Fragmented Grassland Use by Avian Species of Concern in the Upper Mississippi National Wildlife and Fish Refuge

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Abstract

Bird species are decreasing at alarming rates causing organizations, including the United States Fish and Wildlife Service, to conduct long-term monitoring studies. In particular, grassland birds have decreased dramatically in the past few decades. Using data from the Upper Mississippi National Wildlife and Fish Refuge, tests of species richness and diversity were performed to examine how avian species of concern, especially grassland predominant species, use grasslands of varying size during different times of the year. Data were obtained from point counts conducted between 1994 and 2003 and compared against grasslands found near each site. Significant relationships ($P < 0.05$) were seen between species richness of all birds as grassland area increased during spring and fall. When using only grassland birds, there was a significant relationship ($P < 0.05$) during spring and fall between species richness per count and grassland area. There was also a significant increase ($P < 0.05$) in species richness per count of grassland birds during spring and fall as the perimeter-to-area ratios of the grasslands increased. These results provide a basis for future studies of potential habitat changes within the refuge by biologists.

Introduction

The Upper Mississippi National Wildlife and Fish Refuge (UMNWFR) is a refuge managed by the United States Fish and Wildlife Service (USFWS) established in 1924 consisting of approximately 240,000 acres and 261 miles of land in and around the Mississippi River as it runs along the borders of Minnesota, Wisconsin, Iowa, and Illinois (Figure 1) (USFWS, 2006). Grassland management is a part of the Final Environmental Impact Statement for the refuge. It states (USFWS, 2006): "Although mainly a river floodplain, the Refuge does contain 5,700 acres of scattered grassland habitat important to numerous species of grassland birds and other wildlife. Some of these grasslands are tallgrass native prairie, one of the rarest ecosystems in the United States. Active management is critical to safeguard and maintain these grassland areas. Management tools include prescribed or controlled fire to setback the natural succession of shrubs and trees, and the control of invasive species."

In recent years, there has been a greater urge to study the decrease in bird populations, especially in many neotropical migrants (Paxton and Watts, 1999). A critical component of biodiversity protection is understanding

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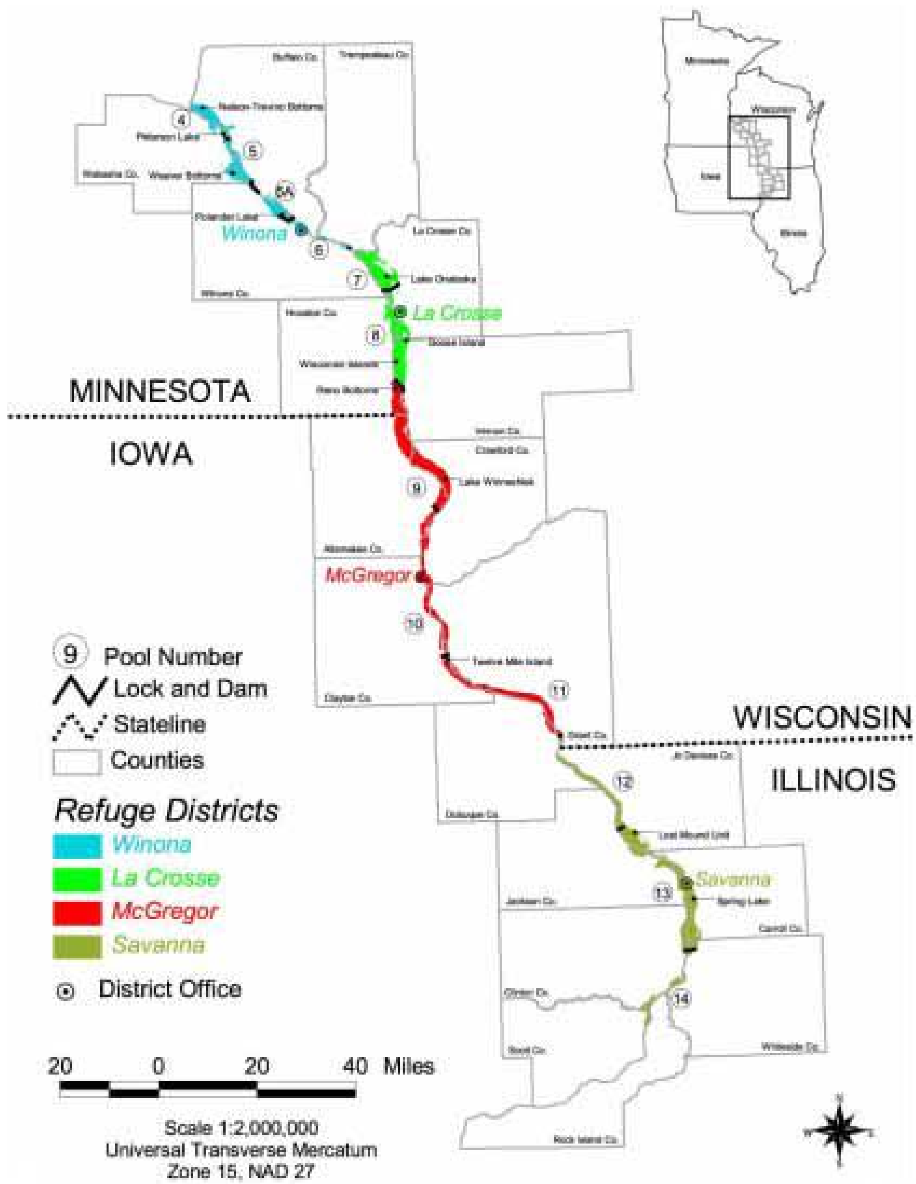

Figure 1. Location of the Upper Mississippi National Wildlife and Fish Refuge in relation to surrounding states (obtained from USFWS, 2006).

the environmental parameters that define species distributions (Debinski et al., 1999). Patch size, shape, and edge habitat affect how suitable an area is for an individual species (Sisk et al., 1997). Habitats containing greater complexity, such as edge habitat where a forest and grassland meet, normally contain a greater number of species (Paxton and Watts, 1999). As grassland goes through succession, it gains a greater level of horizontal and vertical complexity (Paxton and Watts, 1999). Thus, grasslands contain a smaller number of species; however, the declines of species that predominantly rely on this type of habitat are of greater concern. Grassland birds are showing a decline of 1.5% per year according to Sauer et al. (1995). Some of these species, including the Dickcissel (*Spiza americana*), Bobolink (*Dolichonyx oryzivorus*), Grasshopper

Sparrow (*Ammodramus savannarum*), and Field Sparrow (*Spizella pusilla*), are all showing major declines (Knutson, 2001). For these reasons, the USFWS has created a list of priority species for the UMNWFR. Grassland area appears to be one of the driving forces in the use of habitats by predominantly grassland-oriented species (Herkert, 1994). The decline in grassland bird population appears to be reduced with larger areas of grassland and areas where there is a smaller amount of patches (Herkert, 1994).

Monitoring regional changes in populations through field surveys cannot keep pace with the rate of change in agriculture and infrastructure development (Osborne et al., 2001). The best scenario would consist of repeated surveys over an extended length of time. The USFWS has done this in the UMNWFR with counts being performed over a ten-year period. These counts, in conjunction with the habitats associated with the UMNWFR, can be used to determine how diverse the grassland habitats are in terms of avian species and whether avian species are using the refuge's grassland areas. This study intends to answer the question of how do species of concern, and specifically grassland obligate species, use the different sizes of grassland habitat and corresponding edge habitat within the UMNWFR. If it is found that grassland predominant birds are using larger grasslands with greater benefit, then the management techniques currently being performed can be modified to create a better-rounded management scheme.

Methods

Background Data Manipulation

Between 1994 and 2003, the USFWS and volunteers performed multiple point counts within the UMNWFR. Counts were performed during three periods: spring migration, the breeding season, and fall migration. Spring migration counts were performed between March 25 and May 31, while breeding (summer) season counts were performed between May 22 and July 1. The end date for spring migration counts and the start date for the breeding season were variable to allow for two weekends of observations by volunteers and to allow late migrants into the database. Fall migration counts were consistent with a date range of August 15 to October 16. Observations for all years were combined to give one set of records per site per season. All counts were performed between 5 and 10 a.m. under standardized survey conditions.

Each count location was categorized as either forest habitat or prairie/wetland habitat based on the observers' determination of the primary habitat surrounding the count location. The prairie/wetland habitat areas and species will be known as grassland for the rest of this paper. These point counts consisted of a recording of all avian species seen or heard from a particular point within a ten-minute period. Forest counts recorded birds in three area rings from the counter: 25, 50, and greater than 50 meters. Grassland counts used distances of 50, 100, and greater than 100 meters. Data only from the grassland counts were used in this study. Since the data will be analyzed manually using ArcGIS, the data only need particular attributes associated with them. The only attributes needed for the land cover data is the type of cover and a definition for that type. The point count data needed:

- Species – to allow analysis of the selected species only.
- Number seen – allows for diversity indices to be calculated.
- X/Y location data – allows for mapping of the point counts.
- Date – allows for the counts to be placed in their proper category.
- Habitat – allows for obtaining only those points initially categorized as grassland.

Birds of Concern

There are a total of 56 species of concern on the list created by the USFWS. This list consists mainly of songbirds, though it also includes four species of woodpeckers, two species of cuckoos, and the Chimney Swift (*Chaetura vauxi*). These species were determined to be of concern if they were listed as threatened or endangered federally or in the four states containing the UMNWFR, listed as a resource conservation priority for the USFWS, listed in the Bird Conservation Plan of Partners in Flight for physiologic regions 16 or 32, or by appearing on the former ABC Green List (USFWS, 2006). Two species, the Chestnut-sided Warbler (*Dendroica pensylvanica*) and the Connecticut Warbler (*Oporornis agilis*), were also included without being found on any of the lists. Due to the species splits of the Rufous-sided Towhee and Northern Oriole, these observations were assigned to the more common, and listed, Eastern Towhee (*Pipilo erythrophtlalmus*) and Baltimore Oriole (*Icterus galbula*). A smaller selection of grassland predominant species from this list was obtained to perform separate calculations than the list as a whole. This list was obtained in conversation with Stephen Dinsmore, professor of avian ecology at Iowa State University. The overall list was reduced to eleven species (Table 1).

Site Selection

The 2001 National Land Cover Dataset was downloaded (http://www.mrlc.gov/) to provide a generalization of the habitats within the UMNWFR. Land cover data were used as they portray the general vegetative cover of an area. These data are normally obtained from overhead aerial photography or from field methods. This provides a reliable environment for the area. Also, most land cover data production is performed with the same data, so the land cover is for the same time period and is not affected by landscape change over time. If the same organization is providing the

Table 1. List of grassland species obtained from the overall list of bird species observed in the UMNWFR during the count period of 1994 to 2003. This list was obtained in conjunction with Stephen Dinsmore of Iowa State University.

Common Name	Scientific Name
Sedge Wren	*Cistothorus platensis*
Marsh Wren	*Cistothrous palustris*
Field Sparrow	*Spizella pusilla*
Lark Sparrow	*Chondestes grammacus*
Grasshopper Sparrow	*Ammodramus savannarum*
Swamp Sparrow	*Melospiza georgiana*
Dickcissel	*Spiza americana*
Bobolink	*Dolichonyx oryzivorus*
Eastern Meadowlark	*Sturnella magna*
Western Meadowlark	*Sturnella neglecta*
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*

data, they will have the same standards for their data providing consistency to the land cover data. Due to the size of the land cover files, the portion directly in and around the refuge was extracted from the initial file by a mask. Using Spatial Analyst for ArcMap 9.2, the raster land cover data were converted to features to allow for easy calculation of area and perimeter. Three habitat classes were used to determine patch size and perimeter. Homer et al. (2004) defined these classes as:

- Grassland/Herbaceous - Areas dominated by grammanoid or herbaceous vegetation, generally greater than eighty percent of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
- Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than twenty percent of total vegetation.
- Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for greater than eighty percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water. Wetlands were used in the analyses, as they were included in the classification by the USFWS.

Point counts were mapped by the latitude and longitude readings that were associated with each point location using ArcMap. Since the coordinates for the point counts were obtained in the North American Datum of 1927 (NAD 27) and the land cover data were in the North American Datum of 1983 (NAD 83), the land cover data had to be re-projected. Feature classes were created for each of the three seasons of point count data and the count data as a whole. All sites containing an observation of a concerned species were buffered to 150 meters using the Buffer tool in ArcToolbox and those that contained one of the three habitat classes within this buffer were used in the analysis (Figure 2). The habitat classes that were within the buffer were combined with all areas,

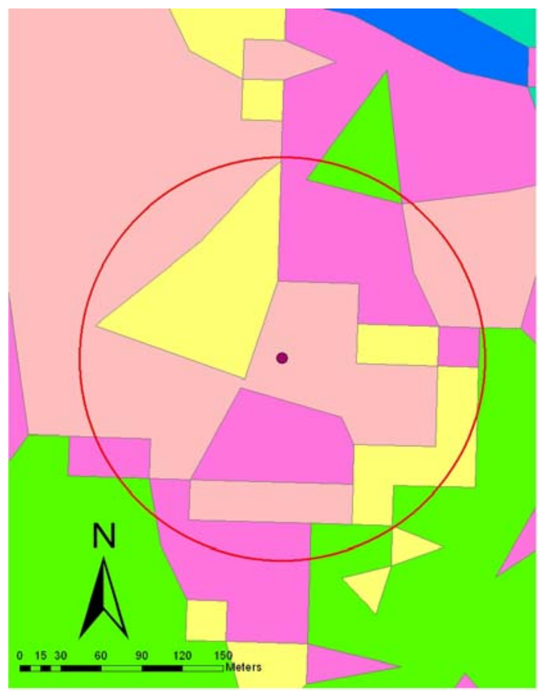

Figure 2. Area within the UMNWFR showing a point count site (dot), its 150-meter buffer (red circle), and the surrounding habitat. Polygons consist of habitats obtained from land cover. Selected habitats include Grassland/Herbaceous (yellow) and Emergent Herbaceous Wetlands (magenta).

through a combination of the Select by Location (those areas sharing a border with the selected features) and Select by Attribute (only those areas within the three classes) tools, to create the largest contiguous areas with a portion located inside the buffer (Figure 3). The perimeter-to-area ratio (perimeter divided by area) of these areas was calculated and combined for each site. If multiple point counts consisted of the same contiguous areas of grassland, these points were combined to create a new single point in the calculations against the ratio. The area of grassland directly within the 150-meter buffer was also calculated for each point count (Figure 4). The buffer was used to clip the largest contiguous areas to the portion of area within the buffer. Each site's seasonal observation and habitat

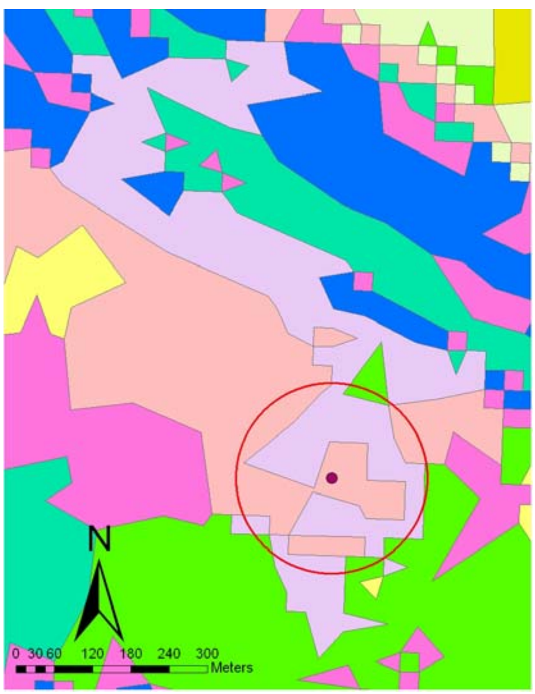

Figure 3. Area within the UMNWFR showing a point count site (dot), its 150-meter buffer (red circle), and the surrounding habitat. Polygons consist of habitats obtained from land cover. The largest contiguous area is shown (light purple).

measurement data was exported out as dBase IV file for analyses.

Statistical Analyses

Using a combination of Microsoft Excel and JMP, a statistical program, various summary statistics were calculated for each site and season. Species richness per count and Simpson's diversity index were calculated to compare the diversity of each site. Species richness is a simple calculation as it is only the number of species recorded. Calculating species richness per count was used to standardize the counts as some sites had only one count for the entire period, while some had multiple counts within the same month. This diversity index also corrects for "rare" species, which may be underrepresented in a small number of surveys.

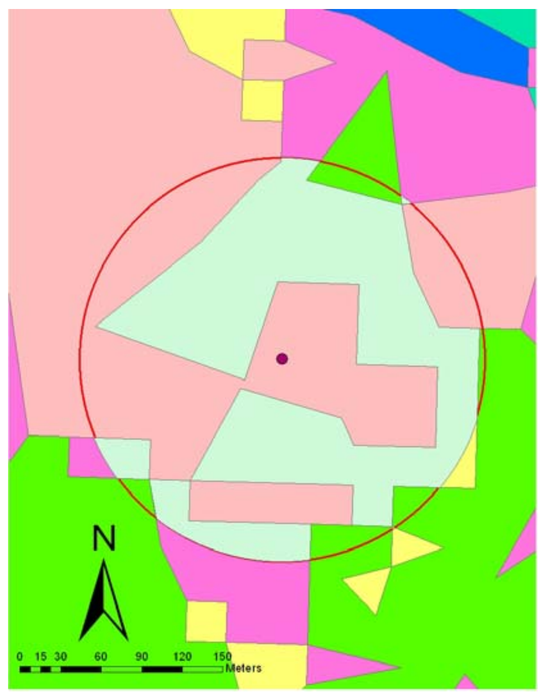

Figure 4. Area within the UMNWFR showing a point count site (dot), its 150-meter buffer (red circle), and the surrounding habitat. Polygons consist of habitats obtained from land cover. The grassland area within the buffer is also shown (light green).

Simpson's diversity index is the probability of two selected individuals not being from the same species (Krebs, 1978). The formula used to calculate Simpson's diversity index as given by Krebs (1978) is:

$$D = 1 - \sum (p_i)^2$$

Where:

D = Simpson's diversity index
p_i = proportion of individuals of species i in the community.

The index ranges from 0 (no diversity) to 1 (extremely high diversity) (Krebs, 1978). ANOVA tests and regression analyses were performed to compare the diversity numbers against the calculated grassland characteristics. F-tests were used to determine if the relationship between diversity and the grassland characteristic was significant ($P < 0.05$).

Results

Twenty-three point count sites were used in the analyses. Thirteen of these sites contained records within all three seasons, while three sites had records for only one season. All sites contained an observation during the breeding season. The spring season contained twenty sites and the fall season contained twelve sites.

The average number of species seen at each site after the ten-year period had ended (± SD) was 7.90 ± 3.99 for spring sites, 6.13 ± 3.79 for summer sites, 6.17 ± 3.21 for fall sites, and 6.78 ± 3.78 for seasons combined. The average number of individuals at each site over that same period (± SD) was 58.30 ± 40.53 for spring sites, 26.70 ± 23.31 for summer sites, 22.17 ± 22.59 for fall sites, and 37.20 ± 34.14 for all seasons combined. The maximum number of species and individuals at a site observed during the spring seasons, breeding seasons, and fall seasons were fourteen, fifteen, and twelve species and 145, seventy, and ninety individuals respectively.

All Birds

A strong pattern was revealed between species richness per count and the amount of grassland area within 150 meters during summer and fall. In the summer season, there was a decrease in species richness as the area increased ($R^2 = 0.22$, $F_{1,21} = 6.08$, $P = 0.022$), while the opposite was seen during the fall season ($R^2 = 0.36$, $F_{1,10} = 5.71$, $P = 0.038$) (Figure 5). Though insignificant, the linear relationship between species richness per count of all bird species and grassland area for spring and all seasons showed a decrease in richness as the amount of grassland within 150 meters increased. The opposite linear relationship was seen in all four tests when species richness per count was compared against perimeter-to-area ratio. Simpson's diversity index showed an increasing relationship in spring, summer, and fall as the 150-meter grassland amount increased. However, when all seasons were combined, there was virtually no change as the amount of grassland increased. All four time period tests showed an increase in Simpson's diversity index as perimeter-to-area ratio increased.

Grassland Birds

When using only grassland birds, there was a strong relationship during spring and fall between species richness per

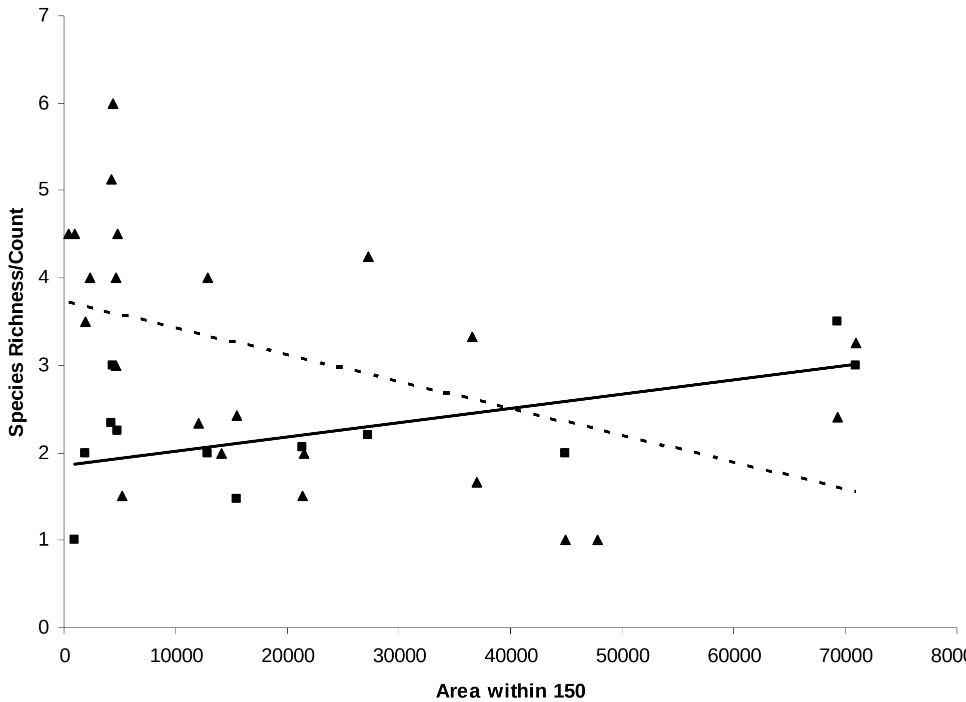

Figure 5. Linear relationships between species richness per count and the amount of grassland area within a 150-meter buffer around a point count site in summer (dashed line and triangles) and fall (black line and squares) for all birds studied in the UMNWFR.

count and grassland amount. Spring ($R^2 = 0.40$, $F_{1,17} = 11.10$, $P = 0.0039$) showed a decreasing relationship, while fall ($R^2 = 0.39$, $F_{1,9} = 5.84$, $P = 0.0389$) (Figure 6) showed an increasing relationship. Summer and the all-season results showed decreases as well, though not as strong as spring and fall. When there was an increase in perimeter-to-area, there was a significant increase in species richness per count during spring ($R^2 = 0.311$, $F_{1,14} = 6.32$, $P = 0.025$) and a significant decrease in fall ($R^2 = 0.49$, $F_{1,8} = 7.55$, $P = 0.025$) (Figure 7). Summer and the all-season results also showed increases. Simpson's diversity index for grassland birds showed a decreasing relationship as the grassland amount within 150 meters increased in spring and summer. However, the diversity index had an increasing relationship as grassland amount increased in fall and when all seasons were combined. Fall showed a decrease in the diversity index as the perimeter-to-area ratio increased, while the three other tests showed increases.

Discussion

Interpretation of Results

The decreasing relationship in combined seasons, spring, and summer was as expected for all species. Since most of the species being tested are forest-predominant or edge species, more of these two kinds of habitat are seen when there is a smaller amount of grassland area. One would expect the relationship to be different during fall because individuals are not setting up breeding territories, singing, mating, or nesting. However the difference was larger than expected. These same reasons explain the relationships between species

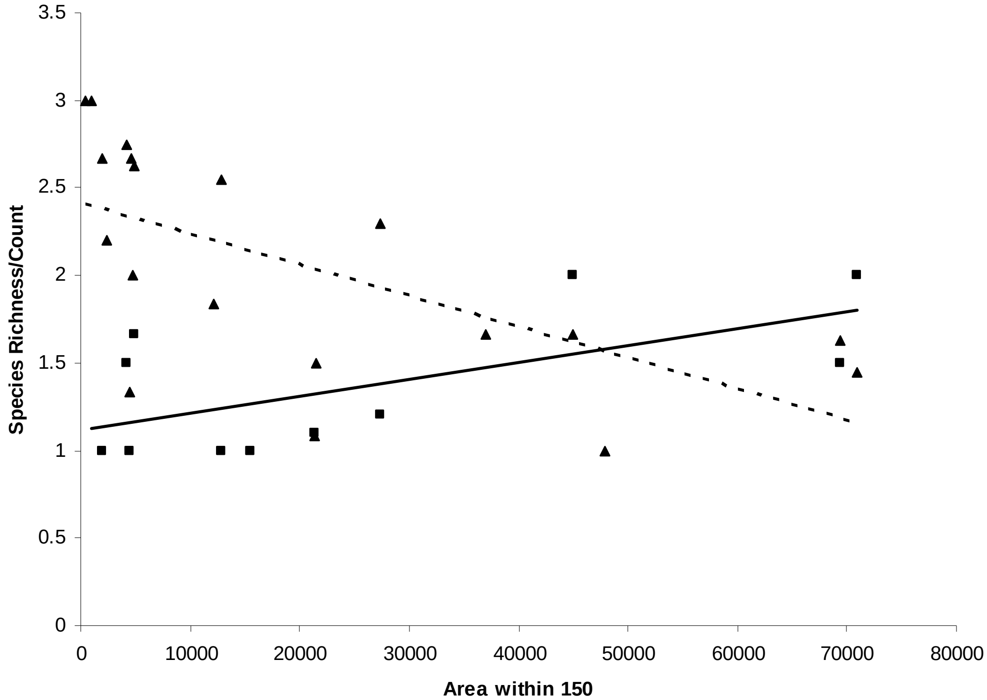

Figure 6. Linear relationships between species richness per count and the amount of grassland area within a 150-meter buffer around a point count site in spring (dashed line and triangles) and fall (black line and squares) for all grassland birds studied in the UMNWFR.

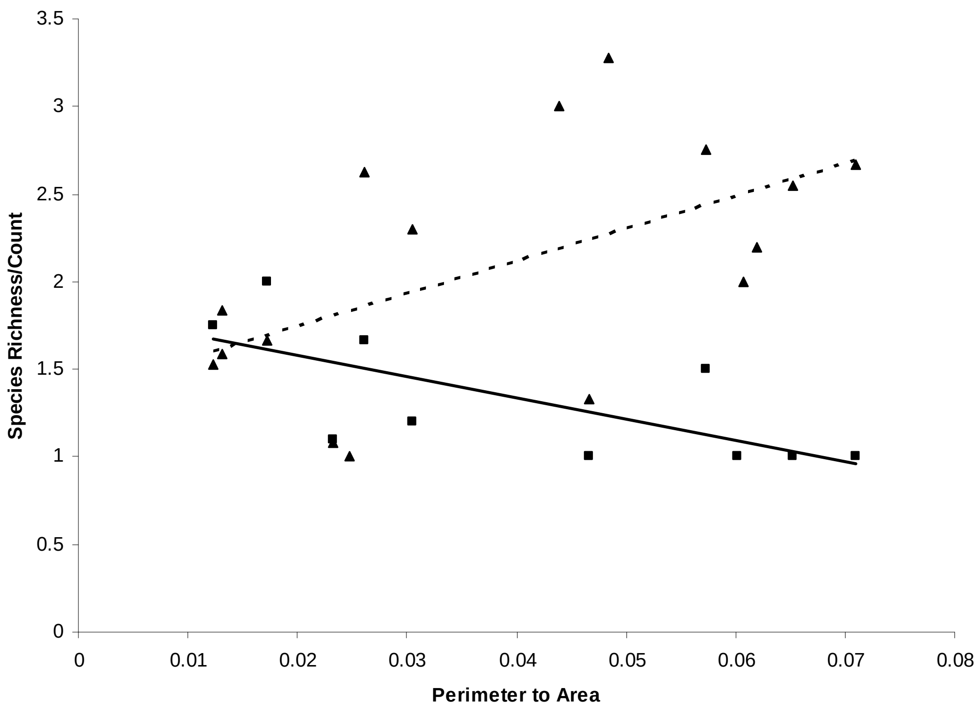

Figure 7. Linear relationships between species richness per count and the perimeter-to-area ratio of the largest contiguous areas around a point count site in spring (dashed line and triangles) and fall (black line and squares) of all grassland birds studied in the UMNWFR.

richness and the perimeter-to-area ratio. Simpson's diversity index takes the number of individuals of a species into its calculation. This could help explain why the three seasonal relationships increased as area and as the perimeter-to-area ratio increased. If multiple species that migrate or roost in larger numbers are seen, this would lead to a larger diversity index. Also if more edge or forest species are seen, they're more likely to be seen when the perimeter-to-area ratio is larger.

The decrease in species richness of grassland species as area decreased was not expected. Since these seasons are the primary migrating seasons, individuals may be on the move more and not recorded during the count. During the breeding season, a decreasing relationship was also seen, however it was not significant. This was not expected as one would most likely see more species in their preferred habitat to breed and nest. However, breeding success, a sign of suitable habitat, is not a result of seeing a species in a given habitat (Store and Jokimäki, 2003). The increases in species richness as perimeter-to-area ratio increased were not expected. Helzer and Jelinski (1999) concluded that maximum species richness occurs when patches are large with a reduced amount of edge. The significant relationships during spring and fall could be tied back to the fact that individuals are migrating during these seasons. Helzer and Jelinski (1999) found that six grassland species, including four used in this study, occurred more often with a lower perimeter-to-area ratio. This is opposite to the results seen here except for fall. This could be caused by the sheer lack of grassland within the refuge. Grasslands make up just over 2% of the total landscape within the refuge (USFWS, 2006). More grassland might lead to more individuals and species stopping at the refuge during migration and possibly setting breeding territories and nesting.

It has been suggested that habitat-selection studies use several scales to measure avian response to vegetation structure (Hostetler and Knowles-Yanez, 2003; Thogmartin and Knutson, 2007). Hostetler and Knowles-Yanez (2003) found the Mourning Dove (*Zenaida macroura*) and Gambel's Quail (*Callipepla gambelii*) to respond to landscapes at a broader scale than if they had measured the landscape within a 100-meter buffer. This may be the case in this study as a 150-meter buffer was used to find the grassland area around the point count. A larger buffer around the point count might present different results, however the odds of the observer obtaining individuals during the count decrease as the distance from the observer increases. The use of the largest contiguous area of grassland to obtain the perimeter-to-area ratio does present a somewhat larger scale but does not present a large enough scale to compare scale differences. There also is the possibility of individuals being affected at different scales within the same species (Hostetler, 1999). A single species could have a positive association to a habitat variable measured at a local scale but the opposite results when measured at a larger scale (Thogmartin and Knutson, 2007). Hostetler and Knowles-Yanez (2003) suggest that there may be a difference in habitat use by older individuals in some species.

Consideration of winter habitat availability might be critical, especially for resident species living in harsher winter conditions (Store and Jokimäki, 2003). Only three species on this list, the

American Tree Sparrow (*Spizella arborea*), Brown Creeper (*Certhia americana*), and Red-bellied Woodpecker (*Melaneres carolinus*), are around in large enough numbers to be considered a winter resident. It is possible that harsher weather conditions could create a situation where fewer individuals of these species are surviving to reproduce or to travel during migration. There is a connection between the factors affecting the habitat preference of a species and the local habitat surrounding the species or to the landscape around that local habitat (Store and Jokimäki, 2003). Sisk et al. (1997) found that a particular species was observed more times when the surrounding habitat of that being tested was of a certain type in species richness and abundance.

Osborne et al. (2001) conclude that while models based on vegetation alone can provide accurate predictions of habitats at some spatial scales, terrain and human influence are also significant predictors and are needed for finer scale modeling. Due to the amount of agriculture around the refuge, it is possible that human influence may have affected some of the results that are closer to the edges of the refuge. Terrain may also have a large influence on the results. The refuge is located in the Mississippi River Valley in between large bluffs. Grassland nesting cover is difficult to maintain in floodplain habitat with constantly changing river levels (USFWS, 2006). It is not known if these bluffs affect the migration patterns of the bird species or whether predatory species prefer these higher points to attack the studied species below them, reducing the number of individuals potentially seen. A bias may be present in observations conducted in sparse habitats because such habitats may be weighted incorrectly (Brotons et al., 2004). In this study, all habitats were given the same weight. It's possible that weights based on individual preference by species, such as what would be used in most models, would create results that would be closer to what was predicted.

Potential Study Problems

One potential problem involves the point count data and the inability to normalize the observations. The observations were not conducted by the same person, which creates a potential observer bias. It is possible that observers were not of the same skill level as each other and may misidentify species or miss them completely. Since the initial selection of sites for this study involved the habitat classification determined by the observer, sites may have incorrectly been used or been left out of the interpretations. To try and correct for this, refuge managers trained observers to the best of their ability. The coordinate readings of the point counts create a source of data that could be flawed if the observer incorrectly obtained the latitude and longitude readings. All counts were within the borders of the refuge, thus were used and assumed to be correct. Since the point count data are not coming directly from the source, there is also the possibility that the data were entered into the computer wrong. Another problem was the difference in projections between the point count data and the land cover data. If they were left in different projections, the data would not align correctly. This would potentially create a situation where the grassland area around the point count was incorrectly calculated and sites were incorrectly left out or included in the study. The land cover was re-projected into the projection of the point count data to resolve this problem.

A further area of concern is the combining of multiple sites into a single site in the calculations against perimeter-to-area ratio. In all cases, the sites combined had their 150-meter buffers overlapping. It was assumed that due to this overlapping, the areas around these counts were generally the same and could be combined. The counts were treated as separate independent counts in the calculation of species richness per count to keep it similar to the calculations for the other sites. The site combinations would affect the Simpson's index for the new site, but due to the proximity of the initial sites, the diversity is likely the same. Due to the varying number of times observers performed the counts during the year, or even month, the counts were combined to create one overall count period. This allowed for years of low counts to be given the same weight as years when there was a higher amount of counts. Species richness was calculated per count to avoid any bias in the number of times the count was performed. The observer should have the same likelihood of seeing an individual on April 15 as seeing one on September 15. Another issue to look at pertains to the small number of sites used in this study. If more sites were used, the results may show relationships closer to what was expected. More sites could have been added if more habitat classes from the land cover dataset were selected.

Future Implications

The results of this study provide a base for future studies of avian species the USFWS is monitoring. Biologists should expand this study to multiple scale levels to get a better understanding of how these species are truly affected by the fragmentation of grasslands. If species are not selected carefully, poor management solutions may occur from the combination of habitat needs of multiple species (Store and Jokimäki, 2003). Store and Jokimäki (2003) found two species of old-forest dwelling birds that needed the same trees had differing results when the trees were in different proportions. This study can also be used in a GAP analysis of the refuge and the surrounding area. However, biologists need to realize that every change that occurs will likely affect another species, positively or negatively (Hostetler, 1999). Expanding grasslands is likely to create a reduction in the amount of edge habitat that other species need to be successful.

Gap analysis compares where actual sightings are in relation to where a species' predicted location should be and analyzes the "gaps" in between (Debinski et al., 1999). Though Hostetler and Knowles-Yanez (2003) suggest that it is likely if management strategies were properly determined, land use would have minimal impact on bird species. Species' occurrences can be estimated between sample points based on their spatial arrangements using varying forms of interpolation (Osborne et al., 2001). The USFWS would be able to predict if species are using other particular areas of the refuge based on interpretation of these results and future studies. If species are using the areas as predicted, biologists would be able to defend changes in landscape practices of the refuge. They can also use these results to modify the landscape in and around their refuges, including the

UMNWFR, by converting agricultural land to grassland and reducing the amount of edge habitat. These two suggestions are particularly helpful in the conservation of the grassland species studied here. Small modifications to the landscape should be studied first to determine if the changes are truly doing any good and they are easier to manage than a large scale operation (Thogmartin et al., 2007). Studies should be performed to address weather differences across years and time of the count during the day to determine if these had any affect on the results of this study.

Conclusion

This research meets one of the criteria for monitoring populations according to the conservation plan put forth by Knutson et al. (2001). Even though some of the results presented in this study were not as expected, there were many factors that could have led to this. This study provides a good, general base for biologists of the UMNWFR to conduct future studies on habitat use by species they are closely monitoring.

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