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Rebecca L. Fitzmaurice
University of Nebraska - Lincoln

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by

Rebecca L. Fitzmaurice

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AVIAN USE OF RIPARIAN CORRIDORS AND ADJACENT CROPLAND

IN EAST-CENTRAL NEBRASKA

Rebecca L. Fitzmaurice, M.S.

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Advisor: Ron J. Johnson

Agriculture today is faced with global competition and increasing pressure for environmental stewardship of the land. One approach that may help harmonize these needs for productivity and environmental stewardship is better understanding and management of natural enemies of crop insect pests. Avian predators of crop pests might contribute to a sustainable farming system in which pesticide levels can be reduced. Not much has been studied, however, regarding bird use of agricultural lands and the potential management of birds for optimum crop pest consumption. This two-year study evaluated bird use of woody and herbaceous riparian corridors and adjacent crop fields in east-central Nebraska. Birds were censused using fixed-width transects along woody and herbaceous corridors and, from each corridor type, perpendicular into adjacent crop fields. Species richness was higher in woody than in herbaceous corridors during all census periods except late summer ($P \leq 0.06$). Abundance of birds, however, did not differ between corridor types in any census period ($P \geq 0.13$), a result possibly influenced by woody vegetation that was distributed throughout the surrounding area. Richness and abundance of neotropical migrants was higher in woody than in herbaceous corridors during spring ($P \leq 0.02$) but did not differ during summer ($P \geq 0.17$). Correlation analyses indicated that, during the breeding season, tree density and the number of tree species was positively associated with richness of woodland birds and negatively associated with richness of grassland birds. Water volume of the stream appeared to be important for richness of birds in woody corridors. In general, corridor type did not affect richness or abundance in adjacent crop fields, but species composition was different between

fields adjacent to woody and herbaceous corridors. Also, bird use of fields appeared to differ according to a bird's habitat and foraging guild classifications. Results of this study further our understanding of bird use of agricultural lands, give insights into potential management of birds for optimal consumption of crop pests, and provide background data on which to base more detailed research.

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Wild places and wild things have always brought me a special joy. As I gradually learned about environmental degradation, I was inspired to become involved. Ultimately, I decided to embark on a career of conserving wildlife. Attaining this degree has been a goal of mine for several years, and the journey along the way has not been without many challenges. Several people assisted me over, around, and through the challenges I faced, and it is with much joy and appreciation that I acknowledge these friends.

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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

Page

AVIAN USE OF RIPARIAN CORRIDORS AND ADJACENT CROPLAND IN EAST-CENTRAL NEBRASKA

The Great Plains was once dominated by prairies, wetlands, savannas, and other native ecosystems. Much of this grassland biome has been changed, however, due largely to fire suppression, agricultural land use, and other human activities. Although it is possible to preserve or restore areas of native habitat in the interest of preventing species or ecosystem extinction, farming and fire suppression will likely remain.

Farming methods of this region and around the world have used pesticides to control crop pests for many years. However, the use of certain pesticides can result in water pollution, wildlife population declines, and human health problems (Gips, 1987). As increasing importance is placed on improving environmental quality, reduction in pesticide use becomes a desired goal. But farmers need realistic alternatives and options before they can make significant changes in farming practices. Reducing pesticide use while maintaining profitable crop yields might be achieved through sustainable agricultural methods such as biological insect suppression (Coppel and Mertins, 1977). Vertebrate predators, including birds, are potential natural enemies of crop insect pests. Habitat or system manipulations to enhance the appropriate bird or other predator species might reduce pest populations, thus reducing the need for pesticides. The current challenge is to determine which habitats and which bird species are most easily enhanced for the most effective reduction of crop pest populations. Although large rowcrop monocultures do not generally provide suitable habitat for most birds (Best *et al.*, 1990), riparian corridors winding throughout heavily-cropped areas of the Great Plains do offer potential bird habitat (Moore *et al.*, 1992). Such habitat may be an integral component of a sustainable agricultural system. In this context, little is known about bird use of riparian habitats and adjoining agricultural areas. Therefore, I studied avian use of woody and herbaceous riparian corridors and adjacent crop fields in east-central Nebraska. The objectives of my research were to compare bird species richness and abundance at woody and herbaceous riparian corridors and in adjacent crop fields, and to evaluate relationships between birds and various vegetation variables.

LITERATURE REVIEW

Although the role that natural predators could play in a sustainable agricultural system is not well understood (Luff, 1983), the potential of natural predators in such a system is indicated by their consumption of crop insect pests. Spider assemblages have been shown to reduce crop damage by tobacco cutworms (*Spodoptera litura*), greenbugs (*Schizaphis graminum*), leaf flies (*Contarina inouyei*) and other crop pests (Riechert and Lockley, 1984). Big brown bats (*Eptesicus fuscus*) feed on several significant agricultural pests, including June bugs (Scarabaeidae), green and brown stinkbugs (Pentatomidae), leafhoppers (Cicadellidae), and cucumber beetles (*Diabrotica undecimpunctata*), the larvae of which are known as corn rootworms (Whitaker, 1972). Several bird species are also documented as impacting crop pest populations. In India, Chakravarthy (1988) determined feeding rates and stomach contents of birds, and concluded that the house crow (avian scientific names, Appendices A and B) appeared to be the most important predator of pod borers of field beans, and that sites with the highest number of bird species had higher bean yields than sites with the lowest number of bird species. Also in India, Sagar (1984) estimated the pest population in a coriander field, revealing a homogenous distribution averaging 12.0 semi-looper (*Plusia orichalcia*) larvae per 3 m^2. Birds were not present when these counts were made, but 7 days later Sagar observed "a fairly large number" of house sparrows feeding on and carrying away these larvae. Pest population estimates that same day (but after the birds had fed) revealed an average of 4.1 larvae per 3 m^2 , and estimates 8 days later showed an average of 0.3 larvae per 3 m^2. Thus, Sagar determined that house sparrows were important in protecting coriander from insect damage. Summers-Smith (1988) reported that tree sparrows were important in controlling insect pests in orchards and asparagus fields in Germany and in grain fields in China.

In Florida (United States), Strandberg (1981) placed pupae of a cabbage pest on the undersides of the crop leaves, and observed the number of pupae eaten per day. Strandberg concluded that the savannah sparrow and palm warbler were "significant predators which actively searched for and consumed" cabbage looper (*Trichoplusia ni*) pupae. Stewart (1975) observed common crows, mockingbirds, eastern bluebirds, house sparrows, and red-winged blackbirds reducing or eliminating infestations of tobacco insects in North Carolina. In corn fields of North Carolina and Virginia, Stewart (1973) also observed flocks of European starlings moving about removing corn earworms (*Heliothis zea*) and fall armyworms (*Spodoptera frugiperda*) until they had worked over the entire fields.

Several woodpecker species are known to feed on corn borer larvae over-wintering in corn stalks. In North Dakota (Frye, 1972) and Louisiana (Floyd *et al.*, 1969), corn plots were caged to exclude birds, and corn borers were counted in caged and uncaged plots before and after winter to determine corn borer reduction attributable to woodpeckers. Frye found a 75% reduction, and Floyd found a 91% reduction of corn borer larvae in uncaged plots compared to caged plots. Because these two studies were in different parts of the country, they involved different pest species and different woodpeckers. In North Dakota, the downy woodpecker fed on the European corn borer, whereas in Louisiana, the northern flicker fed on the southwestern corn borer. In Mississippi, Black *et al.* (1970) conducted field observations of birds from a movable blind in corn fields, and fully determined the status of corn borer infestation of plots before, during, and after winter. Their findings of 64% corn borer removal the first year and 82% the following year led them to conclude that the northern flicker "is a key factor in the reduction of overwintering southwestern corn borer populations in Mississippi." In Arkansas, Wall and Whitcomb (1964) used field observations of birds, corn borer larvae counts before and after winter, and stomach contents analyses, and determined that in individual fields, up to 60% of the larvae were removed by birds. They also reported that the downy woodpecker was the most important avian predator of the European corn borer (*Ostrinia nubilalis*), whereas the northern flicker was the most important avian predator of the southwestern corn borer (*Diatraea grandiosella*). Barber (1925) compared estimates of fall infestation with estimates of spring infestation, and concluded that birds (not restricted to woodpeckers) had taken from 30 to 97% of the overwintering corn borers in corn fields of Massachusetts. Barber attributed feeding in standing corn stalks to woodpeckers and feeding in corn stalks that lay on the ground to other birds.

Habitat for Birds

Birds that might reduce crop insect pest populations need suitable habitat, which is not generally provided by crop fields (Best *et al.*, 1990). Riparian areas of the Great Plains may be important habitat for many birds. Tubbs (1980) reported that 136 bird species use wooded riparian habitats in the Great Plains throughout the course of a year. In Iowa alone, Stauffer and Best (1980) found 32 species using wooded riparian habitats and eight species using herbaceous riparian habitats. Riparian areas may be important as stopover sites during migration for neotropical migrants (Moore *et al.*, 1992), many species of which have declined (Finch, 1991). Rodenhouse *et al.* (1992) reported that during migration and the breeding season, neotropical migrants constitute about 71 % of bird species using farmland in northcentral and northeastern

North America. They found that within the farm landscape, neotropical migrant species richness and abundance were lowest in rowcrops, greater in uncultivated grassy areas, and highest in uncultivated wooded edges.

Other studies in the Midwest focused on bird use of agricultural areas. Best *et al.* (1990) censused birds during summer in the centers and edges of corn fields adjacent to both woody and herbaceous edges. In their study, all study sites with woody edges were in west-central Illinois, and all study sites with herbaceous edges were in central Iowa. They found that more bird species and more individuals used woody than herbaceous edges. However, the number of species and individuals in the corn field centers was unaffected by the edge type, and differed only in species composition. In Iowa, Bryan and Best (1991) censused birds during summer in grassed waterways and surrounding crop field plots similar in dimension to the grassed waterways. They determined that grassed waterways within crop fields had higher bird species richness and abundance than the surrounding crop fields.

Few studies were found that focused on the avian component of lands where riparian areas interface with agriculture. In Central Pennsylvania, Croonquist and Brooks (1993) compared bird richness and abundance between a forested watershed that had been agriculturally and residentially disturbed and an undisturbed forested watershed. Corridor transects at six study sites within each watershed extended 125 m perpendicularly from the stream channel. They found that in the forested watershed, bird species richness and abundance remained relatively constant at increasing distances from the stream, whereas in the disturbed watershed, richness and abundance decreased with increasing distance from the stream (habitat type and distance from the stream appeared to be confounding). Henke and Stone (1978) also studied birds in a disturbed and an undisturbed riparian area in California. They compared bird data between naturally vegetated (forested) and riprapped berms (grass/shrub), and agricultural lands associated with each. They reported that bird diversity and density were higher on forested riparian plots and associated agricultural lands than on riprapped plots and associated agricultural lands. They also found the highest density of birds in agricultural lands associated with riparian vegetation during the latter half of spring (defined as 8 March to 31 May). Along the Colorado River in the Southwest, Conine *et al.* (1978) censused birds in areas of riparian vegetation, at the agriculture-riparian edge and in agricultural lands at increasing distances up to 2.4 km from the riparian edge. They reported that bird densities of riparian species were higher for all seasons in the agricultural-riparian edge than in the riparian habitat or the agricultural area. Average number of riparian species, however, was among the lowest for most seasons in both the agricultural-riparian edge and the agricultural areas as compared to the native riparian vegetation. This study also reported that species commonly using agricultural areas traveled long distances (nearly 2.4 km) from riparian vegetation, whereas species rarely going from riparian vegetation into agricultural areas tended to travel short distances (up to 0.4 km).

Four of the studies mentioned above (Stauffer and Best, 1980; Rodenhouse *et al.*, 1992; Best *et al.*, 1990; and Henke and Stone, 1978) compared woody and herbaceous areas, and determined higher bird species richness and abundance in woody areas. Although Best *et al.* (1990) found similar abundance and species richness between corn field centers adjacent to woody and herbaceous edges (but different species composition), they also found more species and birds in woody than in herbaceous edges. Also, woody riparian corridors can be similar in structure to windbreaks, which have been shown to provide several benefits to agriculture such as soil protection, moisture conservation, and improved crop yields and profits (Brandle *et al.*, 1988; Brandle *et al.*, 1992). The emerging science of agroforestry combines the advantages of agricultural and forestry land practices into more sustainable systems (Johnson *et al.*, 1992). Woody riparian corridors in cropland might be an effective component of a sustainable farming operation because they offer habitat for birds that consume crop insect pests, and because they can directly and indirectly provide other agricultural benefits.

Woody edges, however, can be detrimental for grassland bird species that need large, unfragmented grassland areas (Gates and Gysel, 1978; Johnson and Temple, 1990). Habitat changes in the Great Plains (including the invasion of woody plants) are believed to have contributed to declines in many grassland bird species (Knopf, 1994). Gates and Gysel (1978) studied nest dispersion, clutch size, and fledging success of birds in contiguous field and forest habitats. They found that woody edges can cause increased predation of grassland birds and their nests by providing habitat for predators such as raptors, raccoons (*Procyon lotor*), crows, blue jays, and others. Also, the brown-headed cowbird has reduced the reproductive success of nesting birds through brood parasitism, and thus may have contributed to declining populations of several bird species (Terborgh, 1989; Finch, 1991; Rodenhouse *et al.*, 1992). Grassland birds may have additional difficulties finding suitable habitat in intensively cropped regions if CRP (Conservation Reserve Program) lands go back into production in the near future (Knopf, 1994). Thus, questions remain as to how woody vegetation might play a role in sustainable agriculture, and how uncultivated edges in farmland can be managed for both optimum sustainability of the land and natural resource conservation. Although woody edges have values in agricultural areas of the Great Plains, the needs of grassland species also must be addressed in order to prevent species extinctions.

Data Collection Methods

The strip transect method of censusing birds (Ralph *et al.* 1993) was used for two reasons: the open terrain of crop fields allowed for thorough data collection while walking (Ralph *et al.*, 1993), and more terrain could be censused per unit time than with the spot-map method (Conner and Dickson, 1980). Corridor vegetation was sampled using a modification of the Circular Plots technique devised by James and Shugart (1970) and further described by Noon (1980). This method was chosen for its inclusion of a broad range of vegetation variables in a forested habitat, and for its simplicity and time efficiency.

STUDY SITES

Study sites were located in Lancaster and Saunders counties of east-central Nebraska. The surface landform is rolling hills and the area receives 71 cm of rainfall annually (Johnsgard, 1979). Using field observations and aerial photographs (obtained from the Consolidated Farm Services Agency offices of Lancaster and Saunders counties), sites were chosen to fit several criteria: 1) sites contained at least 300 m of waterway, with the edges consisting of either primarily woody vegetative cover (≥ 75%) or primarily herbaceous vegetative cover with ≤ 25% woody vegetation; 2) cropland bordered each side of the corridor; 3) the primary vegetative cover (woody or herbaceous) extended along the riparian corridor for at least 1.2 km; 4) the waterway contained running water during spring; and 5) the site was at least 1.6 km from others selected.

I found eight woody and four herbaceous corridors that fit all criteria. Two of the herbaceous sites contained some shrubs (≤ 125 shrub stems/ha), shrubs being defined as all woody vegetation smaller than 3 cm (Noon, 1980). The other two herbaceous sites contained larger amounts of woody vegetation (≤ 1875 shrub stems/ha and ≤ 145 trees/ha) including chokecherry (*Prunus virginiana*), honey locust (*Gleditsia triacanthos*), and willow (*Salix* spp.). Trees at these two sites were largely between 3 and 15 cm (diameter at breast height), with 88% of them between 3 and 8 cm. The woody sites contained some understory vegetation, but predominantly consisted of trees. The most common species were green ash (*Fraxinus* *pennsylvanica*), elm (*Ulmus* spp.), mulberry (*Morus* spp.), willow, eastern cottonwood (*Populus deltoides*), and boxelder (*Acer negundo*). Standing dead trees were also abundant. Additionally, some sites had hackberry (*Celtis occidentalis*), black locust (*Robinia pseudoacacia*), honey locust, black walnut (*Juglans nigra*), maple (*Acer* spp.), dogwood (*Cornus* spp.), American plum (*Prunus americana*), chokecherry, and elderberry (*Sambucus* spp.).

Corridor width ranged at the herbaceous sites from 8 to 100 m (x=33 m) and at the woody sites from 17 to 163 m (x=55 m). Water volume (measured in August, 1993) ranged at the herbaceous sites from 0.01 to 1.1 m^3 (x=0.35 m^3) and at the woody sites from zero to 6.3 m^3 (x=0.46 m^3). Seven corridors (six woody and one herbaceous) extended in a north-south orientation, four corridors (one woody and three herbaceous) extended in an east-west orientation, and one woody corridor curved from a north-south into an east-west orientation.

METHODS

Bird Censusing

Eight woody and four herbaceous sites each contained one transect along the corridor-field edge, and two field transects. Transects along the corridor-field edge (also referred to as corridor transects) were 400 m long except for two (at woody sites) that were 300 m long because corridor-field edges did not meet the appropriate criteria. For corridors near a road, which broke the continuity of the habitat, the corridor transect began 50 m in from the road's edge. The width of corridor transects extended 12 m into the adjacent field and 25 m into the corridor or to the outer edge of the opposite side, whichever was less. Thus, for corridors < 25 m wide, widths of corridor transects varied according to the width of the corridor (8 to 20 m).

While walking the corridor-field edge, I recorded three separate sets of data – birds observed up to 25 m into the corridor or to the outer edge of the opposite side, whichever was less; birds observed in the first 12 m of the field edge directly adjacent to the corridor; and birds observed flying from the corridor to any part of the field or vice versa. For birds recorded as flying between corridors and fields, I also recorded the number of trips each bird made from one of these areas to the other. Birds observed in the first 12 m of the field edge were recorded because the proximity of corridor vegetation likely causes birds to use this area of the field more intensively than other areas of the field. Corridor vegetation likely influences bird use of the field, up to some distance away, especially where tree limbs extend out over the field. Twelve meters is a distance about the height of the woody vegetation at the woody sites, and in windbreak studies, this zone adjacent to the windbreak and extending out a distance of the height of the windbreak, undergoes wind reduction and other climatological effects that may cause accumulations of insects in this zone (Pasek, 1988).

The two field transects per site extended from one side of the corridor into the adjacent crop field. Each was 100 m wide, and, at the outer transect edges, 100 m apart from each other. Although these transect lengths ideally would have each been 200 m long, their lengths varied (Table 1) so that nearby edge vegetation was not closer than the censused corridor. Exceptions to this occurred at two sites, where a grassed waterway partially extended through a field transect adjacent to a woody corridor. Birds in fields at these sites were recorded in relation to the grassed waterways and taken into consideration before data analysis. Field transects were marked with small flags at 25-meter intervals.

Bird species richness and abundance data were collected at all 12 sites during 8 different census periods, each during one of five seasons (Table 2). After all data were collected, spring and summer 1993 census periods were separated by selecting a cut-off date by which most migrants had passed through the area. Field transects were censused only during spring, summer, and winter because in late summer and fall, crops were either too tall for counting birds or too dense to traverse.

Four permanent sets of three sites each (two woody and one herbaceous) were established and censused at one set per day. These sets were based on proximity of sites to minimize travel time. The order of censusing within a set and the census order of sets were determined by a Latin square design (Snedecor and Cochran, 1989). Data were collected from sunrise until three to four hours later, but not during substantial precipitation or > 20 km/hour winds (Conner & Dickson, 1980).

Vegetation Measurements

Corridor vegetation was sampled using a modification of the Circular Plots technique devised by James and Shugart (1970) and further described by Noon (1980). Modifications, which are detailed below, included rectangular instead of circular plots, transects centered parallel with the plots instead of parallel with compass headings, ground cover measured by type (grass/sedge, forb, litter, slash/log) instead of as a single ground cover, estimations of ground and canopy cover made using small plots instead of an ocular tube, and use of a light meter instead of a density board to estimate understory foliage volume (cover density).

Five 0.04-ha rectangular plots were randomly selected at each site. Because plots were as wide as the transect-side of the stream corridor, which varied, plot dimensions also varied in width (5 to 40 m) and length (10 to 89 m). At all but two sites, there were more than five plots (from which to randomly choose) on the side of the stream containing the corridor-field transect; therefore all plots selected were from that side of the stream. At two sites, however, five or fewer plots existed on the side of the stream containing the corridor-field transect, so plots were randomly chosen from these plots and from the plots on the opposite side of the stream. For each plot, shrub density, tree density, tree species richness, and percent ground cover by type were determined. At woody sites, canopy height, percent canopy cover, and basal area of trees were also determined. To determine tree density, tree species richness, and basal area, all trees within each plot were counted, identified, and measured for diameter at breast height (1.3 m above ground), respectively. A clinometer was used to measure canopy height at three evenly-spaced points along the edge of each plot. Percent ground cover by type, percent canopy cover, and shrub density within each plot were determined by walking two transects, one along the center of the length and one along the center of the width of the plot. Each transect was separated into several sections, providing a method of determining canopy and ground cover systematically. The width of each transect was arms-length (1.7 m). The lengths of these two plot transects were added together and divided into 20 sections, thus determining section lengths (range: 1.5 to 4.7 m). Percent canopy cover for each section was determined by standing in the center of the section, and visually estimating the percent canopy cover directly above the section as either zero, one-third, two-thirds, or 100%. Percent ground cover by type for each section was determined by visually estimating the percent ground cover for each type (grass/sedge, forb, litter, slash/log) as either zero, one-third, two-thirds, or 100%. The number of shrubs were also recorded without double-counting where the two transects overlapped in the center of the plot.

Because several of the woody corridors contained one or more gaps in the trees where an open area of herbaceous vegetation existed, the number of gaps and the mean and total area of the gaps were determined for each woody corridor. At 50 evenly-spaced points along the center of the transect-side of the stream corridor, a determination was made as to whether the spot was open or not open. Each of the 50 points was the center of a rectangle with width being the transect-side of the stream corridor, and length being either 6 or 8 m, depending on corridor transect length (300 or 400 m, respectively). By looking up, it was determined whether the rectangular area had more or less than 50% canopy cover. An open area or gap was arbitrarily assigned as having 50% or less canopy cover. Based on these readings, the number of gaps and the area of each gap was determined. Also at each of these 50 points, cover density at one and two meters above ground was measured with a light meter (Biospherical Instruments Inc., San Diego, CA, model QSL-100). The amount of light obscured by the vegetation provides a measure of the cover density (Schemnitz, 1980:316). A light reading at each level was also taken near each site in a completely open area for values of full light admittance (zero cover density). Using only readings taken at points with > 50% canopy cover, an average percent light was calculated for each height level (1 and 2 m) by dividing each value by its corresponding full light reading. Subtracting each of these values from 100 resulted in average percent cover density (at the respective heights) for the wooded portions of a corridor.

Water volume of the stream was determined for each corridor on one occasion during late summer, 1993. Width and maximum depth of water at five evenly-spaced points along each transect were measured and these values were multiplied by one meter to calculate volume of water per meter of stream. An average was then calculated for each site.

To determine the area of each corridor, the portion of an aerial photograph representing the entire width of the stream corridor within the boundaries of the corridor transect length (but disregarding corridor transect width) was cut out, and measured with a portable area meter (LI-COR, Lincoln, NE, model LI-3000). The values were converted to hectares for establishing site descriptions (Appendix C).

On a broader scale, it was desirable to assess whether the amount of woody vegetation in the surrounding area affected bird species richness and abundance within the corridors. Therefore, the amount of woody vegetation existing within the area surrounding each study site was recorded. From the center of each site (in the field, halfway between the two field transects, and half the distance of the longest field transect), a circle with radius representing 1.6 km (1 mile) was drawn. All portions representing woody vegetation within this circular area, as well as the entire circular portion itself, were cut out and measured using the portable area meter. From these measurements, the percent surrounding woody vegetation for each site was calculated.

Field Information Sheets

Most of the landowners involved in this study provided information on the field practices used at each site throughout the growing season. This information was requested by means of a Field Information Sheet (Appendix D) and was potentially to be used for further understanding of situations and results on a site-by-site basis. Ten of the 12 landowners provided this information in 1992 and nine of 12 provided it in 1993.

Analyses

Bird species richness and abundance in corridors and in fields (and for neotropical migrants in corridors) were compared between corridor types (woody vs. herbaceous) using analysis of variance (ANOVA) procedures (SAS Institute, Inc., 1988). The Type III mean square was used with corridor type nested within site as the error term. Data for census periods with two years of data collection (summer, fall, and winter) were tested for between-year differences using ANOVA, where the Type III mean square was used with year by corridor type interaction nested in site as the error term. Data were combined across years where no differences were found, and where differences were found but response directions were the same between corridor types. Where response directions were opposite between years, data for each year were reported separately. For example, if differences were found between years, but for both years, richness was higher in woody than in herbaceous corridors, data would be combined;

if richness in woody corridors were higher than in herbaceous corridors one year, but lower than in herbaceous corridors the other year, data would be reported separately. Because the four herbaceous sites contained different amounts of woody vegetation (as described earlier), species richness and abundance of birds in corridors and in fields (and for neotropical migrants in corridors) were also compared among three corridor types: the eight woody corridors (W), the two herbaceous corridors with some woody vegetation (Hw), and the two herbaceous corridors with very little woody vegetation (Hh). Using Fisher's protected least significant difference, the Type III mean square was used with corridor type nested within site as the error term. In addition to mean species richness, the total number of species observed during each census period was also reported.

Given a non-normal distribution of the data, a signed-rank test was also used to ensure that results from the ANOVA were accurate. Because overall results using the signed-rank test did not differ from those of the ANOVA, the latter was used.

Additionally, mean species richness and abundance of birds using fields at each of four 50-m distance intervals out from the edge, were compared between fields adjacent to either woody versus herbaceous corridors. The Type III mean square was used with corridor type nested within site as the error term. These data were not combined across years because sample size was too low to test for interactions. Birds were also evaluated in relation to their habitat classification (Johnsgard, 1979; Peterson, 1980; DeGraaf *et al.*, 1991), foraging guild classification (DeGraaf, 1985), and their use of woody or herbaceous sites. Habitat classifications given by Johnsgard (1979) were used for all species except the Lincoln's sparrow, which was assigned a habitat classification based on DeGraaf *et al.* (1991) and Peterson (1980). Because bird data in fields and during certain seasons in corridors were sparse, statistical significance for ANOVA tests was set at $P \leq 0.10$.

Although numbers were too low for statistical testing, several species were evaluated individually for various reasons. These included: the downy and hairy woodpeckers because they have been found to feed on corn borer larvae in corn fields during fall, winter, and spring (Frye, 1972); the brown-headed cowbird because it is known to potentially reduce other bird species' reproductive success (Terborgh, 1989); raptors because they are attracted by woody vegetation and may cause increased predation of grassland birds and their nests (Gates and Gysel, 1978); and game birds because they are important to hunters as a food and sporting resource.

Spearman rank correlation analyses were used to evaluate any associations between bird parameters (species richness and abundance) and vegetation parameters (Appendix C) of woody and herbaceous corridors. The two corridor types (woody and herbaceous) were analyzed separately because gaps in most of the vegetation parameter values between woody and herbaceous sites pre-empted the representation of a continuum from no woody vegetation to all woody vegetation. Spearman rank correlation analyses were also used to evaluate associations between vegetation and species richness of birds associated with woodland, grassland, limnetic, and miscellaneous habitats. For this analysis, birds were grouped by habitat classification (Johnsgard, 1979; Peterson, 1980; DeGraaf *et al.*, 1991), and the two corridor types were analyzed together. Woody and herbaceous corridors were not separated because corridor type was the basis of at least two of the habitat associations (woodland and grassland). Because vegetation sampling was conducted during summer, analyses with summer bird data used all vegetation parameters, whereas analyses with spring bird data used only vegetation parameters remaining constant throughout the year. Statistical significance for correlation analyses was set at $P \leq 0.05$.

RESULTS

During this study, 70 bird species were observed, of which 36% were neotropical migrants, 48% were short distance migrants, and 16% were permanent resident species (Table 3; migrant status given in Appendix A). Sixty-five species were seen in corridors and 42 were seen in adjacent crop fields. Downy or hairy woodpeckers were common in woody corridors during all seasons and in herbaceous (Hw) corridors during winter and spring (Table 4). Also common in herbaceous corridors were dickcissels and red-winged blackbirds during spring and summer, and barn swallows during late summer and fall. The dickcissel occurred only in herbaceous corridors and was the only grassland neotropical migrant species observed in either type of corridor.

Birds Using Corridors

Mean bird species richness in woody corridors was higher than in herbaceous corridors during spring, summer, fall, and winter ($P \leq 0.06$) but did not differ for late summer ($P = 0.13$). Mean bird abundance did not differ between woody and herbaceous corridors in any census period ($P \geq 0.13$) (Table 5a). Comparisons of the three corridor types (W, Hw, and Hh) showed differences ($P \leq 0.09$) in richness during all census periods except summer. Higher values in W than in Hw corridors, and higher values in Hw than in Hh corridors was a trend that occurred for richness during all census periods, and for abundance during all census periods except summer and late summer (Table 5b).

During spring, more neotropical migrant species ($P = 0.004$) and individuals ($P = 0.02$) were observed in woody corridors than in herbaceous, but during summer, neither richness nor abundance differed between woody and herbaceous corridors ($P \geq 0.17$) (Table 6a). After testing among the three corridor types, species richness was higher during spring in W than Hw corridors ($P = 0.02$), and in W than Hh ($P = 0.005$) but was not higher in Hw than Hh corridors ($P = 0.66$). No differences were found during summers (Table 6b). Of the 21 neotropical migrant species observed in corridors, 20 used the corridors as stopover habitat during spring or fall migration, and 18 used the corridors during summer (Appendix A).

Birds Using Fields

In crop fields, species richness and abundance differed between woody and herbaceous sites only during summer 1993 when fields adjacent to herbaceous corridors had more bird species ($P = 0.06$) and more birds ($P = 0.006$) than did fields adjacent to woody corridors (Table 7a). After testing among Hh, Hw, and W sites, species richness and abundance were found to be similar ($P \geq 0.14$) for all census periods except during summer, 1993, when abundance was greater at Hh ($P = 0.03$) and Hw ($P = 0.06$) than W sites (Table 7b). During winter, only five species were observed in crop fields (American tree sparrow, horned lark, downy woodpecker, blue jay, and dark-eyed junco). Only one bird was observed (twice) in one of the grassed waterways within a field transect. Although the grassed waterway may have influenced this bird's presence in the field, its influence was not certain enough to remove these observations from the analysis.

Analysis of variance tests comparing each 50-meter distance interval between fields adjacent to either woody or herbaceous corridors showed few differences in bird species richness and abundance. During summer, 1993, both species richness and abundance were higher in fields adjacent to herbaceous corridors at 0-50 m ($P \leq 0.04$) and at 50-100 m ($P \leq 0.02$) than at the corresponding distances in fields adjacent to woody corridors (Tables 8 and 9). The number of species and birds using each interval adjacent to herbaceous corridors appeared to decrease with increasing distance from the corridor, whereas the number of species and birds using each interval adjacent to woody corridors appeared to either remain similar among intervals, or vary from one to another with no obvious trend.

Birds using crop fields were separated into four groups based on their habitat classifications (Johnsgard, 1979; Peterson, 1980; DeGraaf *et al.*, 1991) and foraging guild classifications (DeGraaf *et al.*, 1985). Most of the woodland species (of several foraging guilds) tended to use small areas within 25 m of woody corridors, although the American robin, song sparrow, and eastern kingbird tended to use larger areas up to 200 m from woody corridors (Table 10; Figure 1,Graph A). Grassland ground feeders tended to avoid field areas near woody vegetation (Table 11; Figure 1, Graph B). The killdeer and red-winged blackbird (limnetic ground feeders) and swallows (miscellaneous air screeners) tended to be located up to 200 m away from both woody and herbaceous riparian corridors (Table 12; Figure 1, Graph C). These field-use patterns were also apparent within each of the three census periods, before combining summer 1992, spring 1993, and summer 1993 data. The presence of five woodland species in fields adjacent to herbaceous corridors may have been related to nearby woody vegetation. The brown-headed cowbird and gray catbird were seen in woody vegetation within herbaceous corridors, which may have led to their use of the adjacent fields. The single sighting of a red-headed woodpecker in a field adjacent to a herbaceous corridor was followed by its flight from the field directly to a wooded area about 1000 m away. As mentioned above, the eastern kingbird tended to fly large distances (compared to most other birds) into fields from woody vegetation. And the mourning dove was observed to fly large distances (1000 m) between stands of woody vegetation, which may have led to its use of fields located adjacent to herbaceous corridors.

All species observed to make one or more trips between corridor and field were either ground or air feeders (DeGraaf *et al.*, 1985), except the common yellowthroat, indigo bunting, and northern oriole, which were lower or upper canopy feeders and were observed making trips only at woody sites (Table 13). Twenty percent of the birds observed making trips at woody sites were brown thrashers. Sixty-five percent of the birds making trips at Hw sites were red-winged blackbirds and 17% were brown-headed cowbirds. At Hh sites, 69% were red-winged blackbirds and 27% were dickcissels.

Although numbers were too low for statistical testing, mean bird species richness in fields appeared to be highest in corn fields adjacent to herbaceous corridors, whereas mean bird abundance appeared to be highest in grain sorghum fields adjacent to woody corridors (Table 14). Dickcissels and red-winged blackbirds were common in fields adjacent to herbaceous corridors during summer. These two species accounted for 54% of the birds observed in soybean fields and 31% of the species in corn fields adjacent to herbaceous corridors (Table 15).

Birds and Vegetation

During spring 1993, bird species richness in herbaceous corridors was positively associated with tree density ($P = 0.0001$) and the number of tree species ($P = 0.0001$), and bird abundance in woody corridors was negatively associated with basal area ($P = 0.01$) (Table 16). During summer, bird species richness in woody corridors was positively associated with water volume of the stream ($P = 0.001$) and tree species richness ($P = 0.03$), and negatively associated with shrub density ($P = 0.02$) (Table 17).

Considering birds by habitat classification, species richness of woodland birds during both spring ($P = 0.002$) and summer ($P = 0.0001$) was positively associated with tree species richness, and during summer was positively associated with litter ($P = 0.01$) (Tables 18 and 19). Species richness of grassland birds during both spring and summer was negatively associated with tree density ($P \leq 0.05$) and tree species richness ($P \leq 0.05$). During summer, grassland bird species richness was also negatively associated with shrub density ($P = 0.01$), snag density ($P = 0.01$), and percent litter ($P = 0.01$), and positively associated with water volume ($P = 0.04$), ground cover ($P = 0.03$), and grass/sedge ($P = 0.05$). Species richness of limnetic birds was negatively associated with snag density during both spring ($P = 0.002$) and summer ($P = 0.02$), and during summer was negatively associated with percent litter ($P = 0.03$), canopy height ($P = 0.04$), and basal area ($P = 0.03$). The number of openings ($P \leq 0.02$) and the total area of openings ($P \leq 0.05$) were important for species richness of limnetic birds during both spring and summer. Species richness of miscellaneous birds (belted kingfisher and swallows) during spring was negatively associated with tree density ($P = 0.02$), shrub density ($P = 0.04$), and surrounding woody vegetation ($P = 0.03$), and during summer was positively associated with water volume of the stream ($P = 0.01$).

Individual Species

Based on the limited sample size, downy or hairy woodpeckers appeared to be more abundant in woody than herbaceous corridors and were observed only in corn fields adjacent to woody corridors (Table 20). Brown-headed cowbirds appeared to be more abundant in herbaceous corridors and adjacent fields (especially grain sorghum fields) than in woody corridors and adjacent fields (Table 21). Few raptors were seen at these study sites. One red-tailed hawk was observed in a woody corridor during fall 1993, and one great-horned owl was observed during winter 1993 at a woody site, and twice at this same site during winter 1994. Northern bobwhites, ring-necked pheasants, and wild turkeys occurred in corridors most often during summer, but were seldom seen during any other season (Table 22).

DISCUSSION

Riparian corridors in agricultural areas of the Great Plains provide habitat for birds and other wildlife (Stauffer and Best, 1980; Tubbs, 1980), and might thus act as effective components of sustainable agricultural systems, in which birds and other animals contribute to the reduction of crop insect pests. However, the effect of these corridors on birds within the agricultural system is largely unstudied. In this study, the type of vegetation in riparian corridors appeared to affect bird species richness but not abundance within the corridor, and appeared not to affect species richness or abundance of birds in adjacent crop fields. However, the lack of difference in crop fields and the lack of difference in abundance between woody and herbaceous corridors may have occurred, in part, because of the preponderance of woody vegetation throughout the general study area (further discussed below).

Effect of Corridor Vegetation on Birds Using Corridors

Results from analyses of variance tests between woody and herbaceous corridors indicated that woody corridors attract a higher variety of bird species, but not necessarily higher numbers of birds because of flocking tendencies of some species at herbaceous sites. At herbaceous sites, large numbers of red-winged blackbirds were present during spring and summer, many barn swallows during late summer, and many American tree sparrows and dark-eyed juncos during winter. The overall pattern found in bird species richness and abundance in W, Hw, and Hh corridors suggests that increased structural diversity within the vegetation creates more niches for more species and more birds (MacArthur and MacArthur, 1961). Furthermore, the correlations between bird species richnes in herbaceous corridors (having differing amounts of woody vegetation) and both tree density and tree species richness supports the idea that bird species richness increases with increased structural diversity. This association was found during spring, but not summer, possibly indicating that a diversity of woody vegetation might more suitably supply the needs of a variety of bird species that migrate through the area.

Although the more isolated, smaller trees in herbaceous corridors may be useful to some migrants, the larger amounts of woody vegetation in woody corridors were found to be important as stopover habitat to more neotropical migrants. However, this study did not address the suitability of these corridors as nesting habitat. Habitat suitability is of much concern because of possible increased predation and the potential effects of the brown-headed cowbird on area-sensitive species or some of the less common edge species, such as the indigo bunting. These habitats could be population sinks for some species, especially for those not adapted to the behaviors of the prevalent cowbird.

Suitable habitat for grassland species is also a topic of concern because many such species have been reported as declining significantly (Knopf, 1994). Of Johnsgard's (1972) 36 species associated with grasslands, four (dickcissel, horned lark, eastern/western meadowlark, and savannah sparrow) were seen in herbaceous corridors during the breeding season. Only one of these, the dickcissel, was seen regularly and with a mate. Although not all 36 of these grassland species would be expected to occur at the sites in this study, narrow herbaceous stream corridors appear not to provide proper breeding habitat for many grassland species. Herkert (1994) found that the dickcissel was the only species not significantly associated with habitat area or vegetation structure in a study that encompassed 19 species on grassland fragments in Illinois. This may explain the dickcissel's use of relatively narrow corridors in this study, as well as its use of both Hw and Hh sites. This species' breeding success at these sites, however, is unknown. As for species that might have been expected at the herbaceous sites but were not observed (such as grasshopper and vesper sparrows), vegetation structure and/or habitat area might have been factors limiting their use of these sites (Herkert, 1994).

Little of the research on birds reported in the literature is conducted during fall or winter because few birds are present at that time compared to spring or summer. However, for sustainable agricultural purposes, the birds present during fall and winter may be important, because they may consume crop pests that overwinter in fields or adjacent edges. More bird species were observed in woody than in herbaceous corridors during fall and winter, probably because of the cover and additional food resources offered by the woody vegetation.

During spring, the negative association between basal area and bird abundance in the woody corridors might have been partially influenced by somewhat biased data at one of the woody sites. Two of the woody corridors with high values for basal area were older and much wider than the others. One of these corridors was situated in a north-south direction with the transect running along the west side. I observed many birds on the east side of this corridor (possibly attracted there by morning sun) that were not recorded from the west side because of the large width of the corridor. Thus, data at this site (which had high basal area) may have been biased toward lower numbers of species and birds. Morning sunlight was not an issue at the other older and wider woody corridor, as its curving shape was situated in an east-west direction, and the sun regularly shone on the corridor transect. I would, however, have expected higher richness and abundance than was found, given the age and width of this stream system, but the reason for its paucity of birds is unknown.

For summer, the positive correlation between water volume and species richness may have been caused by the additional niche available. For example, ducks and belted kingfishers, which require fairly deep water for feeding, were observed only at sites with the deepest water.

Despite how they used the water, birds may have been attracted to streams with more water volume simply because the water was more visible there.

Effect of Corridor Vegetation on Birds Grouped by Habitat Classification

During the breeding season, tree density and the number of tree species seem to be important for species richness of woodland birds, but may detract from species richness of grassland birds. Correlations between stream water volume and both grassland and miscellaneous (belted kingfisher and swallows) birds may reflect Gray's (1993) finding that aquatic insect emergence and insectivorous bird densities varied directly with the hydrograph (water level over time) of the stream in riparian habitats of the tallgrass prairie in Kansas. During summer, the negative associations between litter and both woodland and grassland species richness probably has no biological basis, except for the indirect relationship between many trees creating more litter in woody corridors.

Limnetic species during spring and summer mainly consisted of common yellowthroats and red-winged blackbirds at woody and herbaceous corridors. The positive correlations between limnetic species and both the number and total area of openings in the woody vegetation reflects the more open type of habitat of these two species. The negative correlations between limnetic species and snag density, litter, canopy height, and basal area during summer seem to have no clear biological basis. Correlations between richness of miscellaneous birds and tree density, shrub density, and surrounding woody vegetation (during spring) are also unclear.

Effect of Corridor Vegetation on Birds Using Fields

Results from analysis of variance tests between fields adjacent to woody and herbaceous corridors indicated that corridor vegetation (woody vs. herbaceous) did not affect the number of birds or species in adjacent crop fields in any season, except summer, 1993. During summer 1993, many red-winged blackbirds and four species normally associated with woodlands (Johnsgard, 1973) were present in fields adjacent to herbaceous corridors, contributing to the higher richness and abundance in those fields. Red-winged blackbirds used adjacent crop fields frequently and tended to occur in larger numbers at herbaceous sites than at woody sites. For instance, an average of 6.1 red-winged blackbirds/ha/visit were observed per herbaceous corridor, whereas an average of 1.0 red-winged blackbirds/ha/visit were observed per woody corridor. Red-winged blackbirds may have been more numerous in summer 1993 than other seasons because of the unusually high amount of rainfall the study area received during that period. The brown-headed cowbird, red-headed woodpecker, eastern kingbird, and mourning dove were the woodland species that accounted for 36% of the species and 19% of the birds in fields adjacent to herbaceous corridors. This apparent influence of nearby woody vegetation is similar to Holmquist's (1991) finding that the most important variable affecting bird species richness within riparian corridors in grazed pastures was the amount of wildlife cover within 0.5 km. Overall, corridor vegetation did not affect the number of birds or species in adjacent crop fields. However, species composition within such fields did differ, which may have different implications for different crop types and pests. These results are similar to those found in corn fields and adjacent edge types in Iowa and Illinois (Best *et al.*, 1990). It appears that species composition differs in fields adjacent to woody and herbaceous corridors, and that bird species richness and abundance in fields can be influenced by woody vegetation in the surrounding area.

Bird use of fields during winter was very low. Tree sparrows, blue jays, dark-eyed juncos, and horned larks were observed in fields, possibly gleaning the fields for waste grain. Downy or hairy woodpeckers observed searching the corn stalks were possibly looking for corn borer larvae (Frye, 1972). The European corn borer is a common pest of corn in east-central

Nebraska (Witkowski and Peters, 1986). As we learn more about the corn borer and its woodpecker predators, we might discover an effective and sustainable means of reducing this pest. The two woodpeckers observed in fields were foraging in corn stubble adjacent to woody corridors. Wall and Whitcomb's study in Arkansas (1964) showed that more woodpeckers foraged in fields near woody vegetation than in fields farther away from a wooded area. Barber (1925) attributed feeding on corn borer larvae in standing corn stalks to woodpeckers, whereas he attributed feeding on larvae in stalks that lay on the ground to other birds. But one of the woodpeckers I observed was foraging in corn stubble laying flat on the ground (the field had been disced). This indicates that woodpeckers might forage for corn borer larvae in downed as well as in standing corn stalks. Future research might entail attempts to attract as many of these birds as possible to wooded areas next to corn fields during fall, winter, and early spring.

MANAGEMENT IMPLICATIONS

This study focused on woody riparian corridors because woody vegetation in cropland provides several agricultural benefits to farmers, and because it provides habitat for many wildlife species, implying greater potential for predation on crop pests by natural enemies. However, woody edges adjacent to grassland habitats can be detrimental to grassland birds, some of which are in decline. Thus, the best type of edge (woody vs. herbaceous) may be determined, in part, by its location in relation to adjacent or nearby habitats. Those who make decisions regarding both future research and final management activities should consider the effects of woody vegetation on a landscape-scale basis and with natural resource conservation in mind.

Woody riparian corridors appear to be important for neotropical migrants as stopover habitat during spring migration. The additional niches and variety of tree species in woody corridors may provide the range of cover and food sources needed for several different neotropical migrant species.

More bird species were found during spring and summer in woody corridors, but herbaceous corridors provided habitat for the dickcissel, a species not found in woody corridors. Similarly, fields adjacent to herbaceous corridors contained a different composition of bird species than fields adjacent to woody corridors. This different composition of species may also be beneficial in reducing certain crop pests. If dickcissels nest in herbaceous corridors, as my observations potentially indicated, these birds may rely on certain crop insect pests to feed their young.

Bird use of fields appeared to differ according to a bird's habitat classification and in some cases, foraging guild classification. Assuming they consume crop pests, woodland birds may impact pest populations most heavily in fields nearest to woody corridors, grassland ground-feeding birds may consume the most pests in fields nearest to herbaceous corridors and farthest from woody corridors, and red-winged blackbirds, killdeer (both ground feeders), and swallows (air screeners) may impact pests throughout fields, regardless of corridor type. Also, brown thrashers and American robins (both ground feeders) may have additional impacts on pests in fields near woody corridors, because they were observed making the most trips between woody corridors and adjacent fields. Adjacent to herbaceous corridors, dickcissels, brown-headed cowbirds, and red-winged blackbirds (all ground feeders) made the most trips between corridor and field.

PROJECT CONCLUSIONS AND OVERVIEW

Landowners frequently clear riparian corridors of all trees to gain more crop area, but these trees may be beneficial to the landowner as well as to society. Woody vegetation in cropland can reduce soil erosion, protect crops from wind damage, prevent water loss from crops, improve water quality, provide wildlife habitat, increase biological diversity, carbon dioxide fixation, energy efficiency, preparedness for climate change, and be aesthetically valuable (Rietveld 1991). My study found that woody riparian corridors are also beneficial for attracting higher species richness of birds than herbaceous riparian corridors, and that many of the species in woody corridors also use the adjacent crop fields. However, in this study, at least one species (dickcissel) occurred in herbaceous corridors and adjacent fields that did not occur in woody corridors and adjacent fields. Without knowing what crop pests each of these species might consume, we cannot know which corridor type is best for optimal crop pest reduction by bird predation. More definitive results are needed regarding the food choices of various bird species within woody or herbaceous corridors adjacent to a particular crop type.

Much can be learned from a research project regarding the food choices of various bird species under specific situations. I would recommend studying woody and herbaceous corridors adjacent to fields of a particular crop type known to harbor a particular crop pest. A study during spring and summer could determine what food items birds are feeding their nestlings (perhaps by placing a camera at the nest). Regular scouting for estimates of the pest population could be correlated with the number of pests being consumed by birds over time. Such a project would be labor-intensive, but just one of these studies in each important crop type would yield much information about specific bird predators of specific crop pests.

My study showed that grassland, woodland, limnetic, and miscellaneous species tended to use different distances away from woody or herbaceous corridors in crop fields, and that ground and air feeders may use fields more often than canopy feeders. Combining this information with knowledge that certain bird species consume particular crop pests would be a considerable step towards understanding the role of birds in sustainable agriculture. Through habitat manipulations, particular bird species might be attracted to given areas of the field in numbers large enough to alter pest populations. In any remaining parts of the field, other means might be employed to maintain pest populations below outbreak levels. Another possibility would be to conduct habitat manipulations that would attract the optimum complex of bird species to decrease the pest in the largest area of the field possible.

Attracting bats to an agricultural area is another important research project that may lead to pest reductions by mammalian predators. Whitaker (1972) determined that big brown bats in Indiana consumed several crop insect pests and may have consumed large numbers of cucumber beetles (larva of which is the corn rootworm) because the beetles were congregating at lights. In their attempts to reduce pesticide levels, Tony and Betty Koch reportedly attracted several hundred little brown bats and many birds to their farm in Oregon, reducing pesticide applications from 13 to two per year (Murphy, 1993). If bats are not currently present in agricultural areas of the Great Plains, it might be possible to attract them to areas within flying distance of water, by mounting bat houses on buildings or bat shelters on trees, and using lights to attract crop pests in large numbers.

Just as research has found that certain bat species consume several crop pests, we may find that woodland birds consume certain pests, and grassland birds consume others. Like grassland birds, many bat species are declining, and regardless of pest consumption, bat species and both grassland and woodland birds are important to maintain. Landowners of a community or region might coordinate planting schemes and types of field border vegetation to optimize both sustainable agriculture and natural resource conservation. By conserving our natural resources and reducing pesticide levels in farming operations, we can create a healthier, more enjoyable environment within the Great Plains and throughout the world.

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Table 1. *Length and area of transects used to census birds in riparian corridors with woody (W1 - W8) or herbaceous (H1 - H4) vegetation and in adjacent crop fields, Nebraska.*

Site	Corridor transect			Field transect 1		Field transect 2	
	Length (m)	Width (m)	Area (ha)	Length (m)	Area (ha)	Length (m)	Area (ha)
W1	400	25	1.0	100	1.0	150[a]	1.25
W2	400	25	1.0	100[b]	0.75	150	1.5
W3	300	25	0.75	150	1.5	175	1.75
W4	400	25	1.0	150	1.5	75	0.75
W5	300	25	0.75	100[c]	0.875	100	1.0
W6	400	25	1.0	200	2.0	200	2.0
W7	400	20	0.8	150[d]	1.375	125	1.25
W8	400	25	1.0	200	2.0	200	2.0
H1	400	25	1.0	200	2.0	125	1.25
H2	400	17	0.68	200	2.0	200	2.0
H3	400	14	0.56	200	2.0	200	2.0
H4	400	25	1.0	125	1.25	125	1.25

[a] One side of the transect from 100 to 150 m was excluded from census because of nearby woody vegetation
[b] One side of the transect from 50 to 100 m was excluded from census because of nearby woody vegetation
[c] One side of the transect from 75 to 100 m was excluded from census because of nearby woody vegetation
[d] One side of the transect from 125 to 150 m was excluded from census because of nearby woody vegetation

Table 2. Census dates and number of visits per site for census periods in woody (W1-W8) and herbaceous (H1-H4) riparian corridors and adjacent crop fields Nebraska.

		Number of visits per site[a]											
Census period	Census dates	W1	W2	W3	W4	W5	W6	W7	W8	H1	H2	H3	H4
Spring, 1993	3 - 25 May	3	3	3	3	3	3	3	3	3	3	3	3
Summer, 1992	5 June - 6 August	4	4	4	4	3	4	3	2	4	3	1	2
Summer, 1993	26 May - 29 June	3	3	3	3	4	3	4	3	3	4	3	3
Late summer, 1993[b]	16 August - 10 September	3	3	3	3	3	3	3	3	3	3	3	3
Fall, 1992[b]	11 October - 8 November	2	2	2	2	2	2	2	2	2	2	2	2
Fall, 1993[b]	30 September - 21 October	3	3	3	3	3	3	3	3	3	3	3	3
Winter, 1993	14 January - 20 February	3	3	3	3	3	3	3	3	3	3	3	3
Winter, 1994	5 January - 5 February	3	3	3	3	3	3	3	3	3	3	3	3

[a] Number of visits per site varied due to sequence of site selection and weather conditions

[b] Crop fields were not censused because crops were too tall for counting birds or too dense to traverse

Table 3. Number and percent of bird species in three migrant categories observed at sites with a woody or herbaceous riparian corridor and an adjacent cropfield, 1992 to 1994, Nebraska.

Migrant status[a]	All sites	Woody sites	Herbaceous sites
Neotropical migrants	25 (36%)	23 (35%)	12 (32%)
Short-distance migrants	34 (48%)	31 (48%)	21 (55%)
Permanent residents	11 (16%)	11 (17%)	5 (13%)
	—	—	—
Total number of species	70	65	38

[a]Peterjohn and Sauer, 1993

Table 4. Most common bird species observed in riparian corridors with woody and herbaceous vegetation, listed in order of their observed abundance and including all species with ≥ 1.0 birds/ha, 1992 to 1994, Nebraska.

	Spring	Summer	Late summer	Fall	Winter
Woody	House wren	Downy/hairy woodpecker	American robin	Downy/hairy woodpecker	European starling
	Downy/hairy woodpecker[a]	House wren	Downy/hairy woodpecker	Lincoln's sparrow	Dark-eyed junco
	Blue jay			Dark-eyed junco	Downy/hairy woodpecker
	Empidonax flycatcher				Blk-capped chickadee
	Red-winged blackbird				American tree sparrow
	Gray catbird				
	American goldfinch				
Herbaceous	Red-winged blackbird	Red-winged blackbird	Barn swallow	Barn swallow	American tree sparrow
	Dickcissel	Dickcissel			Dark-eyed junco
	Downy/hairy woodpecker				Downy/hairy woodpecker

[a]Downy and hairy woodpeckers could not consistently be distinguished from each other under field conditions in this study

Table 5a. Bird species richness [$\bar{x}$/site and (totals)] and abundance ($\bar{x}$/ha) in riparian corridors with woody or herbaceous vegetation, 1992 to 1994, Nebraska.

Season[a]	Species richness			Abundance		
(No. years censused)	Woody ($n = 8$)	Herbaceous ($n = 4$)	P-value[b]	Woody ($n = 8$)	Herbaceous ($n = 4$)	P-value[b]
Spring (1)	10.29 (37)	5.00 (19)	0.0054*	24.08	17.10	0.1780
Summer (2)	8.48 (44)	4.52 (22)	0.0595*	16.73	14.00	0.5240
Late Summer (1)	4.50 (23)	2.42 (12)	0.1345	9.12	8.32	0.8096
Fall (2)	3.80 (29)	1.80 (12)	0.0362*	12.65	7.95	0.1640
Winter (2)	2.06 (20)	0.75 (7)	0.0246*	8.11	3.23	0.1252

[a]Table 1 has dates and number of visits per site for each census period

[b]ANOVA compared woody versus herbaceous corridors (*$P \leq 0.10$)

Table 5b. Bird species richness [$\bar{x}$/site and (totals)] and abundance ($\bar{x}$/ha) in riparian corridors with woody (W), herbaceous-woody (Hw), or herbaceous-herbaceous (Hh) vegetation, 1992 to 1994, Nebraska.

	Species richness				Abundance			
Season[a]	W	Hw	Hh		W	Hw	Hh	
(No. years censused)	($n = 8$)	($n = 2$)	($n = 2$)	P-value[b]	($n = 8$)	($n = 2$)	(n=2)	P-value[b]
Spring (1)	10.29A (37)	7.00B (17)	3.00C (8)	0.0065*	24.08	18.00	16.19	0.4143
Summer (2)	8.48 (44)	5.66 (20)	3.38 (10)	0.1520	16.73	13.61	14.38	0.8176
Late Summer (1)	4.50A (23)	4.17A (10)	0.67B (4)	0.0788*	9.12	11.33	5.30	0.5210
Fall (2)	3.80A (29)	2.40AB (9)	1.20B (6)	0.0870*	12.65	9.70	6.21	0.3227
Winter (2)	2.06A (20)	1.17AB (6)	0.33B (2)	0.0559*	8.11	5.00	1.46	0.2551

[a]Table 1 has dates and number of visits per site for each census period

[b]ANOVA compared W, Hw, and Hh corridors (*$P \leq 0.10$); means followed by the same letter are not different at $P \leq 0.10$ (Fisher's Protected LSD)

Table 6a. Neotropical migrant species richness ($\bar{x}$/site) and abundance ($\bar{x}$/ha) in riparian corridors with woody or herbaceous vegetation, 1992 to 1993, Nebraska.

Season[a] (No. years censused)	Species richness: Woody ($n = 8$)	Species richness: Herbaceous ($n = 4$)	Species richness: *P*-value[b]	Abundance: Woody ($n = 8$)	Abundance: Herbaceous ($n = 4$)	Abundance: *P*-value[b]
Spring (1)	4.96	1.67	0.0039*	10.01	2.92	0.0157*
	(19)	(6)				
Summer (2)	3.84	2.13	0.1707	6.86	4.70	0.3614
	(18)	(7)				

[a]Table 1 has dates and number of visits per site for each census period

[b]ANOVA compared woody versus herbaceous corridors ($*P \leq 0.10$)

Table 6b. Neotropical migrant species richness [$\bar{x}$/site and (totals)] and abundance ($\bar{x}$/ha) in riparian corridors with woody (W), herbaceous-woody (Hw), or herbaceous-herbaceous (Hh) vegetation, 1992 to 1993, Nebraska.

		Species richness				Abundance			
Season[a]		W ($n = 8$)	Hw ($n = 2$)	Hh ($n = 2$)	*P*-value[b]	W ($n = 8$)	Hw ($n = 2$)	Hh (n=2)	*P*-value[b]
Spring		4.96A	2.00B	1.33B	0.0179*	10.01A	2.50B	3.34B	0.0551*
		(19)	(6)	(3)					
Summer	1992	3.38	2.63	2.67	0.8640	1.63	1.03	1.13	0.7219
		(10)	(5)	(4)					
	1993	4.32	2.00	1.71	0.1966	1.77	0.79	0.83	0.3378
		(17)	(7)	(4)					

[a]Table 1 has dates and number of visits per site for each census period

[b]ANOVA compared W, Hw, and Hh corridors ($*P \leq 0.10$); means followed by the same letter are not different at $P \leq 0.10$ (Fisher's protected LSD)

Table 7a. *Bird species richness [$\bar{x}$/site and (totals)] and abundance ($\bar{x}$/ha) in crop fields adjacent to riparian corridors with woody or herbaceous vegetation, 1992 to 1994, Nebraska.*

		Species richness			Abundance		
Season[a]		Woody ($n = 8$)	Herbaceous ($n = 4$)	*P*-value[b]	Woody ($n = 8$)	Herbaceous ($n = 4$)	*P*-value[b]
Spring		1.67 (19)	2.00 (13)	0.6447	1.08	1.10	0.9573
Summer[c]	1992	0.85 (16)	1.02 (6)	0.5582	0.53	0.48	0.8007
	1993	0.95 (13)	1.75 (11)	0.0646*	0.42	1.04	0.0055*
Winter		0.15 (3)	0.17 (2)	0.8704	0.24	0.18	0.8413

[a]Table 1. has dates and number of visits per site for each census period

[b]ANOVA compared crop fields adjacent to woody versus herbaceous corridors (*$P \leq 0.10$)

[c]Years were not combined because interactions were detected for abundance between corridor type and year

Table 7b. *Bird species richness ($\bar{x}$/site) and abundance ($\bar{x}$/ha) in crop fields adjacent to riparian corridors with woody (W), herbaceous-woody (Hw), or herbaceous-herbaceous (Hh) vegetation, 1992 to 1994, Nebraska.*

		Species richness				Abundance			
		W	Hw	Hh		W	Hw	Hh	
Season[a]		($n = 8$)	($n = 2$)	($n = 2$)	*P*-value[b]	($n = 8$)	($n = 2$)	($n = 2$)	*P*-value[b]
Spring		1.67	2.33	1.67	0.7743	1.08	1.45	0.75	0.6414
		(19)	(10)	(7)					
Summer[c]	1992	0.85	0.88	1.17	0.7676	0.53	0.47	0.50	0.9590
		(16)	(4)	(4)					
	1993	0.95	1.50	2.00	0.1400	0.42A	1.01B	1.06B	0.0253*
		(13)	(6)	(10)					
Winter		0.15	0.08	0.25	0.7220	0.24	0.10	0.25	0.9410
		(3)	(1)	(2)					

[a]Table 1 has dates and number of visits per site for each census period

[b]ANOVA compared crop fields adjacent to W, Hw, and Hh corridors (*$P \leq 0.10$); means followed by the same letter are not different at $P \leq 0.10$

[c]Years were not combined because interactions were detected for abundance between corridor type and year

Table 8. Bird species richness ($\bar{x}$/site) at 50-meter intervals in crop fields adjacent to riparian corridors with woody or herbaceous vegetation, 1992 to 1994, Nebraska.

		Corridor	Distance from corridor (m)			
Season[a]		type	0-50	50-100	100-150	150-200
Spring		Woody	0.92	0.38	0.48	0.44
		Herbaceous	1.08	0.50	0.42	0.22
		P-value[b]	0.7644	0.5865	0.8609	0.5185
Summer	1992	Woody	0.54	0.19	0.04	0.25
		Herbaceous	0.67	0.52	0.21	0.19
		P-value[b]	0.5353	0.0840*	0.1547	0.7685
	1993	Woody	0.38	0.17	0.37	0.67
		Herbaceous	1.04	0.54	0.33	0.33
		P-value[b]	0.0362*	0.0052*	0.9046	0.6157
Winter	1993	Woody	0.02	0.02	0	0
		Herbaceous	0.08	0	0.04	0
		P-value[b]	0.1877	0.5059	0.2004	----
	1994	Woody	0.02	0.02	0.10	0
		Herbaceous	0	0.04	0	0.06
		P-value[b]	0.5059	0.6236	0.2821	0.3739

[a]Table 1 has dates and number of visits per site for each census period

[b]ANOVA compared 50-m intervals in crop fields adjacent to woody versus herbaceous corridors ($*P \leq 0.10$)

Table 9. Bird abundance ($\bar{x}$/ha) at 50-meter intervals in crop fields adjacent to riparian corridors with woody or herbaceous vegetation, 1992 to 1994, Nebraska.

Season[a]		Corridor type	Distance from corridor (m) 0-50	50-100	100-150	150-200
Spring		Woody	1.46	0.46	1.04	1.11
		Herbaceous	2.00	0.38	0.92	0.22
		P-value[b]	0.5269	0.7785	0.8558	0.2116
Summer	1992	Woody	0.92	0.23	0.07	1.42
		Herbacous	0.81	0.26	0.33	0.28
		P-value[b]	0.8047	0.8950	0.2415	0.5152
	1993	Woody	0.38	0.12	0.62	1.22
		Herbacous	1.67	0.52	0.54	0.50
		P-value[b]	0.0028*	0.0193*	0.8418	0.4442
Winter	1993	Woody	0.02	0.02	0	0
		Herbaceous	0.13	0	0.17	0
		P-value[b]	0.1209	0.5059	0.2004	----
	1994	Woody	0.02	0.11	0.52	0
		Herbaceous	0	0.19	0	0.06
		P-value[b]	0.5059	0.7336	0.4323	0.3739

[a]Table 1 has dates and number of visits per site for each census period

[b]ANOVA compared 50-m intervals in crop fields adjacent to woody versus herbaceous corridors (*$P \leq 0.10$)

Table 10. Numbers of woodland[a] birds ($\bar{x}$/100 ha) in crop fields at various distances from riparian corridors with woody or herbaceous ( )[b] vegetation, summer 1992 and spring and summer 1993[c], Nebraska.

Species (foraging guild[d])	Distance from corridor (m)							
	0-25	25-50	50-75	75-100	100-125	125-150	150-175	175-200
Brown-headed cowbird (G)	3 (6)	0 (0)	0 (0)	0 (0)	0 (0)	0 (36)	0 (0)	0 (0)
Northern bobwhite (G)	8 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (0)	0 (0)	0 (0)
Mourning dove (G)	5 (6)	0 (12)	0 (0)	0 (6)	0 (0)	0 (0)	0 (0)	0 (0)
Lincoln's sparrow[e] (G)	5 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Common grackle[e] (G)	0 (0)	3 (0)	0 (0)	0 (0)	4 (0)	0 (0)	0 (0)	0 (0)
American crow[e] (G)	16 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Thrush spp.[e] (G)	3 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Wild turkey[e] (G)	8 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Brown thrasher (G, L)	19 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gray catbird (G, L)	8 (6)	0 (0)	0 (0)	3 (0)	0 (0)	0 (0)	0 (0)	0 (0)
American robin (G, L)	22 (0)	24 (0)	8 (0)	6 (0)	4 (0)	5 (0)	0 (0)	13 (0)

Table 10 *(continued).*

Species (foraging guild[d])	Distance from corridor (m)							
	0-25	25-50	50-75	75-100	100-125	125-150	150-175	175-200
Song sparrow (G, L)	0 (0)	3 (0)	0 (0)	3 (0)	0 (0)	5 (0)	10 (0)	25 (0)
American goldfinch[e] (G, L)	0 (0)	0 (0)	0 (0)	6 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Blue Jay (G, U)	11 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Red-bellied woodpecker[e] (G, B)	3 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Indigo bunting[e] (L)	3 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Northern oriole[e] (U)	3 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Red-headed woodpecker (A)	0 (6)	0 (0)	6 (0)	3 (0)	0 (0)	0 (0)	10 (0)	0 (0)
Eastern kingbird (A)	8 (0)	0 (0)	11 (0)	0 (0)	4 (6)	0 (9)	19 (9)	0 (0)
Western kingbird[e] (A)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	10 (0)	0 (0)
Empidonax flycatcher[e] (A)	5 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

[a]Woodland habitat classification (Johnsgard, 1979)

[b]Abundances of woodland birds seen in fields adjacent to herbacous corridors are given in parentheses at the appropriate distances

[c]Table 1 has dates and number of visits per site for each census period

[d]Foraging guild classification, breeding season (DeGraaf, *et al.*, 1985); G = ground, L = lower-canopy, U = upper-canopy, A = air, B = bark

[e]Species with small sample size (<3 sightings in fields adjacent to either W or H corridors)

Table 11. Numbers of grassland[a] birds ($\bar{x}$/100 ha) in crop fields at various distances from riparian corridors with woody ( )[b] or herbaceous vegetation, summer 1992 and spring and summer 1993[c], Nebraska.

Species (foraging guild[d])	Distance from corridor (m)							
	0-25	25-50	50-75	75-100	100-125	125-150	150-175	175-200
Dickcissel (ground)	18 (0)	0 (0)	0 (0)	0 (0)	6 (0)	9 (0)	9 (0)	0 (0)
Horned Lark (ground)	6 (0)	12 (0)	0 (0)	0 (0)	0 (13)	0 (10)	0 (19)	0 (38)
Meadowlark (ground)	0 (0)	18 (0)	0 (0)	12 (0)	6 (0)	0 (0)	9 (0)	0 (0)
Upland sandpiper (ground)	24 (0)	0 (0)	18 (0)	24 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lark sparrow[e] (ground)	0 (0)	0 (0)	0 (0)	0 (3)	0 (4)	0 (0)	0 (0)	0 (0)
Savannah sparrow[e] (ground)	0 (0)	6 (0)	12 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Vesper sparrow[e] (ground)	0 (0)	0 (0)	0 (0)	0 (0)	12 (0)	0 (0)	0 (0)	0 (13)

[a]Grassland habitat classification (Johnsgard, 1979)
[b]Abundances of grassland birds seen in fields adjacent to woody corridors are given in parentheses at the appropriate distances
[c]Table 1 has dates and number of visits per site for each census period
[d]Foraging guild classification, breeding season (DeGraaf, *et al.*, 1985); all species are ground feeders
[e]Species with small sample size (<3 sightings in fields adjacent to either W or H corridors)

Table 12. Numbers of limnetic and miscellaneous[a] birds ($\bar{x}$/100 ha) in crop fields at various distances from riparian corridors with woody ( )[b] or herbaceous vegetation, summer 1992 and spring and summer 1993[c], Nebraska.

Species (foraging guild[d])	Distance from corridor (m)							
	0-25	25-50	50-75	75-100	100-125	125-150	150-175	175-200
Killdeer (ground)	12 (3)	18 (3)	18 (0)	0 (0)	6 (0)	0 (0)	9 (19)	0 (0)
Red-winged blackbird (ground)	100 (3)	12 (5)	18 (0)	12 (0)	6 (4)	0 (5)	36 (0)	0 (0)
Barn swallow (air)	0 (3)	12 (5)	6 (3)	6 (3)	12 (17)	9 (15)	0 (0)	9 (0)
Cliff swallow[e] (air)	0 (0)	6 (0)	0 (0)	6 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Northern rough-winged swallow[e] (air)	0 (0)	0 (0)	0 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

[a]Habitat classification is limnetic for the killdeer and red-winged blackbird, and miscellaneous for the three swallows (Johnsgard, 1979)
[b]Abundances of limnetic/miscellaneous birds seen in fields adjacent to woody corridors are given in parentheses at the appropriate distances
[c]Table 1 has dates and number of visits per site for each census period
[d]Foraging guild classification, breeding season (DeGraaf, *et al.*, 1985)
[e]Species with small sample size (<3 sightings in fields adjacent to either W or H corridors)

Table 13. *Habitat classification, foraging guild, and mean abundance ($\bar{x}$/site) with percent of bird species making one or more trips between woody, herbaceous-woody, or herbaceous-herbaceous riparian corridors and adjacent crop fields, combined across summers, 1992 to 1993, Nebraska.*

Species	Habitat classification[a]	Foraging guild[b]	Corridor type: Woody	Herbaceous-woody	Herbaceous-herbaceous
Dickcissel	grassland	G	0	0.10 (6%)	0.43 (27%)
Horned lark	grassland	G	0	0	0.07 (4%)
American robin	woodland	G	0.11 (16%)	0	0
Northern cardinal	woodland	G	0.02 (3%)	0	0
Brown-headed cowbird	woodland	G	0.02 (3%)	0.27 (17%)	0
Common grackle	woodland	G	0.02 (3%)	0	0
Gray catbird	woodland	G, L	0.02 (3%)	0.07 (4%)	0
Brown thrasher	woodland	G, L	0.14 (20%)	0.07 (4%)	0
Song sparrow	woodland	G, L	0.02 (3%)	0.07 (4%)	0
Blue jay	woodland	G, U	0.07 (10%)	0	0
Red-bellied woodpecker	woodland	G, B	0.02 (3%)	0	0
Indigo bunting	woodland	L	0.02 (3%)	0	0
Northern oriole	woodland	U	0.05 (7%)	0	0
Red-headed woodpecker	woodland	A	0.04 (6%)	0	0
Eastern kingbird	woodland	A	0.07 (10%)	0	0
Red-winged blackbird	limnetic	G	0.05 (7%)	1.04 (65%)	1.11 (69%)
Common yellowthroat	limnetic	L	0.02 (3%)	0	0

[a]Johnsgard, 1979

[b]Foraging guild classification, breeding season (DeGraaf *et al.*, 1985): G = ground, L = lower-canopy, U = upper-canopy, A = air, B = bark

Table 14. Bird species richness [$\bar{x}$/site, range/site, and (totals)] and abundance ($\bar{x}$/100 ha and range/100ha) in three types of crop fields adjacent to riparian corridors with woody or herbaceous vegetation, 2 summers combined, 1992-1993, Nebraska.

		Woody			Herbaceous		
Bird parameter	Crop[a]	$\bar{x}$	range	total	$\bar{x}$	range	total
Species richness	soybean	0.9	(0-3)	(10)	1.6	(0-4)	(9)
	corn	1.1	(0-5)	(14)	2.0	(1-4)	(7)
	grain sorghum	0.8	(0-4)	(10)	1.0	(0-3)	(5)
Abundance	soybean	85	(0-160)		161	(0-240)	
	corn	155	(0-215)		113	(50-225)	
	grain sorghum	240	(0-311)		147	(0-123)	

[a]No corn was planted adjacent to herbaceous corridors in 1992; no grain sorghum was planted in 1993

Table 15. Abundance ($\bar{x}$/100 ha) of bird species observed in three types of crop fields adjacent to riparian corridors with woody or herbaceous vegetation, 2 summers combined, 1992-1993, Nebraska.

Species	Soybean		Corn		Grain sorghum	
	Woody	Herbaceous	Woody	Herbaceous	Woody	Herbaceous
Upland sandpiper	0	28	0	13	0	0
Horned lark	0	0	27	13	0	0
Lark sparrow	9	0	0	0	0	0
Dickcissel	0	14	0	13	0	0
Meadowlark	0	9	0	0	0	1
Barn swallow	0	5	22	19	12	3
Northern rough-winged swallow	0	0	4	0	0	0
Killdeer	5	14	9	0	0	7
Red-winged blackbird	0	55	9	19	12	1
Gray catbird	0	0	5	0	12	1
Blue jay	9	0	0	0	12	0
Northern bobwhite	5	0	0	0	36	0
Red-headed woodpecker	5	5	13	0	0	0
Song sparrow	5	0	9	0	12	0
Wild turkey	13	0	0	0	0	0
American goldfinch	0	0	9	0	0	0

Table 15 *(continued).*

Species	Soybean		Corn		Grain sorghum	
	Woody	Herbaceous	Woody	Herbaceous	Woody	Herbaceous
Brown thrasher	5	0	4	0	0	0
Indigo bunting	0	0	4	0	0	0
American crow	0	0	0	0	72	0
American robin	18	0	22	0	36	0
Eastern kingbird	0	0	4	13	12	0
Northern oriole	0	0	0	0	12	0
Brown-headed cowbird	0	5	0	13	0	0
Mourning dove	5	14	0	0	0	0
Common Grackle	0	0	4	0	0	0

Table 16. *Spearman correlation coefficients between corridor vegetation variables and bird use of corridors during spring, 1993 (*$P \leq 0.05$).*

Vegetation variable	Woody		Herbaceous[a]	
	Bird richness	Bird abundance	Bird richness	Bird abundance
Surrounding woody vegetation (%)	-0.37	-0.31	0.74	0.80
Corridor area (ha)	-0.34	-0.60	0.74	0.80
Tree density (no./ha)	-0.37	-0.14	1.00*	0.74
Shrub density (stems/ha)	-0.08	0.14	0.63	0.40
Tree species richness	0.16	-0.09	1.00*	0.74
Snag density (no./ha)	-0.51	-0.55	--- [b]	--- [b]
Canopy height (m)	-0.08	-0.36		
Basal area (m^2)	-0.68	-0.83*		
No. of openings	0.60	0.51		
Mean area of openings (m^2)	0.45	0.43		
Total area of openings (m^2)	0.66	0.60		

[a]Missing values indicate vegetation variables not measured in herbaceous corridors

[b]Herbaceous sites had no snags

Table 17. *Spearman correlation coefficients between corridor vegetation variables and bird use of corridors during summers, 1992 and 1993, Nebraska* (*$P \leq 0.05$).

Vegetation variable	Woody		Herbaceous[a]	
	Bird richness	Bird abundance	Bird richness	Bird abundance
Surrounding woody vegetation (%)	-0.12	-0.36	0.80	0.80
Corridor area (ha)	0.02	-0.43	0.80	0.80
Water volume (m^3)	0.93*	0.48	-0.32	-0.32
Tree density (no./ha)	-0.41	-0.31	0.74	0.74
Shrub density (stems/ha)	-0.76*	-0.19	0.40	0.40
Tree species richness	0.70*	0.18	0.74	0.74
Snag density (no./ha)	0.12	-0.40	---[b]	---[b]
Ground cover (%)	0.60	0.05	-0.26	-0.26
Grass/sedge (%)	0.23	0.63	-0.80	-0.80
Forb (%)	0.22	-0.05	0.80	0.80
Litter (%)	0.07	-0.44	-0.21	-0.21
Slash/log (%)	0.05	0.15	0.77	0.77
Canopy height (m)	0.00	-0.31		
Basal area (m^2)	-0.05	-0.60		
Canopy cover (%)	-0.28	-0.45		
Cover density at 1 meter (%)	0.24	0.69		
Cover density at 2 meters (%)	-0.02	0.45		
No. of openings	0.05	0.41		
Mean area of openings (m^2)	-0.11	0.36		
Total area of openings (m^2)	0.11	0.57		

[a]Missing values indicate vegetation variables not measured in herbaceous corridors
[b]Herbaceous sites had no snags

Table 18. *Spearman correlation coefficients between corridor vegetation variables and bird species richness of four groups of birds (based on habitat classification) using riparian corridors during spring, 1993, Nebraska* (*$P \le 0.05$).

Vegetation variable	Bird group			
	Woodland	Grassland	Limnetic	Miscellaneous
Surrounding woody vegetation (%)	0.34	-0.56	-0.19	-0.64*
Corridor area (ha)	0.30	-0.44	-0.40	-0.14
Tree density (no./ha)	0.64*	-0.58*	-0.45	-0.66*
Shrub density (stems/ha)	0.48	-0.53	-0.21	-0.59*
Tree species richness	0.80*	-0.73*	-0.47	-0.34
Snag density (no./ha)	0.63*	-0.53	-0.79*	-0.47
Canopy height (m)[a]	-0.05	-0.08	-0.51	0.41
Basal area (m^2)[a]	-0.52	-0.08	-0.58	-0.25
No. of openings[a]	0.23	-0.25	0.85*	0.34
Mean area of openings (m^2)[a]	0.29	-0.08	0.46	0.41
Total area of openings (m^2)[a]	0.46	-0.25	0.71*	0.41

[a]Variable not measured in herbaceous corridors

Table 19. Spearman correlation coefficients between corridor vegetation variables and bird species richness of four groups of birds (based on habitat classifications) using corridors during summers, 1992 and 1993, Nebraska (*$P \leq 0.05$).

Vegetation variable	Bird group			
	Woodland	Grassland	Limnetic	Miscellaneous
Surrounding woody vegetation (%)	0.48	-0.55	-0.39	-0.27
Corridor area (ha)	0.44	-0.40	-0.55	0.02
Water volume (m^3)	0.20	0.60*	0.23	0.73*
Tree density (no./ha)	0.55	-0.85*	-0.29	-0.40
Shrub density (stems/ha)	0.30	-0.72*	-0.25	-0.24
Tree species richness	0.92*	-0.57*	-0.38	0.03
Snag density (no./ha)	0.74*	-0.70*	-0.66*	-0.17
Ground cover (%)	-0.35	0.64*	0.17	0.26
Grass/sedge (%)	-0.45	0.57*	0.49	0.33
Forb (%)	0.09	0.12	0.02	0.09
Litter (%)	0.71*	-0.71*	-0.63*	-0.22
Slash/log (%)	0.53	-0.31	-0.26	0.06
Canopy height (m)[a]	0.25	-0.08	-0.72*	0.22
Basal area (m^2)[a]	0.08	-0.51	-0.74*	0.02
Canopy cover (%)[a]	-0.26	-0.54	-0.57	-0.25
Cover density at 1 meter (%)[a]	0.25	0.45	0.61	0.36
Cover density at 2 meters (%)[a]	0.02	0.31	0.35	0.20
No. of openings[a]	0.01	0.22	0.80*	-0.08
Mean area of openings (m^2)[a]	-0.11	0.06	0.57	-0.04
Total area of openings (m^2)[a]	0.08	0.20	0.77*	0.09

[a]Variable not measured in herbaceous corridors

Table 20. Abundance ($\bar{x}$/ha) of downy or hairy woodpeckers in woody and herbaceous riparian corridors and adjacent cropfields, Nebraska.

	Season	Corridor type	Crop	Field distance (m)	Abundance
Riparian corridors	Fall	woody			0.49
		herbaceous			0
	Winter	woody			0.42
		herbaceous			0.33
	Spring	woody			0.69
		herbaceous			0.33
Fields adjacent to riparian corridors	(field transects were not censused during fall)				
	Winter	woody	corn stubble	100-125	0.17
		woody	corn stubble	0-25	0.17
		herbaceous			0
	Spring	woody			0
		herbaceous			0

Table 21. Abundance ($\bar{x}$/ha) of brown-headed cowbirds in woody and herbaceous riparian corridors and adjacent cropfields, Nebraska.

	Season	Corridor type	Crop	Field distance (m)	Abundance
Riparian corridors	Spring	woody			0.44
		herbaceous			1.0
	Summer	woody			0.47
		herbaceous			0.77
Fields adjacent to riparian corridors	Spring	woody	grain sorghum	0-25	0.67
		herbaceous	grain sorghum	125-150	2.67
	Summer	herbaceous	bean	0-25	0.67
		herbaceous	corn	125-150	1.0

Table 22. Abundance ($\bar{x}$/ha) of three game bird species in woody (W) and herbaceous (H) riparian corridors, Nebraska.

	Spring		Summer		Late summer		Fall		Winter	
	W	H	W	H	W	H	W	H	W	H
Northern bobwhite	0.44	0	0.30	0.25	0	0	0	0	0	0
Ring-necked pheasant	0	0	0.42	1.19	0	0	0	0.29	0.20	0.17
Wild turkey	0	0	0.75	0	0	0	0	0	0	0

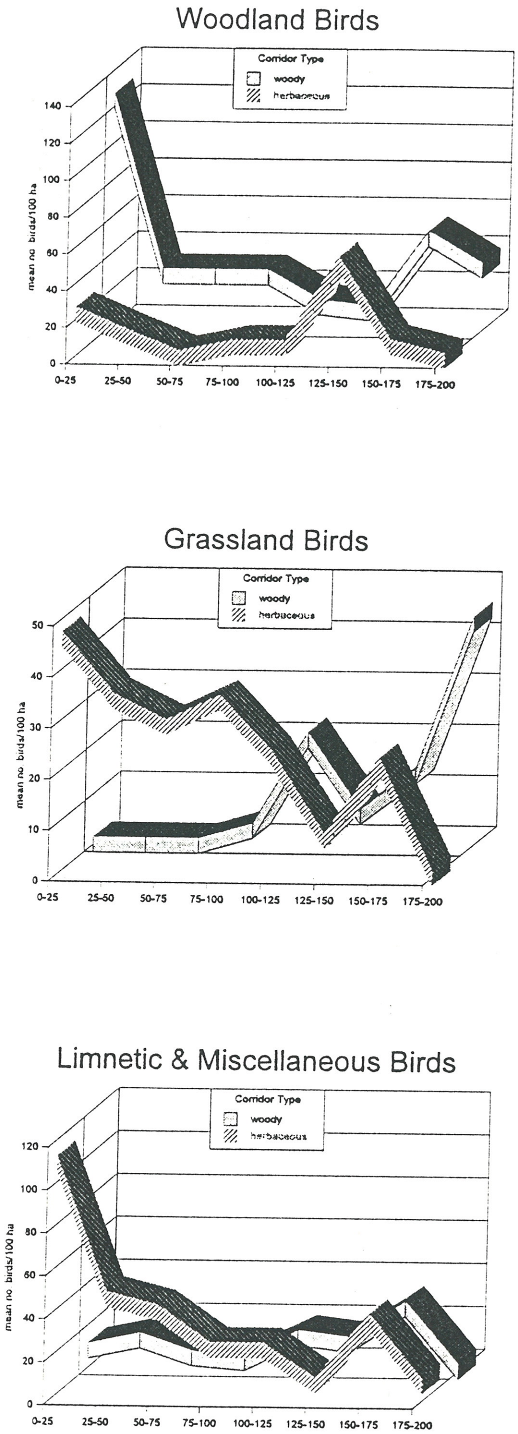

Figure 1. Woodland (A), grassland (B), and limnetic and miscellaneous (C) bird species in crop fields up to 200 meters from woody or herbaceous riparian corridors.

Appendix A

Migratory status, habitat association, and foraging guild classification of bird species observed in woody or herbaceous riparian corridors and adjacent crop fields, during the breeding (B) and non-breeding (N) seasons, Nebraska.

Migrant status[a]	Habitat classification[b]	Foraging guild[c]	Woody		Herbaceous	
			Corridors	Fields	Corridors	Fields
Neotropical migrants						
Upland sandpiper (*Bartramia longicauda*)	grassland	G				B
Lark sparrow (*Chondestes grammacus*)	grassland	G		B		
Dickcissel (*Spiza americana*)	grassland	G	B		B	B
Lincoln's sparrow (*Melospiza lincolnii*)	woodland	G	B, N	B, N	N	N
Thrush (*Catharus* spp.)	woodland	G, L	B	B		
Gray catbird (*Dumetella carolinensis*)	woodland	G, L	B, N	B, N	B	B
Yellow-billed cuckoo (*Coccyzus americanus*)	woodland	L	B			
House wren (*Troglodytes aedon*)	woodland	L	B	B	B, N	
Nashville warbler (*Vermivora ruficapilla*)	woodland	L	B			
Yellow warbler (*Dendroica petechia*)	woodland	L	B		B	
Indigo bunting (*Passerina cyanea*)	woodland	L	B	B		
American redstart (*Setophaga ruticilla*)	woodland	L, A	B			
Red-eyed vireo (*Vireo olivceus*)	woodland	U	B			
Warbling vireo (*Vireo gilvus*)	woodland	U	B			
Rose-breasted grosbeak (*Pheucticus ludovicianus*)	woodland	U	B	B		
Orchard oriole (*Icterus spurius*)	woodland	U	B			
Northern oriole (*Icterus galbula*)	woodland	U	B	B	B	
Eastern kingbird (*Tyrannus tyrannus*)	woodland	A	B	B	B	B
Western kingbird (*Tyrannus verticalis*)	woodland	A		B		
Great-crested flycatcher (*Myiarchus crinitus*)	woodland	A	B			

Appendix A (continued)

Migrant status[a]	Habitat classification[b]	Foraging guild[c]	Woody Corridors	Woody Fields	Herbaceous Corridors	Herbaceous Fields
Neotropical migrants (continued)						
Empidonax flycatcher (*Empidonax* spp.)	woodland	A	B, N	B		
Common yellowthroat (*Geothlypis trichas*)	limnetic	L	B	B	B	B
Northern rough-winged swallow (*Stelgidopteryx serripennis*)	miscellaneous	A	B	B	B	
Barn swallow (*Hirundo rustica*)	miscellaneous	A	B, N	B, N	B, N	B
Cliff swallow (*Petrochelidon pyrrhonota*)	miscellaneous	A				B
Short-distance migrants						
Horned lark (*Eremophila alpestris*)	grassland	G		B, N	B	B, N
Vesper sparrow (*Pooecetes gramineus*)	grassland	G		B	N	B, N
Savannah sparrow (*Passerculus sandwichensis*)	grassland	G			B	B
Henslow's sparrow (*Ammodramus henslowii*)		G	N			
Field sparrow (*Spizella pusilla*)	grassland	G	B			
LeConte's sparrow (*Ammospiza leconteii*)	grassland	G			N	N
Eastern/Western meadowlark (*Sturnella* spp.)	grassland	G	B, N		B, N	B, N
Red-tailed hawk (*Buteo jamaicensis*)	woodland	G	N			
Mourning dove (*Zenaida macroura*)	woodland	G	B, N	B, N	B	B, N
Northern flicker (*Colaptes auratus*)	woodland	G	B, N		B	
American crow (*Corvus brachyrhynchos*)	woodland	G	N	B		
American robin (*Turdus migratorius*)	woodland	G	B, N	B	B	B
European starling (*Sturnus vulgaris*)	woodland	G	B, N			
Rufous-sided towhee (*Pipilo erythrophthalmus*)	woodland	G	N			

Appendix A (continued)

Migrant status[a]	Habitat classification[b]	Foraging guild[c]	Woody		Herbaceous	
			Corridors	Fields	Corridors	Fields
Short-distance migrants (continued)						
American tree sparrow (*Spizella arborea*)	woodland	G	N	N	N	N
Dark-eyed junco (*Junco hyemalis*)	woodland	G	N	N	N	B
Harris' sparrow (*Zonotrichia querla*)	woodland	G	B, N			
White-throated sparrow (*Zonotrichia albicollis*)	woodland	G	N		N	
Brown-headed cowbird (*Molothrus ater*)	woodland	G	B	B	B	B
Common grackle (*Quiscalus quiscula*)	woodland	G	B, N	B	B	B
Brown thrasher (*Toxostome rufum*)	woodland	G, L	B	B	B	B
Song sparrow (*Melospiza melodia*)	woodland	G, L	B, N	B	B, N	B, N
American goldfinch (*Carduelis tristis*)	woodland	G, L	B, N	B, N	B, N	
Blue jay (*Cyanocitta cristata*)	woodland	G, U	B, N	B, N	B, N	B
Yellow-rumped warbler (*Dendroica coronata*)	woodland	L	B, N			
Golden-crowned kinglet (*Regulus satrapa*)	woodland	L	N			
Ruby-crowned kinglet (*Regulus calendula*)	woodland	L	N			
Cedar waxwing (*Bombycilla cedrorum*)	woodland	U, A	B			
Red-headed woodpecker (*Melanerpes erthrocephalus*)	woodland	A	B	B		B
Eastern phoebe (*Sayornis phoebe*)	woodland	A	B			
Killdeer (*Charadrius vociferus*)	limnetic	G		B	B	B
Red-winged blackbird (*Agelaius phoeniceus*)	limnetic	G	B, N	B	B, N	B
Duck (unknown spp.)	limnetic	W	N			
Great blue heron (*Ardea herodias*)	limnetic	W			N	

Appendix A (continued)

Migrant status[a]	Habitat classification[b]	Foraging guild[c]	Woody		Herbaceous	
			Corridors	Fields	Corridors	Fields
Permanent residents						
Wild turkey (*Meleagris gallopavo*)	woodland	G	B	B		
Northern bobwhite (*Colinus virginianus*)	woodland	G	B	B	B	B
Great horned owl (*Bubo virginianus*)	woodland	G	B, N			
Northern cardinal (*Cardinalis cardinalis*)	woodland	G	B, N	B, N	B	
Red-bellied woodpecker (*Melanerpes carolinus*)	woodland	G, B	B, N	B		
Downy or hairy woodpecker (*Picoides* spp.)	woodland	L, B	B, N	N	B, N	
Black-capped chickadee (*Parus atricapillus*)	woodland	L	B, N	B, N		
White-breasted nuthatch (*Sitta carolinensis*)	woodland	B	B, N			
Belted kingfisher (*Ceryle alcyon*)	limnetic	W	B		B	
Ring-necked pheasant (*Phasianus colchicus*)	introduced	G	B, N		B, N	N

[a]Peterjohn and Sauer, 1993

[b]Johnsgard, 1979; Peterson, 1980; DeGraaf *et al.*, 1991

[c]Foraging guild classification during the breeding season: G = ground, L = lower-canopy, U = upper-canopy, A = air, B = bark, W = water (DeGraaf *et al.*, 1985)

Appendix B

Bird species discussed in the text, but not included in Appendix A.

House crow (*Corvus splendens*)

House sparrow (*Passer domesticus*)

Palm warbler (*Dendroica palmarum palmarum*)

Mockingbird (*Mimus polyglottos*)

Eastern bluebird (*Sialia sialis*)

Appendix C

Vegetation parameters measured at woody (W1-W8) and herbaceous (H1-H4[a]) riparian corridors during summer 1992 in Nebraska.

Vegetation parameter	W1	W2	W3	W4	W5	W6	W7	W8	H1[b]	H2	H3	H4[b]
Surrounding woody vegetation (%)	4.0	7.9	4.3	2.5	2.7	8.7	8.1	4.2	3.0	1.9	1.3	4.2
Corridor area (ha)	1.18	5.35	0.78	2.17	1.06	3.28	1.08	1.42	1.19	0.67	0.49	2.81
Water volume (m^3)	0.02	0.19	2.42	0.73	0.01	0.04	0.07	0.16	0.51	0.38	0.38	0.14
Tree species richness	7	9	9	9	3	8	8	5	2	0	0	1
Tree density (no./ha)	2555	2140	950	700	2710	1585	610	1785	145	0	0	15
Shrub density (stems/ha)	6275	150	400	854	3675	2500	550	1275	1875	0	125	75
Snag density (no./ha)	360	605	170	155	65	370	100	135	0	0	0	0
Ground cover (%)	80	100	98	98	84	91	99	91	98	100	100	100
Grass/sedge (%)	34	13	46	52	61	13	2	52	52	79	83	51
Forb (%)	4	30	29	28	15	36	78	19	44	20	17	48
Litter (%)	42	57	22	14	8	37	8	10	2	1	0	0
Slash/log (%)	0	0	1	4	0	5	17	8	0	0	0	1

Appendix C (continued)

Vegetation parameter	W1	W2	W3	W4	W5	W6	W7	W8	H1[b]	H2	H3	H4[b]
Basal area (m^2)	14.6	17.5	11.4	11.9	7.7	15.9	15.1	16.1				
Canopy height (m)	9.5	10.2	9.2	12.2	9.0	14.0	10.2	9.4				
Canopy cover (%)	63	98	52	53	70	91	52	53				
Cover density at 1 meter (%)	81	94	78	64	74	92	89	78				
Cover density at 2 meters (%)	70	90	78	54	70	89	89	76				
No. of openings	1	0	3	4	4	0	9	3				
Mean area of openings (m^2)	348	0	240	572	935	0	265	499				
Total area of openings (m^2)	348	0	720	2288	2805	0	1326	1496				

[a]Missing values indicate vegetation variables not measured in herbaceous corridors
[b]Herbaceous site containing moderate amounts of woody vegetation

Appendix D

Field information sheet.

FIELD INFORMATION 1994 **County:** **Field:**

Crop ________

Acres ________

Planting Date ________

Planting Rate ________

Ground Preparation	Date
cultivation(# passes ___)	______
plow	______
harrow	______
disk	______
no-till	______
other(____________)	

Fertilizers used: (If none used, please check:______)

Compound	Date	Rate
________	_____	_____
________	_____	_____

Pesticides used: (If none used, please check:______)

Compound	Date	Rate	Herbicide or Insecticide	Preplant or Incorporated	Pre-emergence Postemergence	Aerial appl.
________	____	____	__________	__________	__________	______
________	____	____	__________	__________	__________	______
________	____	____	__________	__________	__________	______
________	____	____	__________	__________	__________	______

Harvest date ________

Yield (1994) ________

Yields on this field in the past 2 years

Year	Crop	Yield
1993	_____	_____
1992	_____	_____

Non-crop Area Management (in this field and at edges of this field)

Area	# Acres	Management (mowing, herbicides used, insecticides used, or none)
______	______	____________________
______	______	____________________
______	______	____________________

Appendix E
Vertical Distribution of Birds in Riparian Corridors

INTRODUCTION

Data on avian vertical distribution in riparian corridors is sparse. Yahner (1982) examined vertical distribution of birds in shelterbelts of the Great Plains, which may be interesting to compare with avian vertical distribution in riparian corridors. The objective of this research was to determine avian stratal use for bird species in wooded riparian corridors in east-central Nebraska. These data are not included in chapter 1 because the technique used may have biased the results. Walking through crops and tall grass often was noisy, and potentially caused birds to flush unseen from the ground to the mid-story level. This possibility is reflected in the fact that most stratal indices are in the mid-story range. Data are reported to alert other researchers to the potential bias that may have affected these results. Other results of this study were not affected by this technique or potential bias.

STUDY SITES AND METHODS

Study sites used were all woody corridors described in chapter 1. Census methods were identical to those described in chapter 1 for corridor transects. When possible, I recorded a bird's position in the corridor (height and type of vegetation) upon first sighting. Type of vegetation was recorded as either grass, forb, shrub, tree, dead tree, or brush pile. Height was recorded as either lower, middle, or upper portion of that particular vegetation type being used.

Each of these height-vegetation combinations then closely corresponded to one of the vertical strata categories used by MacArthur and MacArthur (1961): ground - 0.6 m, 0.6 m - 7.6 m, and $\geq$ 7.6 m. I will refer to these as ground, midstory, and canopy, respectively. I assigned one of these stratal categories to each of my height-vegetation type combinations (Table E.1).

In order to determine stratal index, these stratal categories were then assigned the following values: ground, 1; midstory, 2; canopy, 3. I then multiplied these assigned values by the avian frequency in each corresponding category, summed these products, and divided by the total avian frequency (Dickson and Noble, 1978).

Stratal indices were calculated in this way for species having ten or more observations for each season (spring, summer, late summer, fall, and winter). Stratal indices were also calculated for each of four foraging guilds (ground, canopy, ground/canopy, and air feeders) during the breeding (spring, summer, and late summer) and non-breeding (fall and winter) periods. These foraging guilds were based on DeGraaf *et al.* (1985). Stratal indices were also calculated over all birds for each season.

RESULTS AND DISCUSSION

In Table E.2, stratal indices are given for each season. Yahner reported that 60.7 percent of the species were most often observed in the ground stratum (0 - 0.6 m). I observed few birds using the ground; even species known to be ground feeders were rarely seen on the ground. This may have been due to their being flushed off the ground before sighting, as walking along the corridor-field edge often occurred in tall grass or crops which made considerable noise. In this study, five species had a stratal index in both the breeding period (spring, summer, and late summer) and the non-breeding period (fall and winter) for comparison. The blue jay, American robin, and black-capped chickadee each retained a similar stratal index throughout each season, whereas the Northern cardinal and Harris' sparrow had lower indices during the non-breeding period than the breeding period. The blue jay, American robin, and black-capped chickadee are either canopy feeders or ground/canopy feeders, and the Northern cardinal and Harris' sparrow are ground feeders. Also in Table E.2, the stratal index for all species combined appeared to be higher during the breeding season and lower during fall and winter. Yahner (1982) studied birds in farmstead shelterbelts, and also found a higher vertical height distribution during spring and summer, and a lower distribution during fall and winter.

Stratal indices for foraging guilds (ground feeders, canopy feeders, ground/canopy feeders, and air feeders) (Table E.3) show that during the breeding season, ground/canopy feeders appeared to have the lowest stratal index (2.40) and air feeders the highest (2.63). During the non-breeding season, ground feeders appeared to have the lowest stratal index (2.05) and ground/canopy feeders the highest (2.80). Both ground feeders and canopy feeders appeared to shift to lower height distributions during the non-breeding season, whereas ground/canopy feeders appeared to shift upward. This apparently resulted because the only species used to calculate stratal index during the non-breeding season were the blue jay and red-bellied woodpecker, of which many blue jays were observed in the upper canopy.

These data indicate that birds in riparian corridors use higher levels of vegetation during spring, summer, and late summer, and lower levels during fall and winter, when less vegetation is actually present. It appears that this general shift in vertical height distribution from the breeding to the non-breeding season may be characteristic of birds in both riparian corridors and in farmstead shelterbelts.

LITERATURE CITED

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Table E.1. Assignment of stratal categories to height-vegetation combinations for determination of stratal indices.

Height-vegetation combination	Stratal category
upper tree	canopy
upper shrub	mid-story
upper brush pile	mid-story
upper grass/forb	mid-story
middle tree	mid-story
middle shrub	mid-story
middle brush pile	mid-story
middle grass/forb	ground
lower tree/dead tree	mid-story
lower shrub	ground
lower brush pile	ground
lower grass/forb	ground

Table E.2. Year-round and seasonal avian stratal indices for species in riparian corridors of east-central Nebraska.

Species	Spring	Summer	Late summer	Fall	Winter
Rose-breasted grosbeak	3.00	2.71			
American goldfinch	2.89	2.40			
Yellow warbler	2.88				
Northern oriole	2.83	2.61			
Northern cardinal	2.75	2.82		1.82	1.91
Brown thrasher	2.67	2.50			
Red-winged blackbird	2.67	2.41			
Harris' sparrow	2.46				1.38
Empidonax flycatcher	2.33				
Blue jay	2.32	2.52	2.75	2.83	2.74
House wren	2.14	2.29			
Gray catbird	2.08	1.94			
Eastern kingbird		2.74			
Indigo bunting		2.67			
Common grackle		2.45			
American robin		2.42	2.63	2.96	
Black-capped chickadee		2.30		2.40	2.33
Song sparrow		2.27			
Common yellowthroat		2.00			
European starling					2.55
Yellow-rumped warbler				2.23	
Mourning dove			2.45		
Ruby-crowned kinglet				2.00	
Dark-eyed junco				1.71	1.71
Lincoln's sparrow				1.68	
All species combined	2.51	2.45	2.60	2.20	2.26

Table E.3. Avian stratal indices of four foraging guilds (ground, canopy, ground/canopy, and air feeders) during breeding (spring, summer, and late summer) and non-breeding (fall and winter) seasons, for species in riparian corridors in east-central Nebraska.

Foraging guild classification	Breeding season	Non-breeding season
Ground feeders	2.47	2.05
Canopy feeders	2.50	2.31
Ground/canopy feeders	2.40	2.80
Air feeders	2.63	----