1994, Helzer and Jelinski 1999, Ribic and Sample 2001, Johnson and Igl 2001). Species showing a positive association between patch size and density, or frequency of occurrence, have been generally considered sensitive to habitat fragmentation. A recent review (Renfrew and Ribic 2008) indicated that area sensitivity has been reported for a number of species that nest in Iowa grasslands:

Northern Harrier (*Circus cyaneus*), Greater Prairie-Chicken (*Tympanuchus cupido*), Upland Sandpiper (*Bartramia longicauda*), Sedge Wren (*Cistothorus platensis*), Savannah Sparrow (*Passerculus sandwichensis*), Grasshopper Sparrow, (*Ammodramus savannarum*), Henslow's Sparrow (*Ammodramus henslowii*), Dickcissel (*Spiza americana*), Bobolink (*Dolichonyx oryzivorus*), Eastern Meadowlark (*Sturnella magna*), and Western Meadowlark (*Sturnella neglecta*). The degree of area sensitivity varies, with species seemingly requiring 10-50 ha of habitat if the parcel of land is in a block.

Habitat for area-sensitive species and all other grassland species is essential for their persistence. Restoration, management and, conservation of suitable land provides the essential resources for survival. Restoring grasslands in agricultural landscapes can provide suitable habitat for breeding grassland birds even if the restoration effort does not mirror native habitat conditions (Fletcher and Koford 2002). The Iowa State Preserves, with their network of native prairie remnants, can help in the preservation and conservation of avian species. Preservation of relatively large prairie areas is essential for the conservation of midwestern prairie bird populations (Samson and Knopf 1994, Sample and Mossman 1997). Management of the Iowa State Preserves with a prairie component (hereafter prairie preserves) would be enhanced by knowing which preserves provides habitat for which grassland bird species, especially area-sensitive species. Simply comparing the total area of the preserves with the bird species' published minimum area requirements might not clearly explain area sensitivity. Patch area may not adequately explain the effects of fragmentation on habitat-patch occupancy by birds. Patches of equal area may vary in shape; consequently significantly changing the amount of their area exposed to edges and hence may not be equal in their ability to support a given population (Helzer and Jelinski 1999). Prairie preserves have various configurations. Some are block-like, rectangular or polygon-shaped. Others have convoluted shapes and have a high ratio of edge to area. In Iowa's Loess Hills, for example, prairie is often confined to ridge-tops while the draws are wooded. Thus simply knowing the size of these prairie remnants does not permit accurate predictions of which ones provide habitat for the area-sensitive species.

Prairie preserves that are occupied by grassland-bird species are presumably providing the birds with the necessary elements for persistence, such as foraging and nesting habitat. The birds may in turn be providing a benefit to the preserves in the form of ecological services or functions. Although it may be unreasonable to think that ecologists can ever gain a complete understanding of ecological functions in natural systems, it stands to reason that systems with a larger complement of their original species are more likely to perform those functions (Chapin et al. 1997). If species are missing because they are area sensitive, it may be possible to bring some of these species back by restoring habitat adjacent to preserves, thus allowing the preserves to function as larger blocks. It is therefore useful to document current adjacent land uses that that may benefit avian species. In terms of abundance of various bird species, larger habitat blocks would provide more habitats.

To effectively manage for grassland birds in a landscape context and to develop effective conservation strategies in working agricultural landscapes, we need to understand how these bird species use different grassland habitats (Ribic 2009). The prairie preserves within the Iowa State Preserves system have the potential to provide habitat for persistence populations of area-sensitive and other bird species. This study provides an inventory of bird species currently found in those preserves and thus an indication of realized habitat. My objectives were to (1) quantify relative abundance of breeding birds on State Preserves with a prairie component, with a particular focus on area-sensitive species, and relate prairie size to abundance of area-sensitive species, and (2) map land cover on and near State Preserves that are in landscapes that could benefit their bird populations.

Methods

Study areas

Iowa State Preserves were selected for inventory based on the predominant habitat type. A preserve had to be a prairie preserve or a preserve with a substantial prairie component, and we examined 15 preserves with these characteristics (Table 1, Figure1). In each of the selected preserves we performed two bird surveys focusing mainly on area-sensitive species.

Two bird surveys were performed at each prairie preserve from June 10 to July 11, 2008. These surveys can best be described as an "area search," although time constraints did not permit the entire area of the larger preserves to be searched (Ralph et al. 1993). Area search surveys are used when there is a delineated habitat patch to survey. Area search is, by design, less rigid than other standardized techniques, because the observer is allowed to wander within the plot during the course of the survey, in contrast to point-count and transect techniques where the observer's movements are fixed (Ralph et al. 1993). It uses a method that, while quantitative, mimics the method that a bird-watcher would use while searching for birds in a given area. With this method unfamiliar calls can be tracked down and quiet birds can be found and it also allows the observer to track down unfamiliar birds (Ralph et al. 1993).

Two, one hour surveys were performed at two times of day, and we conducted an early and late survey on each preserve. One survey commenced 15 minutes before sunrise, approximately between 5:30 a.m. and 10:00 a.m.. The second survey was during a period of lower bird detectability, between 10:00 a.m. and 1:00 p.m.. The two surveys were done the same day or within two days. During each survey we recorded the presence of each species heard or seen in the preserve. Flyover species were not counted. A flying bird had to actually land in the grassland in order to be recorded.

Iowa State Preserves study sites were mapped using a Geographical Information System (GIS). Digital topographic maps were obtained from the Iowa Geographic Map Server and used as base maps. These maps contained topographic information, roads, watercourses, and various other physical features. Aerial photographs of the study area were included as a GIS layer. The aerial photographs were used to identify additional features such as roads, edge of the preserves, addition of adjacent habitat (purchased habitat bordering the preserves), and forest habitat in preserves with both a prairie and a forest component, and other identifying features not present on the base map layer. We quantified the area and perimeter for each preserve, to the nearest ha, using both Ortho-photos and the 2002 Iowa Land Cover data supplemented by Web Map Services in the Iowa Geographic Map Server

(Environmental Systems Research Institute, 1996). Recent additions to preserves were included when calculating the perimeter (m) and area (m^2).

Statistical Analyses

Survey data were analyzed using Proc (GLM) for Generalized Linear Models in SAS statistical software survey linear regression (SAS 9.1., SAS Institute 2003). A total of 6 linear regression models were analyzed. These models had total species richness (total number of species as a count), number of grassland bird species, number of obligate grassland bird species, number of facultative grassland bird species, total number of area-sensitive bird species and number of grassland area-sensitive species as response variables and preserve area and perimeter-to-area ratio as the explanatory variables. For response variables with small counts, a Poisson distribution was assumed for analysis. Within models variables with P-values less than 0.05 were considered significant. R^2 values were calculated to assess the amount of variation explained in the data of the significant models.

Results

Four of the 15 preserves surveyed have had an addition of adjacent habitat (Table 2). These were: Marietta Sand Prairie State Preserve, Doolittle Prairie State Preserve, Anderson Prairie State Preserve, and Cayler Prairie State Preserve.

A total of 67 species were encountered in all preserves. The number of avian species detected on the 15 State Preserves ranged from 7-20. The total number of grassland bird species was 23. The total number of facultative grassland bird species was 14 and of obligate grassland bird species was 9. The five smallest preserves, under 10 ha, had 20 or fewer bird species. The five largest prairies (>50ha) had 7-19 species, and four of these had more than 14 species. A list of the individual bird species found at each preserve can be found in the Appendix.

Two bird species that were found in the prairie preserves were not considered grassland bird species but are still area sensitive (Herkert et al. 1993). The first species was Scarlet Tanager (*Piranga olivacea*), found in two of the prairie preserves with a substantial amount of forest habitat component, Mount Talbot and Five Ridge Prairie. The second species, Hairy Woodpecker (*Picoides villosus),* was found in Kish-ke-kosh Prairie Preserve. The four smallest preserves had as many as four area-sensitive species and as many as three area-sensitive grassland species. Among the six largest preserves, the number of area-sensitive species varied greatly, with some preserves having no more than the smallest preserves. Four large Preserves, however, had at least two area-sensitive species (Appendix).

Results from the linear regression models (Figure 3) indicated that area or perimeter-to-area ratio were not significant variables when plotted against species richness ($P > 0.05$). Total number of facultative grassland bird species also showed no significant relationship with area or perimeter-to-area ratio ($P > 0.05$).

There was a significant relationship between total number of area-sensitive species and area. As area increased, the total number of grassland area-sensitive species also increased ($R^2 = 0.25$, $P = 0.04$). The relationship between total number of area-sensitive species and perimeter-to-area ratio was not significant ($P > 0.05$).

There was a significant relationship between number of grassland area-sensitive species and area. As area increased the total number of grassland area sensitive species also increased ($R^2 = 0.28$, $P = 0.019$).In contrast, perimeter-to-area ratio was negatively correlated to the number of area-sensitive grassland species ($R^2 = 0.32$, $P = 0.02$; Figure 3). Perimeter-to-area ratio had a higher correlation for number of grassland area-sensitive species found in the preserves (Figure 3). Two large Preserves, Mount Talbot and Five Ridge Prairie, had a single area-sensitive species and no area-sensitive grassland species, respectively. Both of these preserves have narrow strips of prairie along ridgetops, bordered by woodland.

There was a significant relationship between number of grassland bird species and area. As area increased the total number of grassland bird species also increased ($R^2 = 0.63$, $P < 0.01$). Perimeter-to-area ratio also showed a significant relationship with number of grassland bird species ($R^2 = 0.32$, $P = 0.03$). Area explained more of the variation than perimeter-to-area ratio.

Area and perimeter-to-area ratio showed significant relationships with number of obligate grassland bird species. Area explained more of the variation between obligate grassland bird species ($R^2 = 0.37$, $P < 0.01$) than perimeter-to-area ratio ($R^2 = 0.26$, $P = 0.02$).

Discussion

Importance of patch scale variables; area and perimeter-to-area ratio

Both patch area and perimeter-to-area ratio were good predictors of bird species found in the Iowa State Preserves, although perimeter-to-area ratio had a stronger correlation with total number of grassland area-sensitive species (Figure 3). Other studies have found patch area to be a good predictor for area-sensitive species (Herkert 1994, Johnson and Igl 2001). A study focusing on forest birds in Wisconsin found core patch area to be a better predictor than patch area. Core patch area in this study was considered to be the area of forest more than 100 m from an edge of a patch (Temple 1986). Similarly, perimeter-to-area ratio can be a better predictor than patch area because the perimeter-to-area ratio accounts for both area and edge habitat. The patch area model does not correctly predict the presence of birds in preserves that are large in total area but, because of their convoluted shapes, have little habitat that is not close to the edge.

Edge habitat has been shown to negatively affect area-sensitive bird species occurrence, density, and fecundity (Johnson and Temple 1986, Johnson and Igl 2001, Fletcher and Koford 2003). In this study, two preserves, Mount Talbot and Five Ridge Prairie, had a single area-sensitive species and no area-sensitive grassland species. Both of these preserves have narrow strips of prairie along ridge tops, bordered by woodland. These cases illustrate that perimeter-to-area ratio might be a better predictor of occupancy by area-sensitive species than area (Helzer and Jelinski 1999).

Studies have also found that small patches with high perimeter-to-area ratio have different communities of birds than large patches with low perimeter-to-area ratio (Herkert 1994, Vickery 1994, Helzer and Jelinski 1999). Therefore, it is important to recognize that other patch variables such as habitat diversity might be correlated to patch area and perimeter-to-area ratio, since habitat diversity might increase with increased size of the preserves.

Among the bird species found in the State Preserves, several have been documented as being sensitive to area in other studies. These area-sensitive bird species are: Upland Sandpiper, Sedge Wren, Henslow's Sparrow, Bobolink, Eastern Meadowlark and Western

Meadowlark. Upland Sandpiper, Henslow's Sparrow and Bobolink exhibit high sensitivity to area. Sedge Wren, Eastern Meadowlark and Western Meadowlarkhave shown moderate area sensitivity (Herkert et al. 1993). These species, along with many other grassland birds found in the preserves, have specific microenvironment requirements. Large preserves can provide variable habitat types due to increase heterogeneity such as different ranges of vegetation structures. These variations could positively affect grassland bird species richness by providing different vegetation structure to accommodate their different habitat requirements. Also, if habitat near the edge of patches is perceived differently by grassland birds than areas away from edges, large patches had the advantage of providing both (Helzer and Jelinski 1999).

The Iowa State Preserve System is important because it can provide habitat in the way of remnant and restored prairies to grassland bird species. Addition of adjacent habitat might help improve the ecological functions of the preserves, allowing them to function as larger blocks. This has been done, for example, at Cayler Prairie State Preserve (Figure 2). Habitat management on public and private lands is one of the main tools for conservation of grassland bird communities (Ribic and Sample 2001).

In this study perimeter-to-area ratio of the preserves had more influence on the number of grassland area-sensitive species than Preserve area did. Therefore perimeter-to-area ratio should be considered along with area when assessing management or conservational practices on these preserves. In a fragmented environment such as the Iowa landscape, the preservation of relatively large prairie areas is essential for the conservation of midwestern prairie bird populations. Preserves that are highly convoluted (high perimeter-to-area ratio) might not be able to provide the necessary habitat for area-sensitive grassland bird species due to an increase in the amount of edge habitat in the landscape and a decrease in total core patch area.

Literature Cited

Chapin, F. S., B. H. Walker, , R. J. Hobbs, D. U. Hooper, J. H. Lawton, O. E. Sala, and D. Tilman. 1997.Biotic control over the functioning of ecosystems. Science 277:500–503

Fletcher, R. J., Jr., and R. R. Koford. 2002. Habitat and landscape associations of breeding birds in native and restored grasslands. Journal of Wildlife Management 66:1011-1022.

Fletcher, R. J., Jr., and R. R. Koford. 2003. Spatial responses of Bobolinks (*Dolichonyx oryzivorus*) near different types of edges in northern Iowa. Auk 120:799-810.

Helzer, C. J. and D. E. Jelinski. 1999. The relative importance of patch area and perimeter-area ratio to grassland breeding birds. Ecological Applications 9:1448–1458.

Herkert, J. R., R. E. Szafoni, V. M. Kleen, and J.E. Schwegman. 1993. Habitat establishment, enhancement, and management for forest and grassland birds in Illinois. Illinois Department of Conservation, Natural Heritage Tech. Publ. 1. 20pp.

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

Johnson, D. H. and L. Igl. 2001. Area requirements of grassland birds: A regional perspective. Auk 118:24–34.

Johnson, R. G., and S. A. Temple. 1986. Assessing habitat quality for birds nesting in fragmented tallgrass prairies. Pages 245-249 in J. Verner, M. L. Morrison, and C. J. Ralph, eds., Modeling habitat relationships of terrestrial vertebrates. Univ. Wisconsin Press, Madison.

Knopf, F. L. 1994. Avian assemblages on altered grasslands. Studies in Avian Biology 15:247-257.

Littell, R.C., W. W. Stroup, R. J. Freund. 2002. SAS for linear models / Cary, N.C.: SAS Institute; New York, Wiley.

MacArthur, R. M. & Wilson, E. O.. 1967. The Theory of Island Biogeography. Princeton: Princeton University Press.

Ralph, C. J.,G. R. Geupel, P. Pyle, T. E. Martin, andD.F. Desante. 1993. Handbook of field methods for monitoring landbirds. USDA Forest Service General Technical Report PSW-144. Albany, CA.

Renfrew, R. B., and C. A. Ribic. 2008. Multi-scale models of grassland passerine abundance in a fragmented system in Wisconsin. Landscape Ecology 23:181–193.

Ribic, C. A. and D. W. Sample. 2001. Associations of grassland birds with landscape factors in southern Wisconsin. American Midland Naturalist 146:105–121.

Ribic, C. A., R. R. Koford, J. R. Herkert, D. H. Johnson, N. D. Niemuth, D. E. Naugle, K. K. Bakker, D. W. Sample, and R. B. Renfrew. 2009. Area sensitivity in North American grassland birds: patterns and processes. Auk 126: 233-244.

Robbins, C. S. 1979. Effect of forest fragmentation on bird populations. Pages 198-212 in R. M. DeGraaf and K. E. Evans, editors. Management of north-central and northeastern forests for nongame birds. GTR NC-51. U.S. Forest Service, St. Paul, Minnesota.

Sample, D. W., and M. J. Mossman. 1997. Managing habitat for grassland birds: a guide for Wisconsin. Wisconsin Department of Natural Resources, Madison.

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

SAS 9.1SAS Institute. 2003. SAS/STAT user's guide. Version 9.1, SAS Institute, Inc., Cary, North Carolina, USA.

Sauer, J. R., Hines, J. E., and Fallon, J., 2003, The North American Breeding Bird Survey, results and analysis, 1966-2002, Version, 2003.1, U.S. Geological Survey, Patuxent Wildlife Research Center, Laurel.

Smith, D.D. 1998. Iowa prairie: Original extent and loss, preservation and recovery attempts. Journal of the Iowa Academy of Science 105:94-108.

Temple, S. 1986. Predicting impacts of habitat fragmentation on forest birds: A comparison of two models. Pages 301-304 in J. Verner, M. Morrison, and C.J. Ralph editors. Wildlife 2000: modeling habitat relationship for terrestrial vertebrates. University of Wisconsin Press. Madison, Wisconsin, USA.

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.

Zanette, L., P. Doyle, and S. M. Trémont. 2001. Food shortage in small fragments: evidence from an area-sensitive passerine. Ecology 81:1654–1666

TABLE 1. Iowa state preserves selected for inventory of grassland birds, showing area (ha), habitat type, county, latitude and longitude of the preserves.

Preserve	Prairie size (ha)	Preserve type	County	Latitude	Longitude
Clay prairie	1.26	Prairie	Butler	518694.3029	4727512.459
Mount Talbot	3.98	Prairie	Woodbury/Plymouth	215186.414	4718062.193
Nestor Stiles	4.16	Prairie	Cherokee	299376.3184	4730312.428
Kish-ke-kosh	7.20	Prairie	Jasper	498909.4856	4601486.706
Liska-Stanek Prairie	7.73	Prairie	Webster	399155.5427	4696427.595
Doolittle Prairie	10.65	Wetland/Prairie	Story	451273.1325	4666550.525
Williams Prairie	12.72	Prairie	Johnson	599686.0427	4624688.628
Hoffman Prairie	14.46	Wetland/Prairie	Cerro Gordo	462945.6264	4775880.573
Freda HaffnerKettlehole	46.40	Prairie	Dickinson	319925.6229	4801889.29
Five Ridge Prairie	50.85	Prairie/Forest	Plymouth	211093.66	4731272.974
Marietta Sand Prairie	60.60	Prairie	Marshall	497068.2121	4660888.102
Steele	64.56	Prairie	Cherokee	289374.4965	4750375.274
Anderson Prairie	86.79	Prairie/Forest	Emmet	348829.0254	4811466.669
Cayler Prairie	349.75	Prairie	Dickinson	318595.1942	4807764.378

Prairie extent estimated from a Geographic Information Systems Using Ortho-photos and the 2002 Iowa geographic Land Cover data:

WMS Service. http://ortho.gis.iastate.edu/server.cgi?wmtver=1.0&. Iowa Geographic Map Server.

TABLE 2. Iowa State Preserves that have had adjacent habitat added to them.

State Preserve	County	Original Preserve Size (ha)	Additions (ha)
Anderson Prairie State Preserve	Emmet	81	242
Cayler Prairie State Preserve	Dickinson	64	155
Doolittle Prairie State Preserve	Story	10	6
Marietta Sand Prairie State Preserve	Marshall	6	85

FIGURE LEGENDS

FIGURE 1. Location of the 15 Iowa state preserves selected for study in Iowa, 2008. Size and color denote the number of preserves with adjacent habitat added to them.

FIGURE 2. Example of one Iowa State Preserve with an addition. Cayler State Preserve in Dickinson county had an addition of 155 (ha) adjacent to the preserve made in 1998.

FIGURE 3. Linear regressions of area and perimeter-to-area ratio (P/A) against species richness of Iowa State Preserves, 2008.

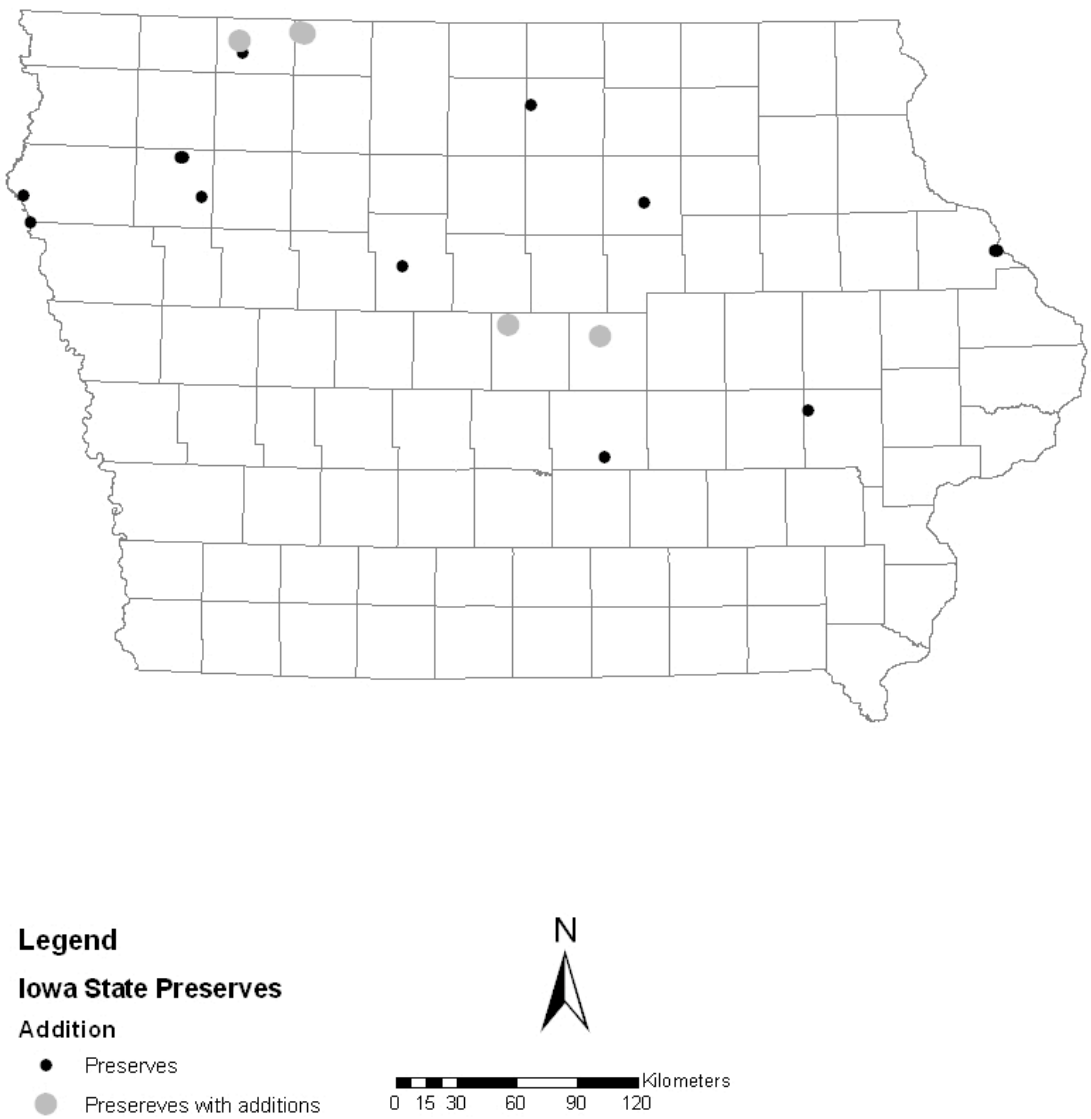

Legend
Iowa State Preserves
Addition
Preserves
Presereves with additions
N
Kilometers
0 15 30 60 90 120

FIGURE 1.

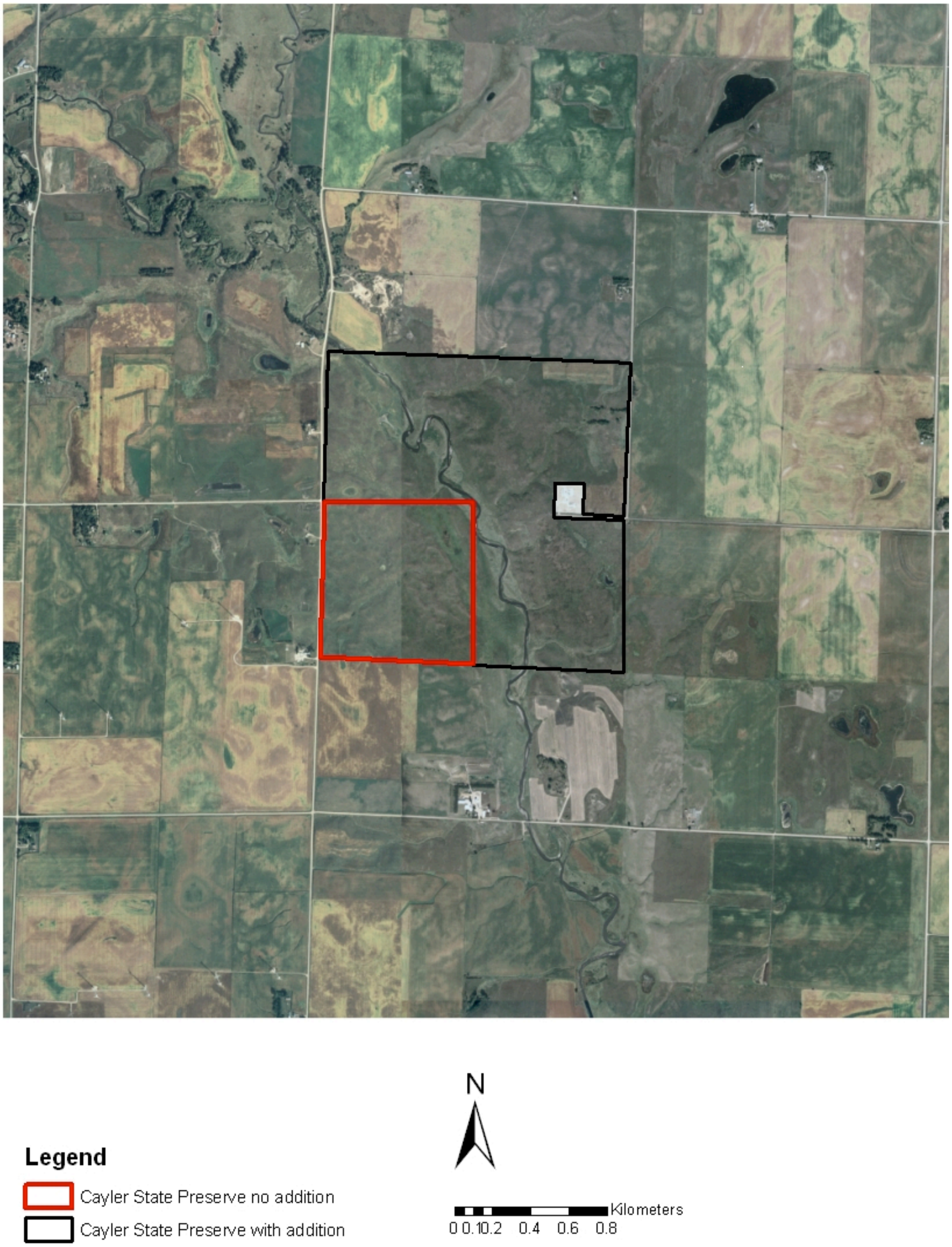
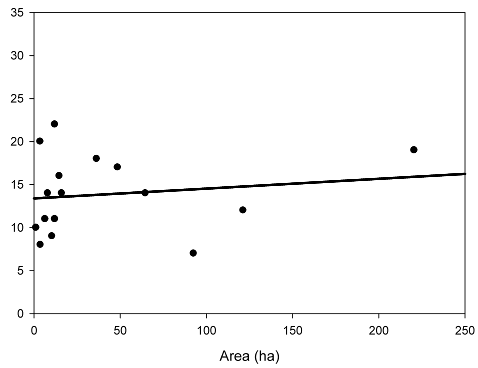
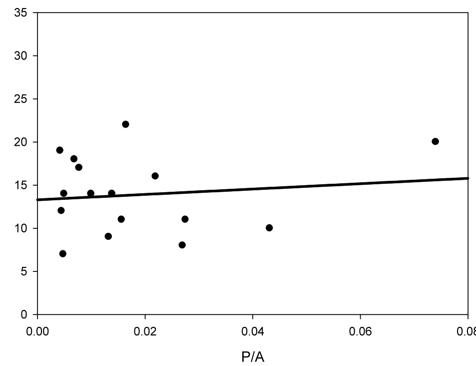

N
Legend
Cayler State Preserve no addition
Cayler State Preserve with addition
Kilometers
0 0.1 0.2 0.4 0.6 0.8

FIGURE 2.



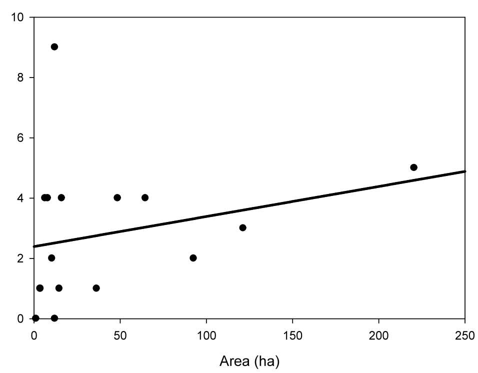
P = 0.09

$R^2 = 0.19$



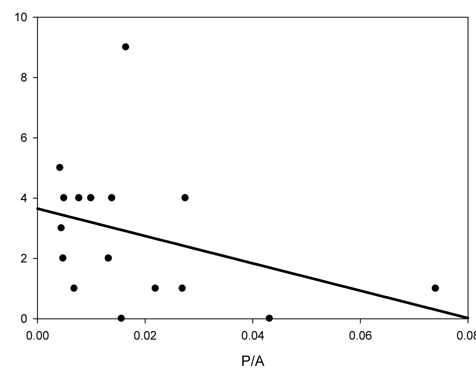
P = 0.94

$R^2 = 0.00$



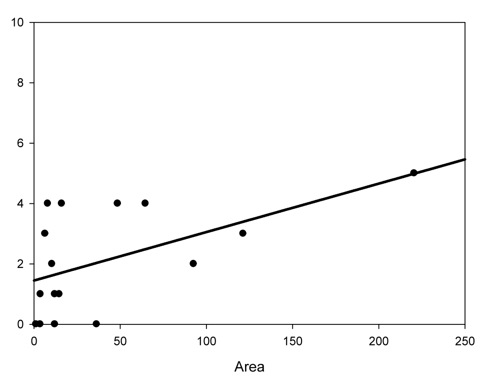
P = 0.04

$R^2 = 0.25$



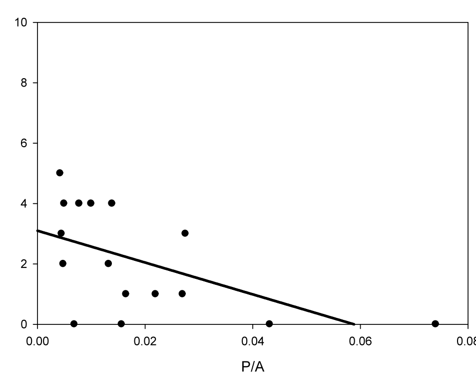
P = 0.06

$R^2 = 0.23$



P = 0.02

R = 0.28



P = 0.01

R = 0.32

FIGURE 3.

APPENDIX. BIRD SPECIES SURVEYED IN THE IOWA STATE PRESERVES SELECTED FOR STUDY, 2008-2009.

	Clay	Nest or Stile s	Kish Ke Kos h	Marr ieta	Will iams	Liska Stane k	Doo-little	Hoff-man	Mount Talbot	Freda Haffner	Ander-son	Cay-ler	Stee-le	Five Rid-ge	Cat fish
Obligate grassland bird species															
Upland Sandpiper (*Bartramia longicauda*)													x		
Sedge Wren (*Cistothorus platensis*)				x		x		x		x		x	x		x
Grasshopper Sparrow (*Ammodramus savannarum*)			x							x		x			
Vesper Sparrow (*Pooecetes gramineus*)							x		x						
Henslow's Sparrow (*Ammodramus henslowii*)			x									x			
Dickcissel (*Spiza americana*)			x	x		x					x	x	x		
Bobolink (*Dolichonyx oryzivorus*)						x				x	x	x	x		
Eastern Meadowlark (*Sturnella magna*)		x	x	x		x	x				x	x			
Western Meadowlark (*Sturnella neglecta*)				x						1	x		x		
Facultative grassland bird species															

Appendix. (Continue)

	Clay	Nestor Stiles	Kish Ke Kosh	Marrieta	Williams	Liska Stanek	Doo-little	Hoff-man	Mount Talbot	Freda Haffner	Ander-son	Cay-ler	Stee-le	Five Rid-ge	Cat fish
Mallard (*Anas platyrhynchos*)				x			x			x		x			
Ring-necked Pheasant (*Phasianus colchicus*)	x			x	x	x	x	x		x		x	x		
Turkey Vulture (*Cathartes aura*)														x	
American Kestrel *(Falco sparverius*)												x			
Killdeer (*Charadrius vociferous*)	x	x				x			x		x	x			
Mourning Dove (*Zenaida macroura*)	x	x				x	x			x			x	x	
Eastern Kingbird (*Tyrannus tyrannus*)								x		x		x			
Western Kingbird (*Tyrannus verticalis*)											x				
Eastern Bluebird (*Sialia sialis*)				x					x						
Common Yellowthroat (*Geothlypis trichas*)	x	x	x	x	x	x	x	x		x	x	x	x	x	x
Clay-colored Sparrow (*Spizella pallida*)												x			

Appendix. (Continue)

	Clay	Nest or Stiles	Kish Ke Kosh	Marrieta	Williams	Liska Stanek	Doo-little	Hoff-man	Mount Talbot	Freda Haffner	Ander-son	Cay-ler	Stee-le	Five Rid-ge	Cat fish
Lark Sparrow (*Chondestes grammacus*)									x					x	
Red-winged Blackbird (*Agelaius phoeniceus*)	x	x	x	x	x	x	x	x		x	x	x	x	x	
Brown-headed Cowbird (*Molothrus ater*)				x					x	x				x	
Other species															
Wood Duck (*Aix sponsa*)								x							
Black-billed Cuckoo (*Coccyzus erythropthalmus*)															x
Ruby-throated Hummingbird (*Archilchus columbris*)			x												
Belted Kingfisher (*Ceryle alcyon*)											x				
Red-bellied Woodpecker (*Melanerpes carolinus*)														x	x
Hairy Woodpecker (*Picoides villosus*)			x												x
Eastern Wood-Pewee (*Contopus virens*)															x

Appendix. (Continue)

	Clay	Nest or Stiles	Kish Ke Kosh	Marrieta	Williams	Liska Stanek	Doo-little	Hoff-man	Mount Talbot	Freda Haffner	Ander-son	Cay-ler	Stee-le	Five Rid-ge	Cat fish
Eastern Phoebe (*Sayornis phoebe*)									x					x	x
Acadian Flycatcher (*Empidonax virescen*)															x
Willow Flycatcher (*Empidonax traillii*)					x										x
Blue Jay (*Cyanocitta cristata*)									x					x	
American Crow (*Covus brachyrhynchos*)									x						
Barn Swallow (*Hirundo rustica*)	x	x				x		x		x			x		
Cliff Swallow (*Petrochelidon pyrrhonota*)						x	x				x		x		
Bank Swallow (*Riparia riparia*)					x			x				x			
Tree Swallow (*Tachycineta bicolor*)								x	x						
Black-capped Chickadee (*Poecile atricapillus*)									x						

Appendix. (Continue)

	Clay	Nest or Stiles	Kish Ke Kosh	Marrieta	Williams	Liska Stanek	Doo-little	Hoff-man	Mount Talbot	Freda Haffner	Ander-son	Cay-ler	Stee-le	Five Rid-ge	Cat fish
White-breasted Nuthatch (*Sitta carolinensis*)															x
House Wren (*Troglodytes aedon*)									x						
Wood Thrush (*Hylocichla mustelina*)															x
American Robin (*Turdus migratorius*)	x			x	x	x		x	x			x			x
Gray Catbird (*Dumetell acarolinensis*)				x										x	x
Brown Thrasher (*Toxostoma rufum*)					x									x	
European Starling (*Sturnus vulgaris*)				x						x					
Cedar Waxwing (*Bombycilla cedrorum*)															x
Black-and-white Warbler (*Mniotilta varia*)															x
Cerulean Warbler (*Dendroica cerula*)															x
American Redstart (*Setophaga ruticilla*)															x

Appendix. (Continue)

	Clay	Nest or Stiles	Kish Ke Kosh	Marrieta	Williams	Liska Stanek	Doo-little	Hoff-man	Mount Talbot	Freda Haffner	Ander-son	Cay-ler	Stee-le	Five Rid-ge	Cat fish
Scarlet Tanager (*Piranga olivacea*)									x					x	
Eastern Towhee (*Pipilo erythrophthalmus*)									x					x	x
Chipping Sparrow (*Spizella passerina*)								x		x			x		x
Field Sparrow (*Spizella pusilla*)									x	x					
Song Sparrow (*Melospiza melodia*)				x	x		x	x				x			
Northern Cardinal (*Cardinalis cardinalis*)					x				x					x	x
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)														x	
Indigo Bunting (*Passerina cyanea*)			x						x					x	x
Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)								x		x					
Common Grackle (*Quiscalus quiscula*)	x	x	x	x		x		x	x	x		x	x		

Appendix. (Continue)

	Clay	Nest or Stile s	Kish Ke Kos h	Marr ieta	Will iams	Liska Stane k	Doo- little	Hoff- man	Mount Talbot	Freda Haffner	Ander- son	Cay- ler	Stee- le	Five Rid- ge	Cat fish
American Goldfinch (*Spinus tristis*)	x	x	x	x	x	x		x	x		x	x		x	x

CHAPTER 3. LANDSCAPE FACTORS INFLUENCING HABITAT USE BY AREA-SENSITIVE GRASSLAND BIRDS IN SOUTHERN IOWA

Abel Robles and Rolf R. Koford

Abstract. The Iowa landscape has been drastically transformed due to agricultural practices causing population declines in many grassland bird species. This study investigates how local factors and landscape factors (within 300 or 800 meters) of a patch affect area-sensitive species in southern Iowa. Five different grassland bird species that have been shown to be area sensitive on other studies; Grasshopper Sparrow (*Ammodramus savannarum*), Henslow's Sparrow (*Ammodramus henslowii*), Dickcissel (*Spiza americana*), Bobolink (*Dolichonyx oryzivorus*) and Eastern Meadowlark (*Sturnella magna*) were selected for study. Red-winged Blackbird (*Agelaius phoeniceus*), a species not considered area-sensitive, was also selected for study to use as a contrasting species. Patch scale variables field size, vegetation height-density, and amount of woody edge surrounding the patches were not important predictors of bird occurrence for any of the study species ($P > 0.05$). The landscape variable, mean fractal dimension was also not significant ($P > 0.05$). The data indicated variable responses to two landscape variables, amount of woodland and amount of grassland, among the study species. Grasshopper Sparrow and Henslow’s Sparrow did not respond significantly to any of the landscape variables ($P > 0.10$). Dickcissel presence was associated with amount of forest in the 800-meter buffer ($P < 0.05$). Bobolink presence was significantly associated with amount of grassland in both the 300- and 800-meter buffer ($P < 0.05$). Eastern Meadowlark was associated with amount of forest in both the 300- and 800-

meter buffers ($P < 0.05$). Red-winged Blackbird did not respond to any of the landscape variables. Exploring the issue of area sensitivity with respect to landscape factors can enhance management and conservation practices for grassland species. This study shows that, to minimize negative effects on declining grassland birds, management of grassland patches will have to take into account the effects of woodland and grassland vegetation surrounding patches at a landscape scale.

Introduction

Native grasslands represent the largest vegetative province in North America (Knopf 1994) but agricultural and urban development have severely reduced and fragmented native habitats throughout the midwestern United States (Herkert 1994a). In Iowa, for example, where tall-grass prairie once covered 79% of the state, less than 0.1% remains (Smith 1998). In addition to the overwhelming loss of tall-grass prairie, most of the remaining prairie fragments in Iowa are small and isolated. These alterations have affected the species found in these areas and contributed to the decline of many avian species that utilize prairie and other grassland habitats (Knopf 1994, Samson and Knopf 1994, Herkert 1995).

Population declines of grassland birds appear to be associated with habitat loss, fragmentation, and degradation of grassland and shrub-steppe habitats (Erickson et al. 2005). Loss or fragmentation of grassland habitat results in a landscape of smaller grassland fields (habitat patches) within a matrix of unsuitable habitat (Horn and Koford 2006), smaller patches, increased isolation, and increased proportion of edge habitat in landscapes (Andren 1994, Fahrig 2003, Fletcher and Koford 2003). Examination of patterns of bird use can lead to insights into how fragmentation and degradation have led to population declines. Woody edges can reduce grassland-bird densities close to edges (Johnson and Temple 1986, Fletcher and Koford 2003). The landscape surrounding grassland fields also can affect densities of bird species within the fields (Ribic and Sample 2001, Fletcher and Koford 2002). As with forest birds (Whitcomb et al. 1981, Robbins et al. 1989), grassland-field area and perimeter-to-area ratio can affect the structure of breeding bird communities of midwestern grassland fragments (Samson 1980, Herkert 1994b, Helzer and Jelinski 1999).

Species that require habitat blocks above a minimum area are referred to as area-sensitive. Area-sensitive species exhibit an increase in either population density or probability of occurrence with increasing size of a habitat patch. Area sensitivity among birds is usually documented by observing distribution patterns that appear to be non-random avoidance of small fields that are larger than the species' territory size (Ambuel and Temple 1983, Robbins et al. 1989, Herkert 1994b, Winter and Faaborg 1999, Ribic and Sample 2001). Some of these area-sensitive grassland species include Upland Sandpiper (*Bartramia longicauda*), Grasshopper Sparrow (*Ammodramus savannarum*), Henslow's Sparrow (*Ammodramus henslowii*), Savannah Sparrow (*Passerculus sandwichensis*), Bobolink (*Dolichonyx oryzivorus*), and Eastern Meadowlark (*Sturnella magna*) (e.g., Herkert 1994b, Bollinger 1995, Johnson and Igl 2001, Fletcher and Koford 2003, Ribic et al. 2009).
Area sensitivity was first documented in forest birds; subsequently studies showed that many grassland bird species were also area sensitive (Herkert 1994b, McCoy 1996, Winter and Faaborg 1999). The mechanisms responsible for area sensitivity among grassland birds in general are not well understood (Ribic et al. 2009). Species vary in their apparent minimum

area requirements (Table 1) and even vary geographically in whether they exhibit area sensitivity (Johnson and Igl 2001). Examining various species in varying environments may further our understanding of the mechanisms involved. For example, in a study performed between 1987 and 1989 in Illinois, Henslow's Sparrows chose habitats of specific vegetation structure and grassland size. Henslow's Sparrows were almost completely restricted to large grassland areas, occurring in only one grassland with an area of less than 100 ha (Herkert 1994b). Bobolinks have been documented as an area-sensitive species throughout most of their range (Herkert 1994b, Helzer and Jelinski 1999) with a minimum area requirement found in some studies of 46 (Helzer and Jelinski 1999) to 50 ha (Herkert 1994b). Grasshopper Sparrows are area sensitive and have been found in fields that were greater than 30 ha (Herkert 1994b) and 10 ha (Helzer and Jelinski 1999). Johnson and Igl (2001) found variation in this species in response to patch size. Dickcissels have also been reported to reach a 50% probability of occurrence at 9 ha in grassland patches in Nebraska (Helzer and Jelinski 1999). Eastern Meadowlark has been reported as the least area sensitive of all these species, requiring a minimum field area of 5 ha (Herkert 1994b).

One proposed mechanism for area sensitivity among grassland birds is avoidance of edges that have trees or shrubs (Johnson and Temple 1986, Johnson and Igl 2001, Fletcher and Koford 2003). Smaller patches with woody edges have higher proportions of edge habitat relative to interior habitat than larger patches, leading to area sensitivity in fragmented environments. If a species avoids small habitat fragments, habitat fragmentation has a negative effect at the population level in extremely area-sensitive species (Winter and Faaborg 1999).

A study on patterns of area sensitivity in Missouri grassland birds showed that woody edges have an effect on habitat use for Henslow’s Sparrows and Dickcissels (Winter et al. 1999). Henslow's Sparrows also had lower densities in small habitat fragments than in larger ones (Winter and Faaborg 1999). The investigators concluded that Henslow's Sparrows decreased in density as a response to proximity to woody edges (distributional area-sensitivity), whereas Dickcissels were mainly affected by a decrease in nesting success (demographic area-sensitivity). They argued that differences in proximity to edges could be caused by differences in habitat selection between species (Winter 2000). In an Iowa study, Fletcher and Koford (2003) found that Bobolink densities in grassland fields were lower near woodland edges than near other edge types, and densities increased as distance from the edge increased. In all of these studies woody vegetation was shown to be a significant factor that influences area sensitive birds. If birds respond differently to different edge types, then some variation in area sensitivity could be explained (Fletcher and Koford 2003).

Several studies have indicated that the landscape in the vicinity of study fields can affect patterns of habitat use (Table 1). A study by Ribic and Sample (2001) in south-central Wisconsin found that, for area-sensitive birds, both landscape and field-level features influence grassland-bird densities. Densities tended to be higher in landscapes with abundant grass and hay land. Field size (3.4 to 76 ha) did not affect grassland bird densities. They noted that birds might not perceive discontinuities between types of grassland as habitat edges (Sample and Mossman 1997). Thus birds in small fields in landscapes with a lot of grass cover had similar densities to larger fields. Horn and Koford (2006) also found that the amount of grassland in the landscape positively influenced Bobolink abundance. A more recent study by Ribic et al. (2009), which examined grassland bird use of remnant prairies in a region of Wisconsin that has a high amount of grassland (~27%), found that habitat type was the most important factor associated with Grasshopper Sparrow, Henslow's Sparrow, Savannah Sparrow, Bobolink, and Eastern Meadowlark densities. Bobolink and Eastern Meadowlark densities in a field were positively associated with the proportion of grassland within 200 m of the site. However, they found no evidence that density of any of the grassland species increased with site size within habitat type. Landscape features, such as amount of woody vegetation, did not appear to affect the density of some area-sensitive bird species, including Bobolinks, in this region of Wisconsin. Further investigation of the effect of landscape characteristics, specifically the amount of surrounding grassland and woody vegetation, on the area sensitivity of grassland bird species might help elucidate the contrasting findings regarding the importance of these landscape characteristics. It is also important to recognize that regional factors might play a big role in these differences and that how birds perceive, and how researchers define, the size of field or grassland area likely contributes to observed differences in area sensitivity (Ribic and Sample 2001).

The preservation of relatively large grassland and prairie areas is essential for the conservation of midwestern prairie bird populations (Sample and Mossman 1997). Habitat management on public and private lands is also one of the main tools for conservation of grassland-bird communities (Ribic and Sample 2001). The review above indicates why it is necessary to learn more about what factors play an essential role in habitat selection for these area-sensitive birds. We have therefore focused on examining the landscape factors that might influence occurrence of five area-sensitive bird species. A better understanding of area-sensitive species could help improve their habitat and management strategies. Southern Iowa is appropriate for this study because of the wide range in amounts of grassland and woodland present in that part of the state. The landscape in the southern part of Iowa has been greatly altered through time. These alterations have not been as severe as the ones found in other parts of the state because most of the landscape has been predominantly grazed and rarely plowed (Zohrer 2006). Consequently, it contains many areas and counties with large portions of grass as well as woodlands and forest.

In this study we examined landscape effects on grassland-patch occupancy by area-sensitive grassland birds in southern Iowa. The research summarized above indicated that amount of grassland and woodland in the landscape were key variables. To maximize statistical power to examine these landscape effects on patch occupancy, the variation of patch size and habitat type were minimized. Cool-season grasses such as smooth brome (*Bromus inermis*) and tall fescue (*Schedonorus phoenix*) are common pasture grasses in the region and also occur in many wildlife management areas.

By documenting patch occupancy of five area-sensitive species and one bird species not considered to sensitive to area, we examined what effect grasslands and woodlands in the surrounding landscape might have on area-sensitive grassland bird species. We tested two hypotheses for each species, (1) that probability of occurrence would increase with more grassland in the landscape and (2) that probability of occurrence would decrease with more woodland in the landscape.

Methods

Study area and sites

This study was conducted in counties found on the Southern Iowa Drift Plain region (Figure 1). Forty sites in the target region were selected for this study using a Geographic Information System (Arc GIS 9.3.1) to analyze surrounding landscapes. I selected fields that met the following criteria: (1) un-grazed field dominated by cool-season grasses; (2) area of 5-15 ha, and (3) site containing landscape characteristics with different ranges of amount of woody vegetation and amount of grassland cover (Table 2).Selection was limited to public areas owned by the Iowa Department of Natural Resources, The State Preserves Board, or the U.S. Fish and Wildlife Service. The un-grazed nature of the sites was assumed at first, and later verified when the sites were surveyed for birds. Similarly, the dominant vegetation in the field was assumed and then verified by ground-truthing ortho-photographs of the selected study areas to ascertain current land-use practices and vegetation. Selected fields had been mostly planted with cool-season grasses such as smooth brome and tall fescue; selecting these fields for study presumably reduced variation in bird densities caused by variation in vegetation composition and structure. The selected patch-area range was such that, based on previous studies, we expected that area-sensitive species might use the relatively small patches if the surrounding landscape was favorable but avoid the patches otherwise. Furthermore, we hoped to have minimal variation in bird occurrence among sites caused by variation in area alone.

Patch edges occurred where they met a habitat patch of a different type (e.g., grassland/forest or grassland/rowcrop field) or were separated from other patches by some kind of barrier. Roads or large bodies of water were considered to be barriers.

We focused on five grassland bird species that have shown varied degrees of sensitivity to area (Bollinger and Gavin 1992, Herkert 1994b, Johnson and Igl 2001) and that have exhibited severe population declines in recent years (Herkert 1995, Peterjohn and Sauer 1999). The five species were: 1) Grasshopper Sparrow, 2) Henslow's Sparrow, 3) Dickcissel (*Spiza americana*), 4) Bobolink, and 5) Eastern Meadowlark. These five species have been shown to be significantly influenced by patch area, with some species occurring on most medium to large fragments (Dickcissel, Eastern Meadowlark), but others occurring only infrequently even on large fragments (Grasshopper Sparrow, Henslow's Sparrow, Bobolink). A species not considered to be sensitive to patch area, Red-winged Blackbird, was added for comparison.

We used Arc GIS 9.2 to quantify the area of each focal patch, to the nearest ha, and amount of edge around the periphery of the patch, to the nearest m. We measured landscape features that may influence densities of grassland birds, as indicated by previous studies: amount of woodland cover and amount of grassland. Within the GIS, 300- and 800-meter buffers were created around the edge of each site (Table 2). Inside the buffers, mean fractal dimension was calculated as a measure of distribution of landscape diversity, using the vector-based landscape analysis tools extension in GIS (Table 2).

To characterize vegetation structure height density readings were taken. Height density is a measurement of overall vegetation height. Measured using a Robel pole marked at 5-cm increments. An observer, at a distance of 4 m, recorded the height at which 90% of the pole was obscured by vegetation. The average of the measurements taken in each of the four cardinal directions was recorded (height density: mean = 16.32, SE = 0.56; Robel 1970). One avian survey was conducted in each selected field between June 1 and July 27, 2009. The surveys were performed commencing 15 minutes before sunrise, roughly from 5:00 a.m. to 9:30 a.m.. Surveying did not take place in inclement weather or if wind speed exceeded 32.2 km/hr.

A transect length of 300 meters within each study area was measured by a Global Positioning System (GPS) to equalize the sampling effort in all fields. The surveys were done by walking the midline of the measured transects until the complete transect was surveyed. The observer (AJR) spent 15 minutes walking each transect line. While moving along the transect line, birds within 100 meters on each side of the established line transect were surveyed for a total transect width of 200 meters. When a bird was seen or heard, the observer recorded the presence of the species. Birds flying over the transects were noted but not included in the final analysis. Only one observer performed the surveys to eliminate inter-observer variation.

Statistical Analysis.

We performed a logistic regression using SAS 9.1. The binary nature of the response variable lent itself to logistic regression, for which we used Proc Logistic, the logistic model procedure in SAS (SAS Institute 1996). A total of 7 variables were considered in different models. At the patch scale explanatory variables included patch size, height-density measurements and amount of woody edge. At landscape scale, explanatory variables were amount of woodland and amount of grassland within 300 and 800 meters from the patch and the interaction between these two and patch fractal density. Presence of each of the six focal bird species was the response variable.

We conducted preliminary modeling to test the assumptions that variation in occurrence rates would not be affected by variation in patch size or vegetation height-density. We found no effect of patch size (P always > 0.25) or vegetation height-density (P > 0.15). There was low correlation between amount of woodland and amount of grassland in the 300-meter buffer (R^2 = 0.14) and the 800-meter buffer (R^2 = 0.13). The range of the explanatory variables (Table 2) was sufficient to examine the effect of variation on the response variable.

We included 13 main models in the model sets for the analysis of presence of the six focal species in relation to local and landscape variables. These models were: (1) amount of grassland in the landscape, (2) amount of woodland in the landscape (3) patch area only (4) mean height-density value (5) amount of woody edge (6) amount of grassland and amount of woodland in the landscape, (7) amount of grassland, amount of woodland in the landscape and their interaction, (8) interaction term only, (9) patch fractal density (10) amount of grassland, amount of woodland, their interaction and area (11) amount of grassland, amount of woodland, their interaction, area and height-density (12) amount of grassland, amount of woodland, their interaction, area, height-density and amount of woody, (13) amount of grassland, amount of woodland, their interaction, area, height density, amount of woodland and patch fractal density.

Patch size, height-density measurements and, amount of woody edge did not depend on buffer size. Therefore the three models sets, patch area only, height density measurement only and amount of woody edge only were fitted once per analysis. Amount of grassland, amount of woodland, their interaction, and patch fractal density models were reevaluated for the two buffer sizes.

To choose the "best" models, we used Akaike's Information Criterion (AIC). AIC is based on information theory and can be used to select between different models (Burnham and Anderson, 1998). We corrected each model's AICc value for sample size (Burnham and Anderson, 1998). The model with the minimum AICc value has the best support from the data. However, we also considered models that had a difference of two or less compared with the minimum AICc model; these models are considered to have substantial support from the data (Burnham and Anderson, 1998). This cut-off is acknowledged by Burnham and Anderson (1998) to be an approximation but, given the number of models we were comparing, we used that cut-off value to be conservative in the number of additional models to consider (Ribic and Sample 2001). We term these additional models competing models (Table 3). The variables in these competing models are considered to be just as important as the variables in the minimum AICc model, as we could not discriminate between the models based on the data. We calculated adjusted R^2 values for the minimum AICc and competing models to evaluate how well the models explained the variation in the data (Table 3). We used a step-wise procedure based on AICc to pick final models from model sets, as we did not believe all variables were important but could not simplify the variable list any further (Ribic and Sample 2001). Within the main models and competing models, variables with P-values less than 0.05 were considered significant.

Results

We observed all five of the area-sensitive species we expected to find. Their overall frequency of occurrence in the 40 study sites varied (Table 4). Red-winged Blackbirds (*Agelaius phoeniceus*), which are not considered area sensitive, were almost ubiquitous (Table 4). The most frequently observed area-sensitive species was Eastern Meadowlark and the least frequently observed was Bobolink (Table 4).

None of the models with interaction terms were significant ($P > 0.05$); I therefore interpreted the main effects when they were significant.

Grasshopper Sparrows were present in almost half of the study sites (Table 4). Grasshopper Sparrow did not respond to any of the variables in any of the models. The model with the minimum AICc had amount of grassland only in the 300-meter buffer and was not significant ($P > 0.10$). The model with the highest correlation had: amount of grassland, amount of woodland and their interaction ($R^2 = 0.13$), had no significant variables. There appeared to be a borderline-significant trend suggesting that, as amount of grassland increased, so did the presence of Grasshopper Sparrows (Figure 2).

Henslow's Sparrow was present in 13 of the 40 study sites (Table 4). Henslow's Sparrow response showed no significant variables and almost no correlation in any of the models.

Dickcissel was the second most frequently encountered species (Table 4). Dickcissel presence was associated with amount of woodland in the 800-meter buffer in two of the models (Table 3). These models were amount of woodland only in the 800-meter buffer and the model with amount of woodland and amount of grassland in the 800-meter buffer.

Amount of forest in the models negatively affected the probability of occurrence of Dickcissel (Figure 2).

Bobolinks were sighted in 7 of the 40 study sites (Table 4). Bobolink presence was significantly associated with one landscape variable, amount of grassland, in two of the models. These models were amount of grassland only in the 800-meter buffers and the model with both amount of woodland and amount of grassland within the 800-meter buffer (Table 3). The model with the minimum AICc was the model with amount of grassland only. This model was significantly correlated to the presence of this species within the sites ($P < 0.01$; $R^2 = 0.25$).

The occurrence of Eastern Meadowlark was associated only with one landscape variable, amount of woodland in the surrounding landscape, in both the 300- and the 800-meter buffers (Table 3). The probability of occurrence of Eastern Meadowlark decreased with increased amount of woodland within the 300-meter and the 800-meter buffer (Figure 2). The model with amount of woodland and amount of grassland in the 800-meter buffer only had the highest correlation ($R^2 = 0.13$). However, model with the minimum AICc was the model with amount of woodland only in the 800-meter buffer (Table 3).

Red-winged Blackbird the only species not considered area-sensitive in this study was found in almost all the study sites (Table 4). Red-winged Blackbird did not respond to any of the variables in any of the models.

Discussion

Patterns of habitat selection for grassland bird species have been a major concern for many ecologists, prompting many studies that investigate factors that might influence these processes (Herkert 1994b, Ribic and Sample 2001, Bakker et al. 2002, Fletcher 2006). Although many of these studies have focus on local, proximate, patch features such as vegetation within a patch and patch area, other studies have examined landscape factors (Winter and Faaborg 1999, Bakker et al. 2002, Cunningham and Johnson 2006, Horn and Koford 2006,Vickery and Renfrew and Ribic 2008, Ribic et al. 2009). The importance of both scales in predicting grassland bird occurrence has increasingly been recognized. Attention has turned to the entire habitat patch in which a territory is located and the landscape in which those patches are embedded (Cunningham and Johnson 2006).

To allow a more focused examination of landscape factors, this study attempted to hold local factors nearly constant and study the effects of landscape factors on five area-sensitive grassland bird species. Of the five species, three, responded to landscape variables. Landscape factors, amount of grassland, and amount of woodland in the 300 and 800-meter buffers showed an association with the Eastern Meadowlark, Dickcissel, and Bobolink. These species had variable responses to the landscape variables.

Amount of woodland

In this study, amount of woodland in the landscape appeared to significantly affect the presence of Dickcissels and Eastern Meadowlarks (Table 3, Figure 2). Results from previous studies have been inconsistent, as discussed above.

Eastern Meadowlark was the species with the highest frequency of occurrence in the study sites, except for the Red-winged Blackbird, which is not considered area-sensitive. Eastern Meadowlarks responded negatively to the amount of woodland in both the 300 and 800-

meter buffers. In a study by Ribic and Sample (2001), the Eastern Meadowlark was associated only with landscape variables in the 200 and 400-meter buffers. They found that woody vegetation variables in the landscape had a negative relationship with Eastern Meadowlark densities. Grassland in the surrounding landscape however, has been positively correlated with Eastern Meadowlark densities in several studies (Winter and Faaborg 1999, Ribic and Sample 2001). In this study the probability of occurrence decreased with increase amount of woodland in the surrounding landscape (Figure 2).

Factors related to forest cover have also been shown to influence Eastern Meadowlark occurrence at a local level. Eastern Meadowlarks have been shown to tolerate areas with a higher percent of forest in their local landscape than other grassland species (Wiens1969, Sample 1989, Sample and Mossman 1997). The different responses to woody vegetation variables in the local and landscape levels suggest an interaction of these scales with the occurrence of this species (Cunningham and Johnson 2006).

Landscape variables have an effect on habitat selection of some grassland species (Ribic and Sample 2001, Cunningham and Johnson 2006, Ribic et al. 2009) but how far away the influences of the surrounding landscape extend need more exploration. For example, in this study, Eastern Meadowlarks responded to the amount of woodlands in both the 300 and the 800-meter buffers while Dickcissel responded most strongly to the amount of woodland in the 800-meter buffer. In a study in Kansas, amount of wooded area within 800-meter of Conservation Reserve Program fields negatively influenced Dickcissel abundance (Hughes et al. 1999). Other studies have found no relation between landscape variables and presence of Dickcissel but rather show that Dickcissel responded more to local variables such as patch size and vegetation variables. In a study by Winter and Faaborg (1998), habitat use by Dickcissels was best explained by local variables, regardless of whether landscape variables were used in model construction. For their study patch area was a significant predictor of occurrence for Dickcissels. The smaller scale response Dickcissels in the 300-meter buffer in this study along with the findings of other studies suggest that Dickcissels are negatively influenced by the amount of woodland in the landscape close to their patch.

Amount of grassland

Presence of Bobolinks was most influenced by grassland variables, amount of grassland in the 300 and 800-meter buffers (Figure 2). Bobolinks responded positively to increased grassland in the surrounding landscape in both of the buffers. Ribic et al. (2009) found that Bobolink densities within a site were greater when proportion of grass was greater within 200-meters of the site, regardless of habitat type. In an earlier study by Ribic (2001), Bobolinks where associated only with landscape variables, such as area of woodlot within 800-meters, where density was higher and area of woodlots was lower. Bobolink densities were also highest in landscapes with low cover type diversity (low diversity were areas with a lot of hayland and pasture) out to 800-meters from their transects. This study and theirs show that the landscape variable, amount of grassland, does have an effect on the presence of Bobolinks. Not surprisingly, at the local level, Bobolinks have been found to respond most strongly to woodland edges, both compressing territories and actively avoiding woodlands (Fletcher and Koford 2003).

Landscape factors were not significant for Grasshopper Sparrows or Henslow's Sparrows. Grasshopper Sparrows, even though not significant (P= 0.10), showed a trend suggesting that, as the amount of grassland in the 300-meter buffer increased, so did the presence of Grasshopper Sparrows. Grasshopper Sparrows were significantly associated with landscape variables, amount of grassland 200 and 400 meters from their buffers (Ribic 2001). Grasshopper Sparrows have also been found to respond to local variables, such as vegetation characteristics (Ribic et al. 2009, Winter and Faaborg 1999), indicating that the buffers might be too big to detect any landscape influences on this species and that landscape effects at a smaller scale may be better predictors for the occurrence of this species.

Henslow's Sparrow, also a species of conservation concern, showed no correlation with any of the landscape variables. Henslow's Sparrow presence might be influenced most strongly by local patch factors. A study by Ribic (2009) showed that the Henslow's Sparrow was associated with habitat type only. Similarly, Bajema and Lima (2001) found that landscape composition (i.e. percent forest or grassland cover), in particular, had a negligible effect on Henslow's Sparrow abundance. However, variation in Henslow's Sparrow abundance was influenced by the composition and structure of local vegetation. Many more studies have documented an increase in number and density of Henslow's Sparrows based on local variables, such as fragment size (Bollinger 1995, Winter and Faaborg 1999, Herkert 2007) and vegetation characteristics (Winter and Faaborg, 1999). These studies, and my results showing no relation to landscape variables, suggest that future studies should focus more on patch scale variables when studying this species.

Given the generalist nature of this species, Red-winged Blackbird, did not respond to any of our local and landscape variables. This species is considered a facultative grassland bird species thus when selecting for sites this species is less discriminatory than area-sensitive bird species.

This study specifically examined the effect of amount of grassland and amount of forest in the landscape on five area-sensitive grassland birds. To my knowledge this is the only study that looks at these effects in the landscape of southern Iowa. The weakness of some of the relationships could suggest that other factors are influencing the presence of these species. This study, along with others, has shown that landscape factors affect the presence of grassland birds. For example, presence of woody vegetation in surrounding landscape has been shown to be associated with lower occurrence and densities of grassland birds in the focal patch (Ribic and Sample 2001, Bakker et al. 2002, Fletcher and Koford 2003).

In agricultural landscapes with high amount of grassland, landscape variables, such as amount of woody vegetation, might not affect bird occurrence as much as patch-scale variables (Ribic 2009), a situation that changes when there is less grassland in the landscape (Renfrew and Ribic 2008). Having the sites in a high grassland landscape such as that of southern Iowa might have decreased the effects of these landscape variables on the focal species. In landscape dominated by grassy habitat types, in North Dakota, some grassland bird species were able to use smaller patches than expected (Horn and Koford 2006). Patch size has had no effect on bird densities in landscapes dominated by grassland (Renfrew et al. 2005, Renfrew and Ribic 2008) compared to landscapes not as dominated by grassland. O'Connor et al. (1999) found that the incidence of grassland bird species across the U.S. was more strongly influenced by patch level variables than by landscape composition; however, this influence was more pronounced in habitats dominated by cropland and woodland than in habitats dominated by grass. How birds perceive the size of a specific patch may depend on the amount of grass in the landscape; a landscape with a large amount of grass may be perceived as one large patch by birds in which settling depends on species-specific habitat requirements (Sample et al. 2003).

Management and conservation practices for grassland species can also be enhanced by exploring the issue of area sensitivity with respect to the landscape factor, amount of woodland. Many grassland birds have been documented to avoid woodland areas (Helzer 1996, Hughes et al. 1999, Bakker et al. 2002), have lower nest success (Johnson and Temple 1990), and experience population declines with the influx of woody vegetation (Coppedge et al. 2001). To minimize negative effects on declining grassland birds, management of grassland patches should take into account the effects of woody vegetation surrounding patches at a landscape scale. The few studies exploring this issue show variable results (e.g. Winter and Faaborg 1999, Fletcher and Koford 2002, Bakker et al., 2002). However, this variability could be due to different study designs (e.g. differences in data collection and variables measured) or biological reasons (e.g. regional variations and difference between ranges of species). Habitat modeling at regional scales should consider that, for most species, landscape-scale data are most useful in combination with local scale information (Cunningham and Johnson 2006).

If birds respond at both local and landscape scales when making decisions concerning habitat selection, it is important to learn more about the specific landscapes and local patch factors, interactions (e.g. Fletcher and Koford 2002, Ribic and Sample 2001), and extent to which the landscape might be influencing species distributions (Cunningham and Johnson

2006). To develop better predictive models, parameters at multiple scales and their interactive effects should be included, and results should be evaluated in the context of microhabitat variability, landscape composition, and fragmentation in the study area (Renfrew and Ribic 2008).

Range

Patterns of species response to landscape variables might also be tied to the historic range in which each species evolved. For example, Henslow's Sparrows, described as a rare resident usually found at only a few locations each year in Iowa (Kent and Dinsmore 1996), evolved in a habitat dominated by grass (Wiens 1969). Large grassland fields appears to be an evolutionary requirement for this species in several studies (Herkert 1994b, Ribic et al. 2009). In a study in Illinois, grassland size was a major factor influencing Henslow's Sparrow habitat selection. In the highly fragmented landscape of Iowa, small habitat patches might not be suitable for this species. The small field size range used in this study compared to the published area requirements might help explain the low occurrence of this species in the field sites.

Similarly, Grasshopper Sparrow is most common in grasslands and hayfields in southern Iowa (Kent and Dinsmore 1996). Grasshopper Sparrow habitat is open grassland of low-to-medium height (Smith 1963, Wiens 1969, Whitcomb 1981).This mixed-grass eco-region species seems to have evolved in a landscape with low amount of woodlands, so tree avoidance might not have evolved as explicitly as it has in other species. Grasshopper Sparrow historical range might give details to its response to the landscape variable, amount of grassland and not to amount of woodland in this study.

In Iowa, Dickcissels are abundant summer residents that occur in grasslands and roadsides throughout the state. It is seen in medium-to-tall grasslands with many tall forbs, in moderately grazed to idle cover (Kent and Dinsmore 1996). Dickcissel historically evolved in mixed-prairie regions in the Midwest, specifically in landscape dominated by grass with few woodlands in the landscape. The increased amount of edge caused in part by habitat fragmentation and landscape alterations in southern Iowa might explain the negative response to amount of woodland in the landscape.

Bobolink and Eastern Meadowlark are species with a historic range in the north and north-eastern United States. This region has historically had woodlands as part of its landscape. Bobolinks, common Iowa residents, nest throughout Iowa and breed across the northern United States and southern Canada south to northern Missouri (Kent and Dinsmore 1996). The range of this species includes mixed prairies to forest. Eastern Meadowlark is also a common breeding bird in eastern and southern Iowa with a similar range. Its range includes a broad variety of eco-regions with a substantial amount of grasslands and woodlands in the landscape. The evolution of these species in these types of landscapes where woodlands form a substantial part of the regions might have promoted the evolution of tree avoidance behavior, thus influencing the responses found in this study.

Area sensitivity is an important factor driving many grassland bird species. Landscape characteristics could be playing a role, along with sensitivity to area, in the occurrence of these species. The development of generalized, spatially explicit models of how species interact with landscape structure would enhance our ability to predict when habitat fragmentation, a disruption in landscape connectivity, is likely to impact species with different life-history responses and dispersal capabilities in a given landscape (With 1997). In this study five area-sensitive species showed variable responses to both local and landscape characteristics. Some of the variation in their responses might be due to the different evolutionary pressures experienced by these species. Nonetheless to conserve grassland bird population in Iowa it is essential to protect and manage large grassland patches for area-sensitive species and if possible take into consideration the amount of grassland habitats and woodland habitat in the landscape as factors influencing the probability of occurrence for many grassland bird species.

Literature Cited

Ambuel, B. and Temple A. S. 1983. Area-dependent changes in the bird communities and vegetation of southern Wisconsin forests. Ecology 64:1057-1068.

Andrén H. 1994. Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: A Review. Oikos 71: 355-366

Bollinger, E. K. 1995.Successional changes and habitat selection in hayfield bird communities.Auk 112,:720-730.

Bollinger, E. K. and T. A. Gavin. 2004. Responses of nesting bobolinks (*Dolichonyx oryzivorus*) to habitat edges. Auk 121:767–776.

Coppedge, B. R., D.M. Engle, S.D. Fuhlendorf, R.E. Masters and M.S. Gregory, Landscape cover type and pattern dynamics in fragmented southern Great Plains grasslands, USA. Landscape Ecology16: 677–690.

Donovan, T. M., and R. H. Lamberson. 2001. Area-sensitive distributions counteract negative effects of habitat fragmentation on breeding birds. Ecology 82:1170 –1179.

Erickson, W., Strickland D, Shaffer J, Johnson D. 2005. Protocol for investigating displacement effects of wind facilities on grassland song birds. U.S. Geological Survey, Northern Prairie Wildlife Research Center, Jamestown, ND 58401.

Fahrig, L. 2003. Effects of habitat fragmentation on biodiversity. Annual Review of Ecology, Evolution, and Systematics 34:487– 515.

Fletcher, R. J., Jr., and R. R. Koford. 2002. Habitat and landscape associations of breeding birds in native and restored grasslands. J. Wildlife. Management.66:1011-1022.

Fletcher, R. J., Jr., and R. R. Koford. 2003. Spatial responses of Bobolinks (*Dolichonyx oryzivorus*) near different types of edges in northern Iowa. Auk 120:799-810.

Helzer, C. J., and D. E. Jelinski. 1999. The relative importance of patch area and perimeter-area ratio to grassland breeding birds. Ecological Applications 9:1448-1458.

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

Herkert, J. R. 1994b. Breeding bird communities of Midwestern prairie fragments: the effects of prescribed burning and habitat-area. Natural Areas Journal 14:128-135.

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

Herzberg, R. and J.A. Pearson. 2001. The Guide to Iowa's State preserves (Bur Oak Guide). University of Iowa Press, Iowa City, Iowa.

Horn, D. J., and R. R. Koford. 2006. Could the area-sensitivity of some grassland birds be affected by landscape composition? Pages 109-116 in D. Egan and J.A. Harrington, eds., Proceedings of the 19th North American Prairie Conference. Madison: University of Wisconsin–Madison.

Hughes, J. P., R. J. Robel, K. E. Kemp and J . L. Zimmerman.1999. Effects of habitat on dickcissel abundance and nest success in Conservation Reserve Program fields in Kansas. Journal ofWildlife Management 63:523-529.

Johnson, D. H. and L. Igl. 2001. Area requirements of grassland birds: A regional perspective. Auk 118:24–34.

Johnson, R. G., and S. A. Temple. 1986. Assessing habitat quality for birds nesting in fragmented tallgrass prairies. Pages 245-249 in J. Verner, M. L. Morrison, and C. J. Ralph, eds., Modeling habitat relationships of terrestrial vertebrates. University of Wisconsin Press, Madison.

Kent T. H., and J. J. Dinsmore. 1996. Birds in Iowa. Published 1996 by the authors, Iowa City.

Knopf, F. L. 1994. Avian assemblages on altered grasslands. Studies in Avian Biology 15:247-257.

Koford, R. R., B. S. Bowen, J. T. Lokemoen, and A. D. Kruse. 2000. Cowbird parasitism in grassland and cropland in the northern Great Plains. Pages 229-235 in J. N. M. Smith, T. L. Cook, S. I. Rothstein, S. K. Robinson, and S. G. Sealy, eds. Ecology and Management of Cowbirds and Their Hosts. University of Texas Press, Austin, TX.

McCoy, T. D. 1996. Avian abundance, composition, and reproductive success on Conservation Reserve Program fields in northern Missouri. M.S. Thesis, University of Missouri, Columbia, Missouri, USA.

O'Connor, R.J., M. T. Jones, R. B. Boone and T.B. Lauber. 1999. Linking continental climate, land use, and land patterns with grassland bird distribution across the conterminous United States. Pages 45-59 in P. D. Vickery and J. R. Herkert, eds. Ecology and conservation of grassland birds of the Western Hemisphere. Studies in Avian Biology 19.

Peterjohn, B.G., and J.R. Sauer. 1999. Population status of North American grassland birds from the North American Breeding Bird Survey, 1966-1996. Pages 27-44 in P.D. Vickery and J.R. Herkert, eds. Ecology and conservation of grassland birds of the Western Hemisphere. Studies in Avian Biology 19.

Ribic, C. A. and D. W. Sample. 2001. Associations of grassland birds with landscape factors in southern Wisconsin. American Midland Naturalist 146:105–121.

Ribic, C. A., R. R. Koford, J. R. Herkert, D. H. Johnson, N. D. Niemuth, D. E. Naugle, K. K. Bakker, D. W. Sample, and R. B. Renfrew. 2009. Area sensitivity in North American grassland birds: patterns and processes. Auk 126:233-244.

Robbins, C. S., D. K. Dawson, and B. A. Dowell. 1989. Habitat area requirements of breeding forest birds of the Middle Atlantic states. Wildlife. Monograph 103.

Robel, J. N. Briggs, A. D. Dayton, L. C. Hulbert. 1970.Relationships between visual obstruction measurements and weight of grassland vegetation. Journal of Range Management 23:295-297.

Rotenberry, J. T. and J. A. Wiens. 1980. Habitat structure, patchiness, and avian communities in North American steppe vegetation: A multivariate analysis. Ecology 61:1228–1250.

Saab, V. A. 1999. Importance of spatial scale to habitat use by breeding birds in riparian forests: a hierarchical analysis. Ecological Applications 9:135–151.

Sample, D. W., and M. J. Mossman. 1997. Managing habitat for grassland birds: a guide for Wisconsin. Wisconsin Department of Natural Resources, Madison.

Samson, F. B. 1980. Island biogeography and the conservation of prairie birds. Proceedings of the North American Prairie Conference 7: 293- 305.

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

Sauer, J.R., J.E. Hines, and J.Fallon 2008. The North American Breeding Bird Survey, results and Analysis 1966-2007, version 5.15.2008.U.S.Geological Survey Patuxent Wildlife Research Center, Laurel Maryland.

Smith, D.D. 1998. Iowa Prairie: Original extent and loss, preservation and recovery attempts. Journal of the Iowa Academy of Science 105: 94-108.

Vickery, P. D., and J. R. Herkert, eds. 1999. Ecology and Conservation of Grassland Birds of the Western Hemisphere. Studies in Avian Biology No. 19.

Whitcomb, R. F., C. S. Robbins, J. F. Lynch, B. L. Whitcomb, K. Klimkiewicz, and D. Bystrak. 1981. Effects of forest fragmentation on avifauna of the eastern deciduous forest. Pages 125-205 in R. L. Burgess and D. M. Sharpe, eds. Forest Island Dynamics in Man-Dominated.

Wiens, J. A. 1969. An approach to the study of ecological relationships among grassland birds. Ornithological Monograph No. 8 Allen Press, Inc., Lawrence, KS. 93p.

Winter, M., and J. Faaborg. 1999. Varying patterns of "area-sensitivity" in grassland-nesting birds. Conservation Biology 13:1324-1434.

Winter, M., D. H. Johnson, and J. Faaborg. 2000. Evidence for edge effects on multiple levels in tallgrass prairie. Condor 102:256-266.

With, K. A., R. H. Gardner, and M. G. Turner. 1997. Landscape connectivity and population distributions in heterogeneous environments. Oikos 78: 151-169

Zohrer, James J. 2006. Securing a future for fish and wildlife a conservation legacy for Iowans. Iowa Department of Natural Resources.

TABLE 1. Reported minimum area requirements (50% probability of occurrence) and small patch occurrence for five grassland area-sensitive bird species in different States.

Species	Area (ha) requirement	References	State
Grasshopper Sparrow	8-12	Helzer and Jelinski 1999	Nebraska
	10-30	Herkert 1991b	Illinois
	30	Herkert 1994	Illinois
	16-32	Johnson and Temple 1986	Minnesota
	100	Vickery et al. 1994	Maine
	20	Samson 1980	Missouri
	134	Davis 1994	Canada
Henslow's Sparrow	55	Herkert 1994	Illinois
	10	Ribic 2009	Wisconsin
Dickcissel	9	Helzer and Jelinski 1999	Nebraska
Bobolink	46	Helzer and Jelinski 1999	Nebraska
	10	Winter and Faaborg 1999	Missouri
	50	Herkert 1994	Illinois
	10- 30	Herkert 1991 b	Illinois
Eastern Meadolark	5	Herkert 1994	Illinois
	0-20	Herkert 1991 b	Illinois
	>10ha	Samson 1980a	Missouri

TABLE 2. Descriptive data (in ha) of the variables used in the logistic regression analysis.

	Mean	Std. Dev.	Std Error Mean
Buffer Forest 300m (ha)	21.37	15.12	2.39
Buffer Forest 800m (ha)	83.46	54.03	8.54
Buffer Grassland 300m (ha)	23.81	9.43	1.49
Buffer Grassland 800m (ha)	94.21	28.81	4.55
Area	9.33	2.47	0.39
Height-density (Robel) (cm)	16.32	3.58	0.56
Amount of Woody Edge (ha)	0.38	0.33	0.05
Mean Fractal Dimension 300m	1.23	0.07	0.01
Mean Fractal Dimension 800m	1.21	0.01	0.00

TABLE 3. Competitive models for grassland bird species seen on study sites in southern Iowa, late May-early July 2009. Models with low ΔAICc values and high R- square have the most support.

Species	Model	ΔAICc	R^2	P-value
Dickcissel	Woodland 800	0.00	0.11	0.04
	Woodland 800	0.07	0.12	0.04
	Grassland 800			0.68
Bobolink	Grassland 800	0.00	0.25	< 0.01
	Woodland 800	0.15	0.27	0.40
	Grassland 800			0.01
Eastern Meadowlark	Woodland 800	0.00	0.10	0.05
	Woodland 300	0.02	0.09	0.05
	Woodland 800	0.03	0.17	0.54
	Grassland 800			0.67
	Interaction			0.17
	Woodland 800	0.03	0.13	0.03
	Grassland 800			0.24
	Woodland 300	0.11	0.10	0.04
	Grassland 300			0.60

TABLE 4. Area sensitive bird species seen on transects in 40 fields in southern Iowa, late May-early July 2009.

Bird Species	Number of sites present
Henslow's Sparrow	13
Bobolink	7
Grasshopper Sparrow	19
Dickcissel	19
Eastern Meadowlark	21
Red-winged Blackbird	33

Figure legends

FIGURE 1. Location of study sites selected within the Southern Iowa Drift Plain region in southern Iowa, 2009.

FIGURE 2. Probability of occurrence of four of the focal species plotted against landscape variables. Each graph shows bird probability of occurrence by amount of tree cover and grassland cover at one scale (300 or 800m buffers). Plots represent only species on which landscape variables were significant or almost significant.

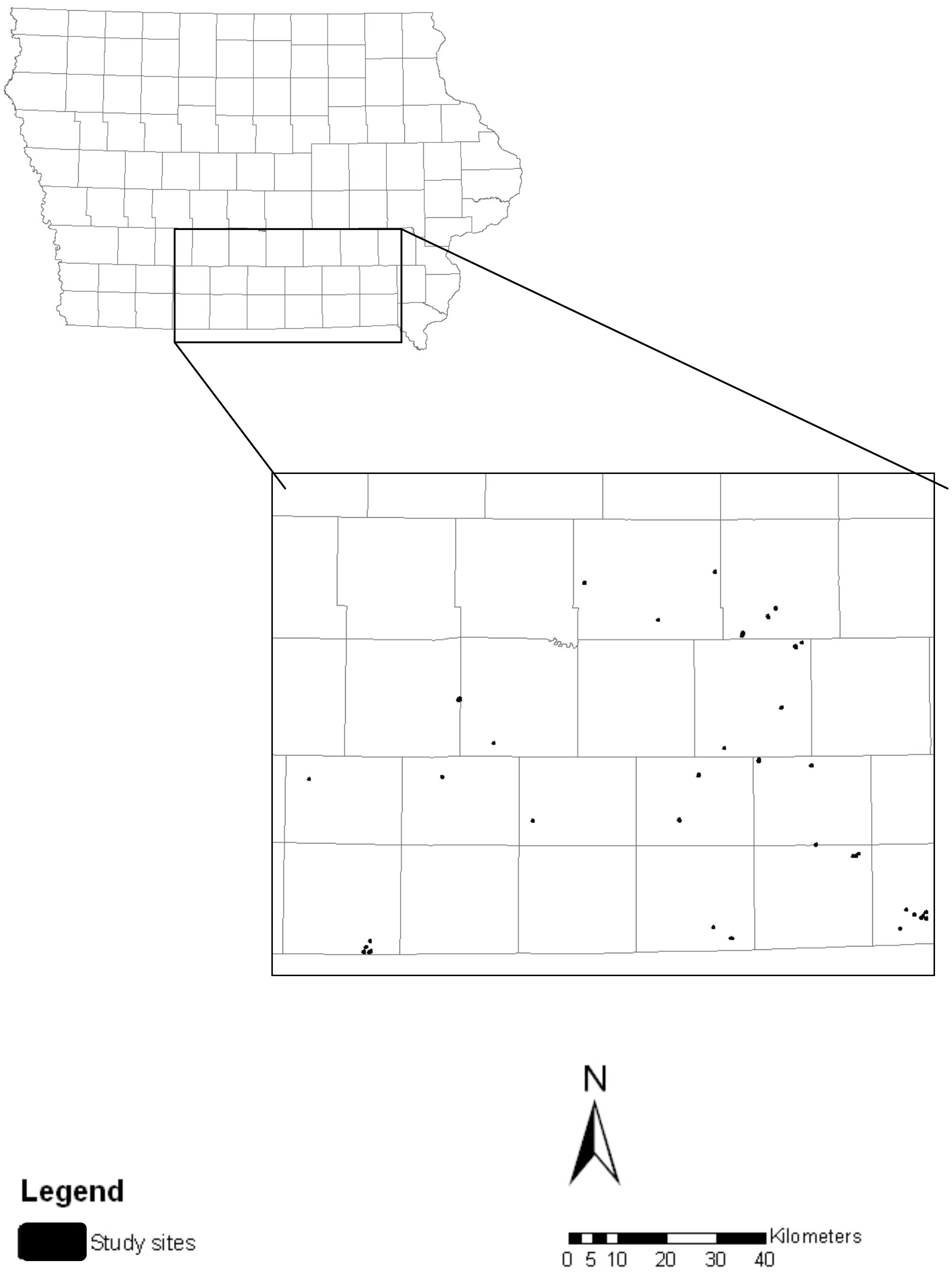


FIGURE 1.

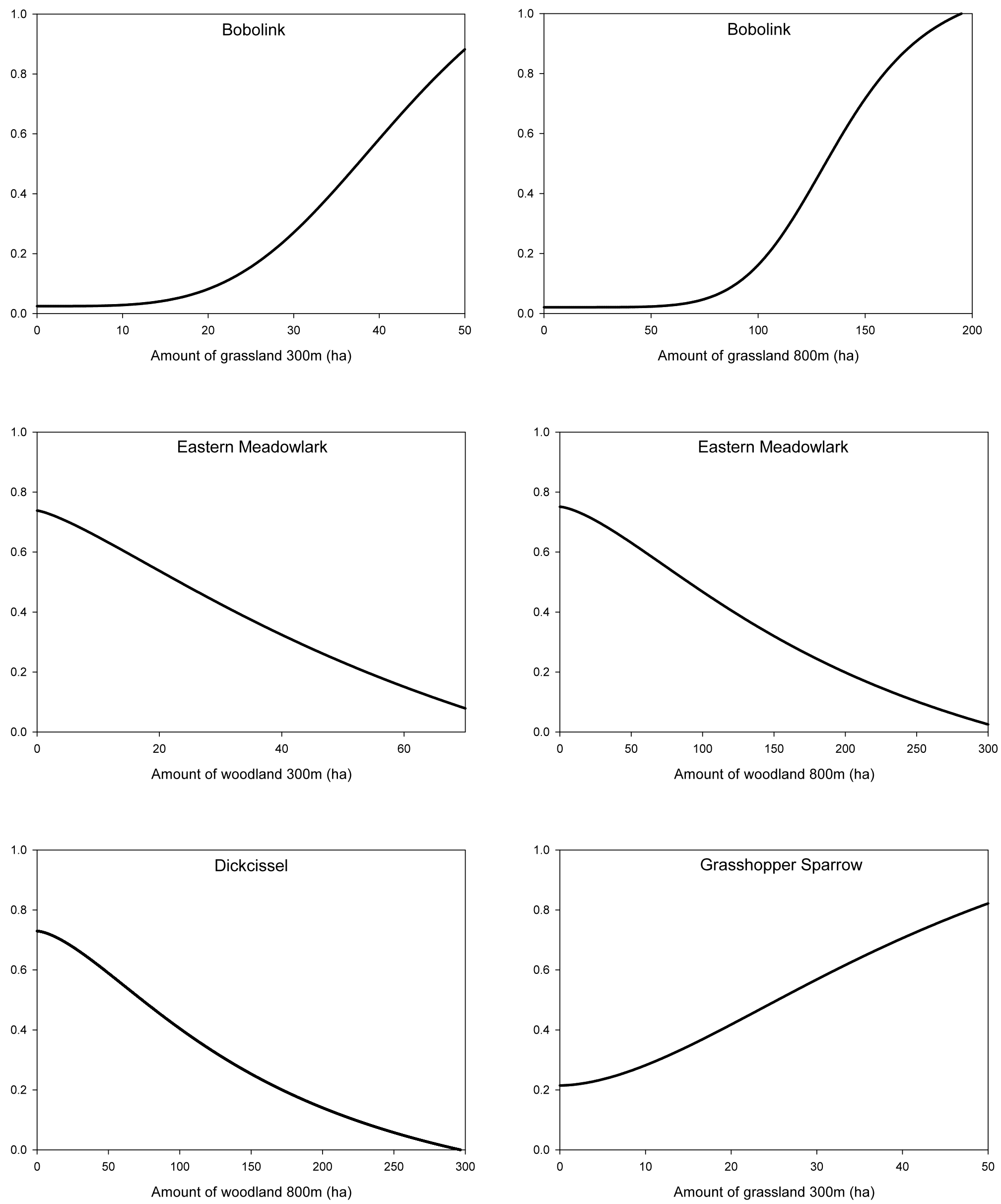

Bobolink
Amount of grassland 300m (ha)
Bobolink
Amount of grassland 800m (ha)
Eastern Meadowlark
Amount of woodland 300m (ha)
Eastern Meadowlark
Amount of woodland 800m (ha)
Dickcissel
Amount of woodland 800m (ha)
Grasshopper Sparrow
Amount of grassland 300m (ha)

FIGURE 2.

CHAPTER 4. GENERAL CONCLUSIONS

One aspect of my research focused on the effect of area and perimeter-to-area ratio on grassland bird species. I surveyed 15 Iowa State Preserves with a prairie component. These preserves are part of the Iowa State Preserve System. The results indicated that perimeter-to-area ratio can be a good predictor of presence for area-sensitive species. As perimeter-to-area ratio increased, that is, as the preserves became more convoluted and the amount of edge increased per area, the total number of area-sensitive bird species decreased. Area was a good predictor for total numbers of grassland bird species. As the area of the preserves increased, so did to total number of area sensitive species. This could be caused by area-sensitive species response directly to patch size or increased habitat diversity with increased patch area.

The data suggest that when taking into consideration management practices such as addition of adjacent grasslands, not only area, but also perimeter of the added habitat patch should be taken into consideration. Increasing deviation from a perfectly circular shape results in increasing perimeter-to-area ratio values (Helzer and Jelinski 1999). Convoluted preserves might not be able to provide habitat for area-sensitive species given the high amount of edge habitat, which many times is woody cover. Amount of woody edge habitat has been shown to negatively affect grassland bird occurrence (Ribic and Sample 2001; Bakker et al. 2002, Fletcher and Koford 2003, Cunningham and Johnson 2006). In fragmented environments for area-sensitive grassland bird species, increased area is necessary to manage for specific species, but additional area should minimize perimeter-to-area ratio in order to work effectively.

The finding that area was a good predictor of number of area-sensitive grassland bird species suggests that these species could be missing from some Preserves because those Preserves are too small. In these preserves, it should be possible to bring some of these species back by restoring habitat adjacent to Preserves, thus allowing them to function as larger blocks. The data gathered in this study could be significant with regard to present status and future management of the Preserves. In addition, my findings may possibly further our understanding of the composition of pre-settlement avifauna in Iowa (Laubach 1984). In this study, similar to a study in Nebraska, perimeter-to-area ratio of preserves had more influence on the presence and richness of grassland bird species than did patch area. While the maintenance of large patches is important to the conservation of grassland birds, patch characteristics such as patch shape should also be recognized and taken into account when planning for conservation (Helzer and Jelinski 1999).

The other major aspect of my research addressed the possible effect of landscape factors on habitat use by area-sensitive grassland birds. I surveyed 40 grassland patches in southern Iowa for five area-sensitive focal species. The species that was present most frequently was Eastern Meadowlark. The species with the least amount of sighting was Bobolink, followed by Henslow's Sparrow. Bobolink and Henslow's Sparrow have been documented to be very area-sensitive, which may explain why they were infrequently seen. Results indicate that landscape features do have an effect on the presence of area-sensitive species. Two landscape features, amount of woodland and amount of grassland, in the two buffers (300 and 800 m) explained some of the variation in occurrence of three of the five area-sensitive species. Amount of woodland in both the 300- and 800 m buffer negatively affected occurrence of Eastern Meadowlark. Amount of woodland in the 800 m buffer was also negatively associated with presence of Dickcissel. Grassland showed a positively effect on presence of Bobolink.

For species such as Henslow's Sparrow and Grasshopper Sparrow, which did not respond to either of the landscape variables, patch scale variables might be a better predictor for their occurrence. Therefore patch-scale variables should be considered closely when managing for these species. Future studies could explore a buffer zone covering a shorter range for these species. A larger buffer zone should be considered when exploring less area-sensitive species such as Eastern Meadowlark.

Investigating the extent of the relationship between grassland birds and landscape factors might provide more information on landscape requirements for area sensitive species (Cunningham and Johnson 2006, Ribic et al. 2009). When managing for area-sensitive species it is important to take into account and, if possible, combine both patch scale and landscape scale variables.

Literature Cited

Bakker, K.K., D. E. Naugle, and K. F. Higgins. 2002. Incorporating landscape attributes into models for migratory grassland bird conservation. Conservation Biology 16: 1638-1646.

Cunningham, M. A., and D. H. Johnson. 2006. Proximate and landscape factors influence landscape factors influence grassland bird distributions. Ecological Applications 16:1062–1075.

Fletcher, R. J., Jr., and R. R. Koford. 2003. Spatial responses of Bobolinks (*Dolichonyx oryzivorus*) near different types of edges in northern Iowa. Auk 120:799-810.

Helzer, C. J. and D. E. Jelinski. 1999. The relative importance of patch area and perimeter-area ratio to grassland breeding birds. Ecological Applications 9:1448–1458.

Laubach R. 1984. Breeding birds of Shreeder Prairie Preserve, west-central Iowa. Proceedings Iowa Academy of Science 91:153-163.

Ribic, C. A. and D. W. Sample. 2001. Associations of grassland birds with landscape factors in southern Wisconsin. American Midland Naturalist 146:105–121.

Ribic, C. A., R. R. Koford, J. R. Herkert, D. H. Johnson, N. D. Niemuth, D. E. Naugle, K. K. Bakker, D. W. Sample, and R. B. Renfrew. 2009. Area sensitivity in North American grassland birds: patterns and processes. Auk 126:233-244.