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Conservation and Beneficial Functions of Grassland Birds in Agroecosystems

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CONSERVATION AND BENEFICIAL FUNCTIONS OF GRASSLAND BIRDS IN AGROECOSYSTEMS

by

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CONSERVATION AND BENEFICIAL FUNCTIONS

OF GRASSLAND BIRDS IN AGROECOSYSTEMS

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Grassland bird populations are declining and our knowledge of how best to manage grassland patches in agroecosystems is incomplete. Birds that suppress crop pests offer one way to integrate the needs of agriculture and environment for mutual benefit. Fifteen CRP grassland study sites were selected in agricultural landscapes with a range from high (51%) to low (7%) amounts of surrounding grassy cover to observe the affects of landscape composition on grassland bird densities at various scales. Each grassland was adjacent to a cropfield (96-306 m wide) with a woody edge on the opposite side, allowing observation of foraging patterns of grassland birds in relation to field size and edge habitat.

Results indicate that both local and landscape variables influenced grassland bird densities in CRP fields. Grasshopper sparrows (*Ammodramus savannarum*) showed a positive response to the amount of grassland in the landscape out to 2000 m, and northern bobwhite (*Colinus virginianus*) out to 500 m. Lark sparrows (*Chondestes grammacus*) responded to the amount of pasture in the landscape at the 2000 m scale. Dickcissels

(*Spiza americana*) and ring-necked pheasants (*Phasianus colchicus*) responded positively to increasing visual obstruction readings, and bobolinks (*Dolichonyx oryzivorus*) to the area of the study site. Our findings indicated that managing to achieve areas with higher percentages (20-40%) of grassland in the landscape would benefit declining grassland bird populations.

Approximately 75% of birds commonly associated with CRP grasslands were found in cropfields within 100 m of the grassland edge. Grasshopper sparrows were rarely observed in cropfields. Meadowlarks (*Sturnella magna* and *neglecta*) and dickcissels were mainly found within 60 m and 80 m of the grassland edge. Trees appeared not to deter grassland bird use of cropfields except by meadowlarks, which avoided the trees by ≥44 m. Cropfield foraging patterns of grassland and woodland birds indicate that an optimal cropfield width of 150-175 m would facilitate cropfield use by birds, potentially benefiting both bird conservation and insect pest suppression.

DEDICATION

To my parents, Mark and Amparo Hanson, who have always been there for me with unending love and support.

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GRASSLAND BIRDS IN AGROECOSYSTEMS: LOCAL VARIABLES AND LANDSCAPE THRESHOLDS

INTRODUCTION

Grassland bird populations are declining faster than any other guild of North American birds (Samson and Knopf 1994, Herkert 1995). According to the North American Breeding Bird Survey, 13 species of grassland birds experienced significant population declines between 1966 and 2004 (Sauer et al. 2005). This decline is primarily attributed to the loss and degradation of their habitat (Johnson and Schwartz 1993, Herkert 1995, Coppedge et al. 2001).

Historically, the North American Great Plains consisted of 162 million hectares of native prairie (Samson and Knopf 1994). Tallgrass prairie has since been severely reduced and fragmented by urban development and agricultural practices leaving the last remaining grasslands as small, isolated patches. These grasslands are further fragmented by woodlands which have been increasing since the disruption of the natural cycle of fire (Bragg and Hulbert 1976), and by the agricultural practice of planting of windbreaks and shelterbelts (Bakker et al. 2002). The spread of woodlands has subsequently decreased the habitable area of these isolated grassland patches as a result of edge effects (Winter et al. 2000, Coppedge 2001, Fletcher 2002, Grant et al. 2004, Renfrew et al. 2005).

A variety of factors can influence the selection of breeding habitat by grassland birds. Previous studies have found associations between grassland bird abundances and local vegetation structure (Rotenberry and Wiens 1980, Maurer 1986, King and Savidge 1995, Delisle and Savidge 1997, Davis 2004), and patch characteristics such as size, shape, and edge (Herkert 1994, Vickery et al. 1994, Helzer and Jelinski 1999, Davis 2004, Grant et al. 2004, Renfrew 2005,). More recently, studies have also begun to examine the effects of surrounding landscape composition on avian abundance. The concept of a linear relationship between species abundance and the amount of suitable habitat available in the landscape has been questioned by various theoretical studies that propose the existence of a threshold, below which populations can no longer persist (Lande 1987, Andren 1994, Hill and Caswell 1999, With and King 1999). Thresholds may be a consequence of fragmentation, which not only reduces the amount of original habitat, but also decreases the size and increases the isolation of remaining habitat patches (Andren 1994, Fahrig 1997).

Using model simulations, Andren (1994) found that landscapes with more than 40% of suitable habitat remaining did not suffer species loss due to the effects of isolation; small patches were typically in the vicinity of large patches. As a habitat type decreased below 20% of the landscape, however, there was an exponential increase in the distance observed between remaining patches. At this critical threshold, rapid changes in patch size and isolation occur, potentially causing populations to decline at a faster rate.

A threshold at 20% of the landscape was also found using model simulations by Fahrig (1997), and Lamberson et al. (1992). Fahrig (1997) determined that species survival was assured when the proportion of suitable habitat in the landscape surpassed 20%, regardless of the degree of fragmentation observed in the landscape. The results of Lamberson et al. (1992) predicted a sharp threshold in the survival of the northern spotted owl (*Strix occidentalis caurina*) when habitat levels declined to 20%. It is difficult to find many field studies that have tested this 20% threshold. Perkins et al. (2003) found similar thresholds for the great crested flycatcher (*Myiarchus crinitus*), which were not observed in areas with ≤14.7% woody cover, and the eastern wood-pewee (*Contopus virens*), absent from sites with ≤24% woody cover.

Although landscape thresholds have not been widely investigated in the literature, there have been studies to determine the effects of surrounding landscape composition on avian populations. Avian responses to landscape structure have been observed in forest birds (Villard et al. 1999, Howell et al. 2000, Lee et al. 2002, Perkins et al. 2003), prairie wetland birds (Naugle et al. 1999), and grassland birds (Coppedge et al. 2001, Ribic and Sample 2001, Bakker et al. 2002, Fletcher and Koford 2002, Cunningham and Johnson 2006). The influence of landscape composition on grassland birds appears to be species specific; however, results from studies are not consistent. The variability observed between studies may be associated with differing study objectives (e.g., landscape effects on area sensitivity, reproductive success), and designs (e.g., scale, field sizes, explanatory variables, data analysis methods, etc.).

This study is unique in that it focuses principally on determining correlations between grassland bird abundance, and the amount of grassland located in the surrounding landscape. Having study sites of similar sizes, located in landscapes with a range of high to low amounts of grassy cover, allowed us to observe the effect that a gradient of varying percentages of grassy habitat in the landscape had on grassland bird abundance. Our study design facilitates the detection of any important landscape thresholds, below which some species could no longer occur.

In order to detect these thresholds, the scale in which a bird interacts with its environment must first be determined. Grassland bird responses to landscape variables have been detected at the 200 m (Ribic and Sample 2001) to the 5 km scale (Winter 1998); however, many studies have been executed at only one scale (King and Savidge 1995, Fletcher and Koford 2002), usually with scales of 1000 m or less (Ribic and Sample 2001, Fletcher and Koford 2002). Important associations between bird abundance and landscape metrics may go unnoticed if the focus on the surrounding habitat is too narrow or too broad. Therefore, we incorporated scale into our study design by analyzing the relationship between species abundance and surrounding landscape factors at the 500 m, 1000 m, and 2000 m scales (Perkins et al. 2003). Detection of potential thresholds, and at what scale, would have critical implications for the conservation of grassland birds.

The main objectives of our study were to determine the affects of landscape composition on grassland bird densities at various scales, and to detect any important landscape thresholds that may exist. We also evaluated effects of local field-scale variables that might affect bird response.

METHODS

Our study was conducted in southeastern Nebraska, an area principally dominated by agriculture, where farmland constituted roughly 93 percent of the total land area (49.1% in rowcrops, 47.8% pastureland, 2.5% enrolled in a conservation reserve program; USDA 2005). The Conservation Reserve Program (CRP) was established through the 1985 Food Security Act (Farm Bill) to remove highly erodible and environmentally sensitive land from production and plant it to a variety of cover types (principally grasses; Patterson and Best 1996). Although originally created to reduce soil erosion and lower crop surpluses, CRP fields have greatly benefited grassland bird populations by increasing the amount of grassland habitat available. In order to determine relationships between grassland birds and various habitat characteristics, bird surveys, vegetation sampling, and landscape-level habitat assessments were performed during the 2005 and 2006 breeding seasons.

Study Design

Fifteen study sites were selected across nine counties in southeastern Nebraska (Table 1, Figure 1). Sites were located using rectified Digital Ortho Quarter Quad photos (taken in 2003), and on-site investigations. All study sites had a Conservation Reserve Program (CRP) grassland adjacent to a corn, soybean, or sorghum cropfield (Figures 2-16). Grasslands were all of similar size (mean = 13 ha, range: 10.5 – 24.7 ha) to negate issues that species were selecting sites as a result of patch area (Table 1). Sites were located in landscapes that ranged from high (51%) to low (7%) amounts of grassy cover, along with varying percentages of cropland, pastureland and woodland.

Initially, our intentions were to select study sites 10 ha in size to meet species minimum habitat requirements (grasshopper sparrow: 10 ha, dickcissel: 9 ha, meadowlark: 5 ha) (Helzer 1996, Helzer and Jelinski 1999). However, we could not locate fifteen separate 10 hectare CRP grasslands in southeastern Nebraska that fulfilled all of our study design requirements (e.g., located next to a cropfield ranging 100-300 m in width, terminating at a woodland edge, and in a landscape composed of 0-50% grassland).

Bird Surveys

Birds were surveyed using line transects and distance sampling techniques. Three-hundred meter line transects were flagged prior to commencing the study. To obtain a representative sample of the population, all transects began or ended at the cropfield edge and extended out through the core area of the grassland (Figures 2-16). Distance and angle to birds were measured both years using a LaserAce 300 range finder (Measurement Devices Ltd., Houston, TX) to establish species density estimates (Buckland et al. 2001). Transects were walked at approximately 10 m per minute (Ralph et al. 1993). All birds seen or heard in the CRP fields were recorded; birds flying over the transect were noted but not included in the data set. Two to four sites were surveyed per day, contingent on travel and time restrictions. Sites were grouped to ensure varying grassland landscape percentages were sampled each day. Each site was surveyed four times from early June through mid-July 2005, and seven times from mid-May to mid-July

2006. Surveys were performed between sunrise and five hours later, and were not conducted during rain or heavy winds (> 20 kph) (Robbins 1981). Sites were surveyed at different times of the morning during each round to reduce any potential temporal biases (e.g., bird activity, temperature).

A technician was hired to assist with field work during the 2006 season. Surveys by the technician were conducted using a Bushnell YardagePro 500 range finder (Bushnell Corporation, Overland Park, KS). To reduce any potential observer biases, all sites were surveyed as equally as possible by both observers (AH: 4 surveys, Tech: 3 surveys). Observers alternated sites each week.

The ranges of the eastern and western meadowlark overlap in southeastern Nebraska. Although they have markedly different vocalizations, they are similar in appearance, making it difficult to distinguish them in the field. Because their life histories are largely comparable (Lanyon 1994; 1995), we combined the two species into one group called 'meadowlark,' or MEAD.

Program DISTANCE

Data on the distance and angle to birds were used in Program DISTANCE (Thomas et al. 2006) to estimate species detectability and density. We compared four models to estimate bird densities: global detection, site-specific detection, observer effect, and detection method. The global detection function model pooled (averaged) the data from all fifteen sites, and used a common detection function to estimate densities at each site.

Conversely, the site-specific detection function model used site-specific detectability functions to estimate density for each site. The observer effect model considered potential differences in skill levels between observers, which could result in differing detection functions. Finally, the detection method model determined whether visual and auditory observations had different detection functions.

During the 2005 season, there was only one observer and data on detection method lacked detail, therefore only global and site-specific detection functions were used. The available models were compared using Akaike's Information Criterion (AIC) to determine the best model for each species, per year (Burnham and Anderson 1998; Table 2). Density estimates from the models with the lowest AICc values were used in the analyses (Table 3). Program DISTANCE was used only with species that had sufficient numbers of observations (>140 over both years) (i.e., grasshopper sparrow, dickcissel, meadowlark, red-winged blackbird, brown-headed cowbird). The remaining species were analyzed using presence/absence data for each site.

Local Habitat Variables

Vegetation was sampled every 25 m along the 300 m line transect for a total of twelve samples per site (mid-August 2005, end of July 2006). Sample points were placed a random number of paces either left or right of the transect. Direction from the transect was determined by flipping a coin. The number of paces walked perpendicular to the transect was established using a random number table (0 – 9 paces). Because of the potential trampling of vegetation directly along the bird-survey transect, five paces were added to the number selected above (Min. # of paces from the transect possible = 5, Max. # = 14). The Robel pole (Robel et al. 1970) was grounded using the right or left hand depending on the number of paces walked (odd number = left hand, even number = right hand). A GPS point was taken to provide information on the exact location of each sample.

Visual obstruction readings (VOR) were taken 4 m from a Robel pole, observed from a height of 1 m above ground from the four cardinal directions. The lowest decimeter visible was recorded. Maximum heights of living and standing dead vegetation within 2 cm of the pole were also recorded (Robel et al. 1970).

Perpendicular distance from the transect to the nearest treeline was measured at each sample point using a laser range finder, or in ArcGIS. A treeline was defined as a line of four trees or more, with heights greater than 2 m.

Litter depth was measured at the center of a Daubenmire frame (Daubenmire 1959) placed 1 m from the Robel pole following the same perpendicular line from the survey transect. Percentages of standing dead vegetation, bare ground, litter, grass, forbs, and woody vegetation were categorized into one of the six Daubenmire ranges (0-5, 5-25, 25-50, 50-75, 75-95, 95-100). Two survey methods were used to calculate these percentages. The first method determined the percent coverage using a non-overlapping technique, where the percent coverages totaled 100%. This technique measured what the composition of the vegetation appeared to be from above the canopy (no shifting of the vegetation). The second method included the composition of the vegetation in the understory. Here, the percent coverage could exceed 100% by shifting the vegetation to observe what was found below the grass canopy (overlapping technique). Both methods have merit relating to bird habitat selection, and are commonly used in avian studies. Although the best method for this study is most likely the overlapping technique as used in Henningsen and Best (2005), the data for non-overlapping coverages were also recorded because of the minimal effort required.

Vegetation that was not rooted within the frame, but rather hung over it, was also included in the tally. Plants that were not found within the frame but only surrounded it were also assigned a Daubenmire range. By drawing a polygon around the extremities of the plant, the portion of the polygon above the plot frame was included as coverage (Daubenmire 1959).

The twelve sample points measured per site were averaged to have one representative value for each variable. Vegetation could not be sampled at site 4 in 2005 because of the unexpected introduction of cattle. Bird surveys had already come to an end, and were therefore unaffected.

Landscape Variables

Landscape buffers included the area within 500 m, 1000 m, and 2000 m of each study site. Land cover was determined by ground-truthing the surrounding area out to 2000 m from the outside edge of the study grassland. Total areas (ha) of grassland, cropland, pastureland, and woodland in the landscape were calculated using rectified Digital Ortho Quarter Quad photos (taken in 2003) in conjunction with a geographic information system, or GIS (ESRI 2004) (Figures 2-16). Grasslands included: CRP, hayland, wheat, and alfalfa fields. Although the latter two are cropfields, they appear to represent habitat resources similar to that of grasslands (Best et al. 1995). Grassland amounts were also calculated without alfalfa and wheat fields for those species that may not recognize these fields as suitable habitat. Pastureland included any grassland with a grazing regime; they were not included within the grassland category because of the differences in avian abundance observed between the two habitats (Kantrud 1981, Best et al. 1995). Croplands consisted of corn, soybean, and sorghum fields. Woodlands comprised areas with high concentrations of trees (distance to nearest tree < 25 m) such as forested areas, windbreaks, and wooded riparian areas.

FRAGSTATS

Two landscape metrics were computed using FRAGSTATS 3.3 (McGarigal et al. 2002): area-weighted mean shape index (SHAPE), and connectance index (CONNECT). The SHAPE index calculates the perimeter-area ratio by dividing the perimeter of each patch by the smallest equivalent perimeter (a square). Therefore, if SHAPE is equal to one, the patch represents a square. As the SHAPE index increases, the patches become more irregular in shape with greater edge per unit area. The SHAPE index represents a mean of all the grassland patches in the landscape, adjusted by adding more weight to larger patches. SHAPE index was calculated at the 500 m, 1000 m, and 2000 m scales.

The CONNECT index demonstrates how connected grassland patches are in the landscape. The index is calculated by determining the number of patches that are connected in the landscape, and dividing it by the total number of patches. The results are multiplied by 100 to represent a percentage. CONNECT equals zero when none of the patches in the landscape are connected, and equals one when all of them are connected. Connectance is a user-specific defined metric. Patches were considered connected when two grassland patches were separated by 50 m or less. Because of their more timorous behavior, connectance for the grasshopper sparrow was defined as 20 m or less. These distances were generated by considering various life history traits of grassland species, including average foraging distances into cropfields (Sunderman 1995). Cropfields were considered a potentially 'hostile' environment, so Sunderman's (1995) estimate provides an indication of how far species might travel across habitats that are not typically their own. SHAPE and CONNECT were calculated twice; once including alfalfa and wheat fields as grassland, and then again excluding them.

Data Analysis

Data was initially graphed in Microsoft Excel to examine for any potential landscape thresholds or trends that may have existed. SAS software (SAS Institute, Inc. 2003) was used to perform all of the subsequent analyses. Prior to selecting models for analysis, Pearson correlation coefficients (r) were calculated for local habitat and landscape variables to measure the strength of the linear relationship between each set of variables. Variables with high correlations ($|r| \geq 0.70$) were not included within the same model.

To determine whether to classify alfalfa and wheat fields as a grassland habitat, *The Birds of North America* (BNA) series, which compiles results from many published sources, was used to find any reference of grassland birds using these fields as a habitat resource. Dickcissels (Temple 2002), red-winged blackbirds (Yasukawa 1995), bobolinks (Marin and Gavin 1995), and both eastern (Lanyon 1995) and western meadowlarks (Lanyon 1994) have all been shown to use alfalfa and wheat fields. Pearson correlation coefficients were also derived to examine whether species densities were more closely associated with grassland percentages including or excluding these supplementary fields. The grasshopper sparrow was the only species to show a slight inclination towards grassland percentages without alfalfa and wheat ($|r| = 0.4$, $P = 0.03$ at the 2000 m scale). Alfalfa and wheat fields were included in the analyses of the dickcissel, red-winged blackbird, and meadowlarks, but were excluded from the analysis of the grasshopper sparrow.

A correlation analysis was also performed on bird species densities to determine whether fluctuations in densities may have been a response to interspecies interactions. Grasshopper sparrows showed a negative relationship with all of the species, with P-values <0.05 for the dickcissel and red-winged blackbird. Therefore, a 'community' variable was included in the analysis to represent the combined densities of the four other main species (addition of densities). Species densities were also included in the analysis of the brown-headed cowbirds because of their reproductive practice of brood parasitism.

A compilation of *a priori* models was created for each species using independent variables thought to be of biological importance, potentially affecting species presence and densities (response variables) (Tables 4-5). Included in every model was the effect of year to account for variation resulting from differences observed between years. These models were analyzed using linear and logistic regression with two SAS software procedures. PROC MIXED was used for the five species with density estimates from Program DISTANCE (response variable = density; grasshopper sparrow, dickcissel, meadowlark, red-winged blackbird, brown-headed cowbird). Species with presence/absence data were analyzed using PROC GENMOD (response variable = 0 or 1; vesper sparrow, lark sparrow, field sparrow, bobolink, northern bobwhite, ring-necked pheasant, sedge wren, and common yellowthroat). We were unable to analyze the twelve remaining species because of insufficient data (Table 6).

The information-theoretic method, using Akaike's Information Criterion (AIC), was used to determine which model(s) best explained the variation observed in the data. A modified criterion, AICc, was used to allow for small sample sizes (Burnham and Anderson 1998). The model with the lowest AICc was considered to be the best model (Burnham and Anderson 1998). The differences between all AICc values were calculated against the top model ($\Delta AICc_i = AICc_i - \min AICc$) to demonstrate how competitive the alternative models were (Burnham and Anderson 1998). Akaike weights (w_i) were computed to represent the strength of evidence for each model, indicating the probability of a model being the best model. The relative importance of a variable, or its parameter weight (Σw_i), was calculated by adding the weights of all models containing the variable.

Burnham and Anderson (1998) suggest that all models with a ΔAICc ≤ 4 be considered. Models within 2 AICc units from the best model (ΔAICc ≤ 2) are believed to explain much of the variation observed in the data. Since a ΔAICc ≤ 2 suggests considerable support for the model, it is difficult to designate a single top model from the models within this range. Burnham and Anderson (1998) recommend calculating weighted estimates of the variables across multiple models using the Akaike weights to assist in averaging over model selection uncertainty. The resulting model averaged estimator (MAE) $(\hat{\bar{\theta}})$ indicates the parameter's effect on the response variable (e.g., positive/negative, significantly different from zero). When using presence-absence data, the estimates were raised to the power of *e* (e^{estimate}) to approximate the probability, or odds, of presence. For example, results with an estimate of 0.5 will be raised to the power of *e* ($e^{0.5} = 1.65$), indicating that for every unit increase in the independent variable, the odds of presence will increase by 1.65 times. The precision of the model averaged estimator is demonstrated by calculating the unconditional standard error

$(\hat{se}(\hat{\theta}))$ (Burnham and Anderson 1998).

RESULTS

Local and landscape habitat measurements resulted in a range of values (Tables 7-10). Visual obstruction readings ranged from 2.81 to 9.35 cm, distance to treeline varied from 88.8 to 608.9 m, and forb cover ranged from 2.5 to 46.9%. Amounts of pastureland and woodland in the landscape ranged roughly from 14-36% and 7-23% respectively at the 2000 m scale. However, variables did not always present a smooth gradient, and may not have provided enough variation in the data to allow for precise species-habitat associations (Figures 17-20).

Twenty-five bird species were observed using CRP grasslands during the 2005 and 2006 breeding seasons (Table 6). A total of 2,730 individual species observations were recorded (Table 11). Of the 13 species analyzed, local variables and landscape metrics were found in the best models for seven species. No landscape thresholds were observed for any species.

Species with Density Estimates (Linear Regression)

For the grasshopper sparrow, there were eight models with a $\Delta AICc \leq 4$; these included the three % grassland scales, the three % pasture scales, Year, and VOR (Table 12). The best model was percent grassland in the landscape at the 2000 m scale, with a weight (w_i) of 0.3192, and a parameter weight (Σw_i) of 0.4088. However, because the Year model had a $\Delta AICc \leq 2$, it was unclear which model best described the variation observed in grasshopper sparrow densities. The great variability in the data resulted in large standard errors that included zero for every parameter.

Dickcissels had four models with a $\Delta AICc \leq 4$, which were all combinations of the variable VOR and the three % grassland scales (Table 13). The variable having the greatest effect was VOR, being found in all of the top models for a parameter weight of (Σw_i) 0.9951. The best model included VOR and % grassland at the 2000 m scale (% Grass 2000 + VOR, $w_i = 0.3334$). The % Grass 2000 variable improved the model (VOR found alone) enough to counteract the negative effect of attaching an additional parameter (k). Therefore, VOR was the most important variable for dickcissels, but the % Grass 2000 contributed as well. The model '% Grass 1000 + VOR' ($w_i = 0.2596$) also had substantial support from the data with a $\Delta AICc \leq 2$. As with the grasshopper sparrow, the effect of grassland in the landscape was strongest at the largest scale, and diminished with scale.

Meadowlarks and red-winged blackbirds had similar results with Year as the best models, and % Pasture at the 1000 m and 2000 m scales as alternative models (Tables 14-15). The amount of grassland in the landscape had no apparent effect on meadowlark or red-winged blackbird densities in our study. Variation between years was responsible for most of the variation observed in the data. There was some evidence of percent pasture influencing densities, but the effect was weak and variable based on the model averaged estimator and standard error.

Brown-headed cowbirds exhibited a strong response to the densities of meadowlarks in CRP grasslands ($w_i = 0.9777$). The next model was % Pasture at the 2000 m scale, however, it was 11.6 AICc units from the best model.

Species with Presence/Absence Data (Logistic Regression)

The best model for the northern bobwhite was the percent of grassland in the landscape at the 500 m scale ($w_i = 0.5953$) (Table 17). With every one percent increase in the amount grassland in the landscape at the 500 m scale, the odds of finding northern bobwhites increased by 3,249 times. The percent of grassland at the 1000 m scale also had a ΔAICc ≤ 2, but the weight of evidence was not as strong ($w_i = 0.2217$).

Lark sparrows exhibited a mixture of local and landscape variables in the models with a ΔAICc ≤ 4: % Pasture 2000, Litter Depth, % Bare Ground, and Year (Table 18). The best model was a positive relationship with the percent of pasture in the landscape at the 2000 m scale ($w_i = 0.3158$). Results indicated that increasing the amount of pasture in the landscape by 1%, would increase the odds of observing this species by 430 times. Lark sparrows also showed a weaker negative response to litter depth, with a ΔAICc ≤ 2 and a weight (w_i) of 0.2442.

Vertical obstruction reading, shape index, and variation between years were models considered (ΔAICc ≤ 4) for the ring-necked pheasant (Table 19). This species exhibited a positive response to increasing VOR ($w_i = 0.3408$), and a weaker negative response to landscapes with irregularly shaped grasslands ($w_i = 0.2607$). Field sparrows had five models with a ΔAICc ≤ 4 (Table 20). Field sparrows had a weak negative response ($w_i = 0.3595$) to increasingly distant treelines, and a weak but positive response ($w_i = 0.1805$) to grasslands with increasingly irregular shapes.

For the common yellowthroat, there were two models with a ΔAICc ≤ 4, consisting of the % Wood 2000 and Litter Depth (Table 21). This species demonstrated a strong negative relationship with increasing woodland in the landscape at the 2000 m scale ($w_i = 0.7489$).

Bobolinks and sedge wrens exhibited strong positive responses to local habitat variables. Area of the study site (grassland patch) was the best model for bobolinks, with a weight (w_i) of 0.7403 (Table 22). Sedge wrens appeared to be responding to increasing litter depth ($w_i = 0.9968$); with every 1 cm increase in litter depth, the odds of finding sedge wrens increase by 7 (Table 23).

All models included in the analysis of vesper sparrows resulted in having a $\Delta AICc \leq 4$; therefore the weight of evidence for each model was low (Table 24). The best model was the percent of bare ground in the grassland, however, the support for this model was weak ($w_i = 0.1610$). Of the variables measured in this study, none appeared to explain the variation observed in the data for vesper sparrows.

DISCUSSION

Management to benefit grassland birds, especially in areas of intensive agricultural or other land use, requires understanding of landscape effects and potential habitat thresholds. This study evaluated these landscape questions at three scales for 13 avian species that use CRP grasslands, including 7 grassland dependent birds. Landscape variables out to 2000 m in the surrounding landscape affected 6 species (grasshopper sparrow, dickcissel, lark sparrow, common yellowthroat, field sparrow, ring-necked pheasant), indicating that landscapes out to at least 2000 m from nesting areas should be included in management considerations. As the percentage of grassland in the surrounding 2000 m increased, densities of grasshopper sparrows and dickcissels in our CRP study fields increased, and as the percentage of pasture increased, so did the abundances of lark sparrows and vesper sparrows. Northern bobwhites also responded to the percentage of grassland in the surrounding area, though at a smaller scale (500 m).

The scale at which species respond to their environment depends on the particular ecological cues they follow. Species that select for landscapes at the 500 m scale may be selecting for nesting sites with sufficient habitat in close proximity to provide ample food resources. It is difficult to make the same assumption for species selecting landscapes at the 2000 m scale, because it is improbable that grassland species frequently forage out to 2000 m. Two possible explanations for why species would select breeding habitat at larger scales (i.e., 2000 m) include greater rates of return to reproductively successful areas (L. Fahrig, personal communication), and/or attraction to a large assemblage of singing males and potential mates (conspecific attraction).

Results from a study by Horn et al. (2005) showed that ground-nesting ducks in North Dakota experienced greater reproductive success in areas with high amounts of grassland in the landscape (45-55%) when compared to landscapes with lower amounts (15-20%). Several studies have demonstrated that reproductively successful males return to the same site year after year, while unsuccessful males select different breeding grounds the following year (bobolink, Bollinger and Gavin 1989; American robin, brown thrasher; Hass 1998; ovenbird (*Seiurus aurocapillus*), Porneluzi and Faaborg 1999; prothonotary warbler (*Protonotaria citrea*), Hoover 2003). These unsuccessful males have also been shown to select nesting sites adjacent to males that were successful the previous year, referred to as public information (Doligez et al. 2002). Consequently, areas with larger amounts of grassland in the landscape may successfully produce more juveniles, resulting in the return of both successful males and prospecting unsuccessful males to the area. As a result, species abundance may increase in areas with high amounts of grassland in the surrounding landscape.

Larger landscapes may also influence habitat selection by providing greater social cues, which can produce a response known as conspecific attraction, a response where birds are attracted to areas with large numbers of singing males (reviewed in Ahlering and Faaborg 2006). This was demonstrated in a study by Ward and Schlossberg (2004) on black-capped vireos (*Vireo atricapilla*), where playbacks (vireo vocalizations) were used to attract individuals to previously unoccupied sites. Seventy-three individuals were attracted to five study sites, whereas no vireos established territories in the control sites. Many individuals were successful in reproduction, and were observed returning to the same sites the following year.

Possible explanations for conspecific attraction may include assistance with habitat quality assessments, and an increase in reproductive fitness. Males have been found to use conspecifics as indicators of habitat quality (Doligez et al. 2002). Studies suggest that by doing this, species can decrease mortality rates by reducing habitat search and settlement costs (Stamps 1998, Stamps 2001, Fletcher 2006). Juveniles would benefit greatly from conspecific attraction because of their lack of experience in selecting suitable habitat (Muller et al. 1997, Ward and Schlossberg 2004). Other incentives for selecting territories near conspecifics may include greater opportunities for mate selection, extra-pair copulations, and fertilizations (Ramsay et al. 1999, Tarof and Ratcliffe 2004). Further study is needed to determine the extent of influence conspecific attraction has on the habitat selection process of grassland birds.

Seven species in our study exhibited a response to local habitat variables (dickcissels, ring-necked pheasant, field sparrow, lark sparrow, bobolink, sedge wren, vesper sparrow), which have been shown to play an important role in the habitat selection process of grassland birds (see references in the introduction). However, our study sites were not selected according to their local vegetation structure, and may not have provided enough variation in these variables to accurately detect affects on species.

Individual Species

Our results indicate that landscape composition plays an important role in the habitat selection process of grasshopper sparrows. Grasshopper sparrows showed a positive response to the amount of grassland in the landscape at the 2000 m scale, but because the AICc values for Year were comparable (ΔAICc = 1.2), either model could be considered the best model (Burnham and Anderson 1998). Six of the remaining seven alternative models (ΔAICc$\leq$4) for the grasshopper sparrow were composed solely of landscape metrics (% Grass, % Pasture). Other studies have also found an effect of landscape composition on grasshopper sparrow abundance (Ribic and Sample 2001, Fletcher and Koford 2002, Grant et al. 2004, Cunningham and Johnson 2006). As with our results, Cunningham and Johnson (2006) found a response by grasshopper sparrows to the landscape at their largest scale (1600 m). Therefore our results, in conjunction with previous studies, point to the amount of grass in the landscape at the 2000 m scale or greater as being an important factor in grasshopper sparrow abundance.

Our findings are in contrast with previous landscape-level studies, which found that models with local-only or landscape-only metrics were weaker than models that combined the two (Ribic and Sample 2001, Fletcher and Koford 2002, Cunningham and Johnson 2006). Other studies have shown local vegetation structure, in particular VOR, to be a principal factor in grasshopper sparrow habitat selection (Wiens 1969, Sample 1989, Madden et al. 2000, Fletcher and Koford 2002). We did detect a negative response to increasing VOR in our study; however, the effect was weak.

Dickcissels exhibited a strong positive response to the vertical density of the local vegetation (VOR). Previous studies that incorporated both local and landscape variables into analysis of the dickcissel also found the strongest relationship with local vegetation structure (Bakker et al. 2002, Fletcher and Koford 2002). Vertical density has also been shown to be the key variable in dickcissel habitat selection by studies focused solely on local habitat variables (Patterson and Best 1996, Delisle and Savidge 1997, Hughes et al. 1999). This association may be a result of dickcissel nesting preferences. Dickcissels nest in moderate to tall (approx. 50-150 cm), dense (approx. 80-100% cover) vegetation, with nests found approximately 0.15-2 m in height (Zimmerman 1971, Wiens 1973, Patterson and Best 1996, Winter 1998, Winter 1999). Females select mates according to the quality of nest sites available within the male's territory. Males with optimal territories have been observed attracting up to 6 mates (resource-defense polygyny) (Zimmerman 1966).

Therefore, the importance of nesting habitat to the mating system of the dickcissel may be heavily influencing their habitat selection process.

As with the grasshopper sparrow, dickcissel response to the amount of grassland in the landscape was strongest at the largest scale (2000 m). Behaviors observed during the breeding season, such as site fidelity (Zimmerman and Finck 1989) and polygyny (Zimmermann 1966), may lend cause to the theories that reproductive success and conspecific attraction potentially influence dickcissels to select sites at larger scales.

Lark sparrow response to the amount of pasture in the landscape at the 2000 m scale may be attributed to their nesting preferences, and highly social nature. Nests are located on bare ground, in hollow depressions, near the base of woody plants, and in small shrubs or trees (McNair 1985), all characteristics associated with pastures. Previous studies have demonstrated that lark sparrows prefer grazed habitats over ungrazed areas (Bock and Webb 1984, Bock et al. 1984, Lusk et al. 2003). Nesting preferences most likely also explain the observed negative response to litter depth and positive response to bare ground. Site fidelity (Martin and Parrish 2000) and a high degree of sociality (feeding in flocks; Martin and Parrish 2000) may influence lark sparrows to respond to their landscape at the 2000 m scale.

Northern bobwhites showed a strong positive response to the amount of grassland in the surrounding landscape at the 500 m scale. In the Midwest, northern bobwhites are primarily associated with heterogeneous landscapes consisting of grassland, cropland, brushy areas, and woodland cover (Burger and Linduska 1967, Johnsgard 1973, Roseberry and Sudkamp 1998). Recent land-use changes, such as large scale conversions to rowcrops and the establishment of clean farming techniques, are believed to have negatively affected bobwhite abundance by reducing available nesting habitat and food resources (via herbicides and pesticides) (Brennan 1991). This negative response to increasing cropland may provide an explanation of our results. A general trend observed in our study sites was as the amount of grassland in the landscape increased (8-46%), the amount of cropland decreased proportionately (71-14%). Increasing grassland also represented increasing heterogeneity at the 500 m scale because grassland percentages increased to only 46%. Therefore, the positive response observed in northern bobwhites to increasing amounts of grassland in landscapes dominated by rowcrops may be the result of increases in food and nesting resources within an increasingly heterogeneous environment. Northern bobwhites' response to the landscape at the 500 m scale may be attributed to their short dispersal distances (Thogmartin 2002), and non-migratory status. Preference for the local scale (500 m) versus the broader scale (1000 m) can be noted by observing the differences in AICc values and weights between % Grass 500, and the only alternative model, % Grass 1000.

Although common yellowthroats are not considered to be a grassland species, they are commonly observed in grassland habitats characterized by tall, dense vegetation with high concentrations of forbs and shrubs (Herkert 1994, Patterson and Best 1996, Delisle and Savidge 1997, Grant et al. 2004). Our results indicated that common yellowthroats were responding negatively to the amount of woodland habitat in the landscape at the

2000 m scale. These findings are in contrast to a study by Grant et al. (2004), which found a positive response to increasing woodlands at the 500 m scale; however, this effect was not found in their best models.

The occurrence of ring-necked pheasants was positively associated with increasing VOR. Previous studies have shown ring-necked pheasant preference for tall, dense vegetation to provide adequate cover for nesting, brood-rearing, and over-wintering (Herkert 1994, King and Savidge 1995, Riley et al. 1998). Field sparrow occurrence was associated with trees, where the odds of occurrence decreased with increasingly greater distances to the nearest treeline. A study by Cunningham and Johnson (2006) also found field sparrows responding positively to trees located in grasslands, most likely a result of their preference for breeding near woody vegetation (Best 1977, Carey et al. 1994).

Both ring-necked pheasants and field sparrows also responded to the average shape of grasslands in the landscape. The presence of ring-necked pheasants was associated with landscapes characterized by grassland patches that were more compact (square in shape), encompassing less edge habitat. This preference may be attributed to the increase in mortality rates (2% for every 10 m/ha of edge), and decrease in daily survival rates associated with increasing edge for ring-necked pheasants (Schmitz and Clark 1999). The presence of field sparrows, on the other hand, was weakly associated with landscapes characterized by irregularly shaped grasslands (larger perimeter-area ratio, more edge habitat), which may be a consequence of their use of woodland edges (Best 1977, Carey et al. 1994).

In our study, bobolinks, sedge wrens, red-winged blackbirds, and meadowlarks did not respond to any of the landscape metrics measured. Bobolinks were strongly affected by the area of the study site, demonstrating a positive response to increasing patch size; a relationship that was also observed in studies by Herkert (1994), Vickery et al. (1994), and Helzer (1996) who found bobolinks reaching 50% incidence in fields 45-50 ha in size. Ribic and Sample (2001) found bobolink densities to be associated solely with landscape variables, while Bakker et al. (2002) observed associations with only local variables. Inconsistent results may be attributed to differences in study objectives, designs, and explanatory variables.

Sedge wrens exhibited a strong positive response to increasing litter depth, however, they are generally associated with areas of tall, dense vegetation (Herkert 1994, Bakker et al. 2002, Fletcher and Koford 2002, Grant et al. 2004). Wetlands have also been shown to affect sedge wren occurrence at the landscape scale (Fletcher and Koford 2002, Cunningham and Johnson 2006), but wetlands were not present in our study landscapes.

Differences observed between years (2005-2006) accounted for most the variation in red-winged blackbird and meadowlark densities. None of the variables we measured accurately described the fluctuations observed in species densities. Both species had % Pasture (1000, 2000) as alternative models but support for these models was weak. Red-winged blackbirds are generalists (Stauffer and Best 1980), which are able to forage and nest in a wide variety of habitats (Yasukawa and Searcy 1995). Patterson and Best (1996) were also unable to detect a relationship between red-winged blackbird abundance and local vegetation variables. They hypothesized that this was because of the red-winged blackbird's ability to exploit a large array of substrates such that they are not constrained by the variables measured. The presence of wetlands has been associated with red-winged blackbird abundance (Cunningham and Johnson 2006), however wetlands were not present in our study landscapes.

Meadowlarks have been shown to use a wide range of vegetation heights and densities, but responses to local vegetation structure have varied between studies (Herkert 1994, Patterson and Best 1996, Madden et al. 2000, Bakker et al. 2002, Grant et al. 2004; reviews: Dechant et al. 2002, Hull 2003). As with our results, Winter (1998), Winter and Faaborg (1999), and Cunningham and Johnson (2006) found no associations between meadowlark densities and local vegetation characteristics. Studies by Ribic and Sample (2001), and Cunningham and Johnson (2006) determined that meadowlark densities were negatively affected by woodlands in the landscape. Therefore, we considered woodland models *a postori* to determine whether the amount of woodland in the landscape was responsible for the variations in meadowlark densities observed in our study. Including woodlands in the analysis did not significantly alter our results; woodlands at all three scales had a ΔAICc>4.

The finding that brown-headed cowbird densities were strongly associated with those of meadowlarks in CRP grasslands raised interesting questions about why this association would occur. Meadowlarks might serve as specific target species for brown-headed cowbirds, or perhaps even as an indicator species for associated avian communities and habitat characteristics. Brown-headed cowbirds are known to parasitize meadowlark nests, with rates ranging from 0% to 70%, depending on the specific study and region in North America (Shaffer et al. 2003). Meadowlarks' large size (~150 g) and conspicuous behavior may attract the attention of brown-headed cowbirds, thus increasing their chances of being parasitized, and potentially indicating the presence of a grassland bird community as well; brown-headed cowbirds also parasitize the nests of dickcissels, bobolinks, grasshopper sparrows, lark sparrows, vesper sparrows, and field sparrows.

According to Herkert et al. (2002), rates of brood parasitism by brown-headed cowbirds are not a consequence of the degree of fragmentation in the landscape, but of the abundance of cowbirds in the area. Cowbird abundance is commonly associated with moderately to heavily grazed pastures (Kantrud 1981), with scattered trees or woodland edges (Johnson and Temple 1990, Lowther 1993). Thus, the association we found between cowbirds and meadowlark densities might alternatively have resulted from similar habitat preferences. We were unable to find a clear association between meadowlark densities and the habitat variables we measured but, like the brown-headed cowbird, they are also frequently associated with pastureland (Wiens 1969, Sample 1989). Although additional studies are needed to clarify this finding of correlation between brown-headed cowbirds and meadowlarks, the questions this association poses are intriguing.

Vesper sparrow habitat is generally characterized by short, sparse, and patchy vegetation (Best and Rodenhouse 1984, Sample 1989). Our results indicate a response to the percentage of bare ground available in grassland, but the support for this model was weak. A combination of small sample sizes, and a limited amount of variation in the local vegetation measured, may have inhibited our abilities to detect important relationships between local habitat characteristics and vesper sparrow occurrence.

Thresholds

No habitat thresholds were observed indicating that the species studied would be present, albeit in lower densities, regardless of surrounding habitat amounts. However, our study fields were larger than minimum area requirements of the species analyzed, so the fields might have been large enough to obscure surrounding grassland threshold effects. According to Helzer (1996), area requirments for a 50% chance of species occurrence is approximately 10 ha for grasshopper sparrows and 5 ha for meadowlarks. Had we been able to locate smaller study fields (~10 ha), it is possible that surrounding habitat would have had greater importance and a threshold effect might have been observed. Consistent with this point is the fact that bobolinks, which require roughly 45-50 ha (Herkert 1994, Helzer and Jelinski 1999), were present in the three largest fields (area: 24.7, 17.0, and 15.6 ha) and in two others with ≥21% grassland in the surrounding landscape out to 500 m, the area most likely to provide nearby food or other resources. So although our results do not provide support for a threshold effect, they also do not eliminate the possibility that one could exist.

CONCLUSION

Our results indicated that both local and landscape variables influenced grassland bird densities in southeastern Nebraska. Landscape metrics, such as the amount of grassland, pastureland, and woodland, proved to be important factors in the habitat selection processes of grasshopper sparrows, dickcissels, lark sparrows, and common yellowthroats at the 2000 m scale, and for the northern bobwhite at the 500 m scale. Other species were shown to be more affected by local patch characteristics, such as area (bobolink), and vegetation structure (dickcissel, ring-necked pheasant, sedge wren). Therefore, species that use CRP grasslands would benefit from management plans that consider both the quality of grassland patches at the local level, and the proportion of grassland habitat in the landscape out to at least 2000 m. These results may assist in the allocation of grassland habitat restoration funds, and in determining optimal locations for establishing new grasslands by local and federal programs, such as the Conservation Reserve Program.

The tendency observed in grassland birds to respond to landscapes at the highest scale (2000 m) may signify that species are affected by the composition of the landscape at even greater scales than previously believed (>2000 m). Future studies should consider encompassing larger landscape areas to determine the scale in which species interact with their environment. The results will assist in developing appropriate management strategies to include species landscape-level habitat requirements.

Although researchers have acknowledged potentially valuable landscape influences on grassland bird populations, few studies have investigated the effects of landscape structure and composition on grassland bird abundance, or the scales at which they respond to their environment. Although we did not detect any landscape habitat thresholds, we demonstrated the value of including landscape-level variables in the analysis of grassland birds. The amount of grassland and pastureland in the surrounding landscape was shown to be an important factor in abundance of grasshopper sparrows, dickcissels, northern bobwhites, lark sparrows, and vesper sparrows; all species which are currently experiencing significant population declines (Sauer et al. 2005). Our results indicate that planting or managing to achieve areas with higher percentages (20-40%) of suitable grassland in the landscape would benefit these declining grassland species.

LITERATURE CITED

Ahlering, M. A., and J. Faaborg. 2006. Avian habitat management meets conspecific attraction: If you build it, will they come? The Auk 123:301-312.

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

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

Best, L. B. 1977. Territory Quality and Mating Success in the Field Sparrow (*Spizella pusilla*). Condor 79:192-204.

Best, L. B., and N. L. Rodenhouse. 1984. Territory preference of Vesper Sparrows in cropland. Wilson Bulletin 96:72-82.

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

Bock, C. E., and B. Webb. 1984. Birds as grazing indicator species in southeastern Arizona. Journal of Wildlife Management 48:1045-1049.

Bock, C. E., J. H. Bock, W. R. Kenney, and V. M. Hawthorne. 1984. Responses of birds, rodents, and vegetation to livestock exclosure in a semidesert grassland site. Journal of Range Management 37:239-242.

Bollinger, E. K., and T. A. Gavin. 1989. The effects of site quality on breeding-site fidelity in Bobolinks. Auk 106:584-594.

Bragg, T. B., and L. C. Hulbert. 1976. Woody plant invasion of unburned Kansas bluestem prairie. Journal of Range Management 29:19-24.

Brennan, L. A. 1991. How can we reverse the Northern Bobwhite population decline? Wildlife Society Bulletin 19:544-555.

Burger, G. V., and J. P. Linduska. 1967. Habitat management related to bobwhite populations at Remington Farms. Journal of Wildlife Management 31:1-12.

Burnham, K. P. and D. R. Anderson. 1998. Model selection and inference, a practical information theoretic approach. Springer-Verlag, New York. 353 pages.

Carey, M., D. E. Burhans, and D. A. Nelson. 1994. Field Sparrow (*Spizella pusilla*). In *The Birds of North America*, No. 103 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural sciences: Washington, D.C.: The American Ornithologists' Union.

Coppedge, B. R., D. M. Engle, R. E. Masters, and M. S. Gregory. 2001. Avian response to landscape change in fragmented Southern Great Plains grasslands. Ecological Applications 11:47-59.

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

Davis, S. K. 2004. Area sensitivity in grassland passerines: Effects of patch size, patch shape, and vegetation structure on bird abundance and occurrence in southern Saskatchewan. The Auk 121:1130-1145.

Dechant, J. A., M. L. Sondreal, D. H. Johnson, L. D. Igl, C. M. Goldade, a. L. Zimmerman, and B. R. Euliss. 2002. Effects of management practices on grassland birds: Western Meadowlark. Northern Prairie Wildlife Research Center, Jamestown, ND. 33 pages.

Delisle, J. M, and J. A. Savidge. 1997. Avian use and vegetation characteristics of conservation reserve program fields. Journal of Wildlife Management 61:318-325.

Doligez, B., E. Danchin, and J. Clobert. 2002. Public information and breeding habitat selection in a wild bird population. Science 297:1168-1170.

Environmental Systems Research Institute (ESRI). 2004. ArcGIS. Version 9.0. Environmental Systems Research Institute, Redlands, California, USA.

Fahrig, L. 1997. Relative effects of habitat loss and fragmentation on population extinction. Journal of Wildlife Management 61(3):603-610.

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

Fletcher, R. J., Jr. 2006. Emergent properties of conspecific attraction in fragmented landscape. American Naturalist 168:207-219.

Grant, T. A., E. Madden, and G. B. Berkey. 2004. Tree and shrub invasion in northern mixed-grass prairie: Implications for breeding grassland birds. Wildlife Society Bulletin 32:807-818.

Hass, C. A. 1998. Effects of prior nesting success on site fidelity and breeding dispersal: An experimental approach. Auk: 115:929-936.

Helzer, C. J. 1996. The effects of wet meadow fragmentation on grassland birds. M. S. thesis. University of Nebraska-Lincoln, Nebraska. 65 pages.

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

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

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

Herkert, J. R., M. Winter, E. J. Finck, S. K. Sherrod, and S. K. Robinson. 2003. Effects of prairie fragmentation on the nest success of bredding birds in the Midcontinental United States. Conservation Biology 17:587-594.

Hill, M. F., and H. Caswell. 1999. Habitat fragmentation and extinction thresholds on fractal landscapes. Ecology Letters 2:121-127.

Hoover, J. P. 2003. Decision rules for site and territory fidelity in a migratory songbird. Ecology 84:416-430.

Horn, D. J., M. L. Phillips, R. R. Koford, W. R. Clark, M. A. Sovada, and R. J. Greenwood. 2005. Landscape composition, patch size, and distance to edges: Interactions affecting duck reproductive success. Ecological Applications 15:1367-1376.

Howell, C. A., S. C. Latta, T. M. Donovan, P. A. Porneluzi, G. R. Parks, and J. Faaborg. 2000. Landscape effects mediate breeding bird abundance in Midwestern forests. Landscape Ecology 15:547-562.

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

Hull, S. D. 2003. Effects of management practices on grassland birds: Eastern Meadowlark. Northern Prairie Wildlife Research Center, Jamestown, ND. 35 pages.

Johnsgard, P. A. 1973. Grouse and quail of North America. M.S. thesis. University of Nebraska-Lincoln, Nebraska. 553 p.

Johnson, D. H., and M. D. Schwartz. 1993. The Conservation Reserve Program and grassland birds. Conservation Biology 7:934-937.

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

Kantrud, H. A. 1981. Grazing intensity effects on the breeding avifauna of North Dakota native grasslands. Canadian Field-Naturalist 95:404-417.

King, J. W., and J. A. Savidge. 1995. Effects of the Conservation Reserve Program on wildlife in southeast Nebraska. Wildlife Society Bulletin 23:377-385.

Lamberson, R. H., R. McKelvey, and B. R. Noon Curtis Voss. 1992. A dynamic analysis of northern spotted owl viability in a fragmented forest landscape. Conservation Biology 6(4):505-512.

Lande, R. 1987. Extinction thresholds in demographic models of territorial populations. The American Naturalist 130:624-635.

Lanyon, W. E. 1994. Western Meadowlark (*Sturnella neglecta*). In *The Birds of North America*, No. 104 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Lanyon, W. E. 1995. Eastern Meadowlark (*Sturnella magna*). In *The Birds of North America*, No. 160 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Lee, M., L. Fahrig, K. Freemark, and D. J. Currie. 2002. Importance of patch scale vs landscape scale on selected forest birds. Oikos 96:110-118.

Lowther, P. E. 1993. Brown-headed cowbird (Molothrus ater). In The birds of North America, No. 47 (A. Poole and F. Gill, editors). The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington, D.C.

Lusk, J. J., K. S. Wells, F. S. Guthery, and S. D. Fuhlendorf. 2003. Lark Sparrow (*Chondestes grammacus*) nest-site selection and success in a mixed-grass prairie. The Auk 120:120-129.

Madden, E. M., R. D. Murphy, A J. Hansen, and L. Murray. 2000. Models for guiding management of prairie bird habitat in Northwestern North Dakota. American Midland Naturalist 144:377-392.

Martin, S. G., and T. A. Gavin. 1995. Bobolink (*Dolichonyx oryzivorus*). *In* The Birds of North America, No. 176 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.

Martin, J. W., and J. R. Parrish. 2000. Lark Sparrow (*Chondestes grammacus*). In The Birds of North America, No. 488 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Maurer, B. A. 1986. Predicting habitat quality for grassland birds using density-habitat correlations. Journal of Wildlife Management 50:556-566.

McGarigal, K., S. A. Cushman, M. C. Neel, and E. Ene. 2002. FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps. University of Massachusetts, Amherst. www.umass.edu/landeco/research/fragstats/fragstats.html. Sept. 2006.

McNair, D. B. 1985. A comparison of oology and nest record card data in evaluating the reproductive biology of Lark Sparrows, *Chondestes grammacus*. Southwestern Naturalist 30:213-224.

Mueller, K. L., J. A. Stamps, V. V. Krishnan, and N. H. Willits. 1997. The effects of conspecific attraction and habitat quality on habitat selection in territorial birds (*Troglodytes aedon*). American Naturalist 150:650-661.

Naugle, D. E., K. F. Higgins, S. M. Nusser, and W. C. Johnson. 1999. Scale-dependent habitat use in three species of prairie wetland birds. Landscape Ecology 14:267-276.

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

Perkins, M. W., R. J. Johnson, and E. E. Blankenship. 2003. Response of riparian avifauna to percentage and pattern of woody cover in an agricultural landscape. Wildlife Society Bulletin 31:642-660.

Porneluzi, P. A., and J. Faaborg. 1999. Season-long fecundity, survival, and viability of Ovenbirds in fragmented and unfragmented landscapes. Conservation Biology 13:1151-1161.

Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. DeSante. 1993. Handbook of field methods for monitoring landbirds. U.S. Department of Agriculture, U. S. Forestry Service, Pacific Southwest Research Station, General Technical Report PSW-GTR-144. Albany, California, USA.

Ramsay, S. M., K. Otter, and L. M. Ratcliffe. 1999. Nest-site selection by female Black-capped Chickadees: Settlement based on conspecific attraction? Auk 116:604-617.

Renfrew, R. B., C. A. Ribic, and J. L. Nack. 2005. Edge avoidance by nesting grassland birds: A futile strategy in a fragmented landscape. The Auk 122:618-636.

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

Riley, T. Z., W. R. Clark, K. E. Ewing, and P. A. Vohs. 1998. Survival of Ring-necked Pheasant chicks during brood rearing. Journal of wildlife management 62:36-44.

Robbins, C. S. 1981. Bird activity levels related to weather. Pages 52-57 in C. J. Ralph, J. M. Scott, editors. Studies in Avian Biology Number 6: Estimating numbers at terrestrial birds. Proceedings of an International Symposium, cooper Ornithological Society, Asilomar, California, USA.

Roseberry, J. L., and S. D. Sudkamp. 1998. Assessing the suitability of landscapes for Northern Bobwhite. Journal of Wildlife Management 62:895-902.

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

Sample, D. W. 1989. Grassland birds in southern Wisconsin: habitat preference, population trends, and response to land use changes. M.S. thesis. University of Wisconsin, Madison, Wisconsin. 588 pages.

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

SAS Institute Incorporated. 2003. SAS/STAT User's Guide, Version 9.1. SAS Institute, Cary, NC, USA.

Sauer, J. R., J. E. Hines, and J. Fallon. 2005. The North American Breeding Bird Survey, Results and Analysis 1966 - 2004. Version 2005.2. USGS Patuxent Wildlife Research Center, Laurel, MD.

Schmitz, R. A., and W. R. Clark. 1999. Survival of Ring-necked Pheasant hens in relation to landscape features. Journal of Wildlife management 63:147-154.

Shaffer, J. A., C. M. Goldade, M. F. Dinkins, D. H. Johnson, L. d. Igl, and B. R. Euliss. 2003. Brown-headed cowbirds in grasslands: Their habitats, hosts, and response to management. Prairie Naturalist 35:145-186.

Stamps, J. A. 1998. Conspecific attraction and aggregation in territorial species. American Naturalist 131:329-347.

Stamps, J. A. 2001. Habitat selection by dispersers: integrating proximate and ultimate approaches. Pages 230-242 in J. Clobert, E. Danchin, A. A. Dhondt, and J. D. Nichols, eds. Dispersal. Oxford University Press, New York.

Stauffer, D. f. and L. B. Best. 1980. Habitat selection by birds of riparian communities: Evaluating effects of habitat alterations. Journal of Wildlife Management 44:1-15.

Sunderman, N. J. 1995. Avian use of field windbreaks, herbaceous fencerows, and associated cropfields in east central Nebraska. MS Thesis, University of Nebraska-Lincoln, Nebraska, 108 pages.

Tarof, S. a., and L. M. Ratcliffe. 2004. Habitat characteristics and nest predation do not explain clustered breeding in Least Flycatchers (*Empidonax minimus*). Auk 121:877-893.

Temple, S. A. 2002. Dickcissel (*Spiza americana*). In *The Birds of North America*, No. 2703 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Thogmartin, W. E. 2002. Spatio-temporal dynamics of Northern Bobwhite (*Colinus virginianus*) in Illinois. M. S. thesis. Southern Illinois University, Illinois. 308 pages.

Thomas, L., Laake, J.L., Strindberg, S., Marques, F.F.C., Buckland, S.T., Borchers, D.L., Anderson, D.R., Burnham, K.P., Hedley, S.L., Pollard, J.H., Bishop, J.R.B. and Marques, T.A. 2006. Distance 5.0. Release 1. Research Unit for Wildlife Population Assessment, University of St. Andrews, UK. http://www.ruwpa.st-and.ac.uk/distance/.

United States Department of Agriculture (USDA), Economic Research Service. 2005. Washington, D.C. Http://www.ers.usda.gov/statefacts/NE.HTM. Accessed January 2006.

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

Vickery, P. D. 1996. Grasshopper Sparrow (*Ammodramus savannarum*). In *The Birds of North America*, No. 239 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Villard, M., M. K. Trzcinski, and G. Merriam. 1999. Fragmentation effects of forest birds: Relative influence of woodland cover and configuration on landscape occupancy. Conservation Biology 13:774-783.

Ward, M. P., and S. Schlossberg. 2004. Conspecific attraction and the conservation of territorial songbirds. Conservation Biology 18:519-525.

Wiens, J. A. 1969. An approach to the study of ecological relationships among grassland birds. Ornithological Monographs 8:1-93.

Wiens, J. A. 1973. Pattern and process in grassland bird communities. Ecological Monographs 43:236-270.

Winter, M. 1998. Effect of habitat fragmentation on grassland-nesting birds in southwestern Missouri. Ph.D. Dissertation, University of Missouri-Columbia. 215 pages.

Winter, M. 1999. Nesting biology of Dickcissels and Henslow's Sparrows in Missouri prairie fragments. Wilson Bulletin 111:515-527.

Winter, M., and J. Faaborg. 1999. Patterns of area sensitivity in grassland-nesting birds. Conservation Biology 13:1424-1436.

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

With, K. A., and A. W. King. 1999. Dispersal success on fractal landscapes: a consequence of lacunarity thresholds. Landscape Ecology 14:73-82.

Yasukawa, K., and W. A. Searcy. 1995. Red-winged Blackbird (*Agelaius phoeniceus*). In *The Birds of North America*, No. 184 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Zimmerman, J. L. 1966. Polygyny in the Dickcissel. Auk 83:534-546.

Zimmerman, J. L. 1971. The territory and its density dependent effect in *Spiza americana*. Auk 88:591-612.

Zimmerman, J. L., and E. J. Finck. 1989. Philopatry and correlates of territory fidelity in male Dickcissels. North American Bird Bander 14:83-85.

2

FORAGING PATTERNS AND CONTRAINTS OF GRASSLAND BIRDS IN CROPFIELDS

INTRODUCTION

Historically, grasslands were the predominant ecosystem of the Midwest. Nebraska was covered by an estimated 13.8 million hectares of tallgrass and mixed grass prairies (Samson and Knopf 1994). Large-scale conversions of native prairie to agriculture have drastically changed the landscape today. In 2002, farmland comprised 93.3% of Nebraska's total land area, 49.1% of which was planted into row crops (USDA 2005). The widespread declines observed in many grassland bird populations have been primarily attributed to the severe loss and degradation of their grassland habitat (Johnson and Schwartz 1993, Herkert 1995, Coppedge et al. 2001).

As the natural habitat of grassland birds decreases, cropfields have the potential to become a supplemental source of avian resources. More than 50 species of birds have been observed using cropfields (Best et al. 1995; 2001, Beecher et al. 2002), primarily to feed (Best et al. 1990; 1995). Grassland and other birds such as the vesper sparrow, lark sparrow, red-winged blackbird, brown-headed cowbird, and both the eastern and western meadowlark, are believed to provide important economic benefits to farmers because of their potential services in pest control (Kirk et al. 1996). However, various constraints observed in cropfields may deter their use of the available cropland.

Increasing energetic costs and predation risks may limit the distance to which grassland birds forage into cropfields. Use of cropfields has been shown to depend on the concentration of food resources available, and the protective vegetative cover provided (Rodenhouse and Best 1994, Beecher et al. 2002). The cost of searching for food must be exceeded by the nutritional benefit of the prey item (Benton et al. 2002). Arthropods are typically found at greater numbers near cropfield edges than in the cropfield interior (Kemp and Barrett 1989). Birds also prefer to remain near edges where there is better protective cover from avian predators (Rodenhouse and Best 1994, Best et al. 1995). Best et al. (1990) determined that the number of birds found along the perimeter of cornfields (< 50 m from edge) during the breeding season was five times that found at the center. These findings were supported by Rodenhouse and Best (1994), Fitzmaurice (1995), and Sunderman (1995), who reported having the greatest proportion of bird observations in cropfields within 50 m of an edge. According to Best et al. (1990), the optimum cropfield size to maximize bird use would be 4 hectares, where the entire field would consist of 'perimeter' habitat only 50 m from the nearest edge. Further increases in cropfield sizes would cause a decrease in the field-perimeter ratio, causing bird abundance to fall logarithmically. Although the Best et al. (1990) concept of edge is clear, a 4 ha field would have a 1 ha core area more than 50 m from an edge.

Bird use of cropfields is also affected by the type of edge vegetation present (Best et al. 1995, Fitzmaurice 1995, Sunderman 1995). Woody vegetation elicits edge-avoidance responses in many grassland birds as has been observed in the bobolink (Johnson and Temple 1990, Helzer 1996, Ribic and Sample 2001, Grant et a. 2004, Cunningham and

Johnson 2006), dickcissel (Hughes et al. 1999, Henningsen and Best 2005), grasshopper sparrow (Johnson and Temple 1990, Bakker et al. 2002, Grant et a. 2004, Cunningham and Johnson 2006), sedge wren (Johnson and Temple 1990, Bakker et al. 2002, Grant et a. 2004, Cunningham and Johnson 2006), eastern meadowlark (Ribic and Sample 2001, Henningsen and Best 2005), and western meadowlark (Bakker et al. 2002, Grant et al. 2004, Cunningham and Johnson 2006). Increases in predation and nest parasitism rates are potential causes of woodland avoidance by grassland birds (Johnson and Temple 1990, O'Leary and Nyberg 2000, Winter et al. 2000). Studies by Fitzmaurice (1995) and Sunderman (1995) have indicated that some grassland birds avoid woody edges by more than 50 m. The presence of a woodland edge bordering a cropfield would act as a constraint, therefore increasing the optimum field size for grassland birds.

Data on foraging patterns and constraints of grassland birds are required to determine optimum field sizes to maximize use of cropfields, which will in turn optimize crop pest control by grassland birds. We conducted bird surveys in cropfields of various widths located between grassland and woodland edges to determine the distances grassland birds forage into cropfields and the changes in foraging patterns resulting from progressively closer woodland edges. Analyses were also performed to determine whether species densities in adjacent grasslands or species of crop planted affected abundance levels observed in cropfields.

METHODS

Our study was conducted in southeastern Nebraska, an area principally dominated by agriculture. Much of the remaining grassland habitat in the area is Conservation Reserve Program grasslands (Chapter 1, page 5). The cropfields and grasslands located in the study area are commonly intersected by woodlands, which generally consist of riparian areas, windbreaks, and shelterbelts. Historically, the natural cycle of fire prevented the spread of woodlands onto the Great Plains, but the suppression of fire and the agricultural practice of planting trees to provide protection from the elements, increased the amount of woodlands in the area.

Study Design

Fifteen study sites were selected across nine counties in southeastern Nebraska (Figure 1). Sites were located using rectified Digital Ortho Quarter Quad photos (taken in 2003), and on-site investigations. All study sites had a Conservation Reserve Program (CRP) grassland adjacent to a corn, soybean, or sorghum cropfield. The grassland formed one edge of the cropfield and the opposite edge was a woody habitat (e.g. wooded riparian, windbreak), with the two edges separated by ~100 to 300 m of crops, depending on the site (Figures 2-16, Table 25). This variation in cropfield widths allowed us to observe the degree to which woody habitat acted as a constraint to grassland birds, therefore altering their foraging pattern.

Bird Surveys

Birds were surveyed using line transects, which ran perpendicular between the grassland and woodland edges (Figures 2-16). Because of the low incidence of bird detections in cropfields, transects were walked twice (across and back). In order to allow birds to settle after the disturbance, a delay of 10 minutes or more was observed between survey walks. Transects were walked at approximately 10 m per minute (Ralph et al. 1993), and all birds seen or heard were recorded; birds flying over the transect were noted but not included in the data set

When a bird was detected in a cropfield, a GPS (global positioning system) waypoint was created (GeoExplorer 3, Trimble, Sunnyvale, CA) to reference the exact location where the observation was made, and the distance and angle to each bird was measured using a LaserAce 300 range finder (Measurement Devices Ltd., Houston, TX). The data collected was later used to calculate the exact location of each bird observed in the cropfields (see 'Location Calculations' below).

Two to four sites were surveyed per day, contingent on travel and time restrictions. Sites were grouped to ensure varying cropfield widths were represented each day. Each site was surveyed four times from early June through mid-July 2005, and five times from mid-May through the end of July 2006. Surveys were performed between sunrise and five hours later, and were not conducted during rain or heavy winds (> 20 kph) (Robbins 1981). Sites were surveyed at different times of the morning during each round to reduce any potential temporal biases (e.g., bird activity, temperature). As described in Chapter 1 (page 7), eastern and western meadowlarks were combined into one group called 'meadowlarks.'

A modified ladder-assisted line transect was used after the cornfields grew to a height (~ 1.5 m) that made observations in the field difficult. With the assistance of a ladder, observations were executed along the transect line every 50 m, for 5 minute intervals. Only birds detected in front of the line of observation (180 degrees) were recorded. Both survey methods allowed an equal amount of total observation area and time per field.

A technician was hired to assist with field work during the 2006 season. Surveys by the technician were conducted using a Bushnell YardagePro 500 range finder (Bushnell Corporation, Overland Park, KS). To reduce any potential observer biases, all sites were surveyed as equally as possible by both observers (AH: three surveys, Tech: two surveys). Observers alternated sites each week.

Local Habitat Variables

Height of the crops was measured using a meter-long measuring stick. As cornfields grew to heights > 2 m, a decimeter-marked ladder was used to measure the heights. Measurements were taken from the ground to the highest point on the crop. Descriptions of the non-crop vegetation (Beecher et al. 2002), insect concentration, and soil moisture of cropfields were also recorded based on field observation criteria (Table 26). Woodland edges were not measured, however, all edges presented a solid continuous treeline, with a height of 7 m or greater. Woodlands in this area typically contain hackberry (*Celtis* *occidentalis*), American plum (*Prunus americana*), American elm (*Ulmus americana*), and green ash (*Fraxinus pennsylvanica*) (Perkins et al. 2003).

Location Calculations

Exact locations (i.e., Universal Transverse Mercator (UTM) coordinates; Northing, Easting) of birds in the cropfields were determined using the observer's reference point (GPS waypoint referencing exact site of observation), and the corresponding data collected on the distance (b) and angle (a) to each bird observed (Figure 21). The calculated distances of 'X' and 'Y' were added or subtracted to the UTM coordinates of the observer to determine coordinates of the bird using Excel. Distances were added or subtracted depending on the direction of the bird relative to the observer (north, south east, or west). Distance 'X' was added to the observers northing coordinate if the angle measured was between $270^\circ < a < 90^\circ$, and subtracted if the angle was between $270^\circ > a > 90^\circ$. Distance 'Y' was added or subtracted to the observers easting if the angle was between $0^\circ < a < 180^\circ$, or $0^\circ > a > 180^\circ$ respectively (Figure 22).

The UTM coordinates calculated for each bird observation were brought into a GIS (ESRI 2004), where distances to both grassland and woodland edges were measured using aerial photos and the Arc Map measuring tool.

Data Analysis

Various analyses were preformed to examine species abundance and location in cropfields using linear regression and descriptive statistics. In this chapter, abundance will refer to the total number of observations made for each species, per year. Pearson correlation coefficients (r) were derived to measure the strength of the linear relationship between CRP densities (calculated in Chapter 1) and cropfield abundances for grasshopper sparrows, dickcissels, meadowlarks, red-winged blackbirds and brown-headed cowbirds. Associations between cropfield abundances and CRP densities, species of crop, and cropfield widths were analyzed for each of these five species using the PROC MIXED procedure in SAS (SAS Institute, Inc. 2003). The information-theoretic method, using Akaike's Information Criterion (AICc), was used to determine which model(s) best explained the variation observed in the data (Burnham and Anderson 1998); a more in-depth explanation of this procedure can be found in Chapter 1 (pages 14-15). Associations for the remaining species could not be analyzed because of low sample sizes observed in the CRP grasslands.

Descriptive statistics were used to demonstrate locations of seven species in cropfields; four grassland birds of particular interest (i.e., grasshopper sparrow, dickcissel, meadowlark, vesper sparrow), and the remaining three most abundant species observed (observations ≥ 140; red-winged blackbird, brown-headed cowbird, lark sparrow). Minimum, maximum, and mean distances into cropfields were calculated for each species to distinguish potential patterns of foraging distances into cropfields and woodland edge avoidance.

RESULTS

Thirty-eight species were observed in cropfields during the 2005 and 2006 breeding seasons (Table 27), for a total of 1,170 observations (Table 28). Species with the most observations included the brown-headed cowbird, dickcissel, lark sparrow, and red-winged blackbird. Roughly 75% of grassland-dependent birds in our study (grasshopper sparrow, dickcissel, meadowlark) were found within 65 m of the grassland (Figure 23a). Although lark sparrows and vesper sparrows are classified as a successional-scrub and a grassland species (Gough et al. 1998), they were not included in the grassland-dependent analysis because of their use of cropfields as breeding habitat. Approximately 75% of birds commonly found in CRP grasslands (grasshopper sparrow, dickcissel, meadowlark, red-winged blackbird, brown-headed cowbird) were found within 100 m from the grassland edge (Figure 23b).

There was a strong association between the abundance of grasshopper sparrows in cropfields and their densities in adjacent CRP grasslands ($w_i = 1.0$, $|r| = 0.78$; Table 29). Results indicated that as densities in grasslands increased by one, observations in cropfields increased by 6.5 birds. There were very few observations of grasshopper sparrows in cropfields (i.e., 13). They were observed at six sites, with a maximum distance of 58.5 m, and an overall mean of 11.5 m from the grassland edge (Table 30, Figure 24). Roughly 75% of all sightings were within 10 m of the grassland edge (Figure 25). In our study, grasshopper sparrows did not forage far enough into cropfields to detect an affect of the woodland edge.

Dickcissel abundance was associated with the species of crop planted ($w_i = 0.99$), however, the standard errors of the coefficients were large and encompassed zero (Table 31). Dickcissels were observed at thirteen sites, and although they were observed 250.9 m from the grassland edge, their overall mean distance into cropfields was 49.1 m (Table 30, Figure 26). Approximately 75% of all observations were within 80 m of the grassland edge (Figure 27). Dickcissels did not appear to be affected by the woodland edge; they were observed using cropfields 8.9 m from the edge, and were often seen using the woodland edge to perch.

Meadowlark abundance in cropfields was positively associated with their densities in the adjacent CRP grasslands, however the estimate standard errors were large and encompassed zero (Table 32). They were observed at nine sites, with a maximum distance of 96.6 m, and an overall mean of 39.0 m (Table 30, Figure 28). Roughly 75% of meadowlarks were observed within 60.0 m of the grassland edge (Figure 29). Meadowlarks were not observed in cropfields within 44.0 m of the woodland edge.

Although there was a correlation between red-winged blackbird abundance in cropfields and their densities in the adjacent CRP grasslands ($|r| = 0.50$), their strong association with the sorghum field resulted in a best model of Crop (Table 33). Red-winged blackbirds were observed in ten fields, at a maximum distance of 233.6 m from the grassland edge, with an overall mean of 79.5 m (Table 30, Figure 30). Approximately 75% of red-winged blackbirds were found within 120 m of the grassland edge (Figure

31). They were observed in cropfields 0.5 m from the woodland edge, as well as using the edge to perch.

Brown-headed cowbird abundance in cropfields was associated with the species of crop planted; however, standard errors were large and encompassed zero (Table 34). They were observed across the widths of fields with an overall mean distance of 75.0 m, and a maximum distance of 279.3 m (Table 30, Figure 32). Roughly 75% of brown-headed cowbirds were observed within 110 m of the grassland edge (Figure 33). Brown-headed cowbirds were observed in cropfields within 0.1 m of the woodland edge, and were also observed perching in it.

Lark sparrows were observed at thirteen sites, and were generally found across the entire cropfield (Figure 34). They were observed at a maximum of 288.3 m from the grassland edge, and within 0.1 m from the woodland edge (Table 30). Their overall mean distance from the grassland edge was 104.7 m, but this overall distance was limited by the smaller fields with narrower widths. Mean distances were usually found near the center of the field, or closer to the woodland edge. Lark sparrows were commonly seen perching in the woodland edge.

Vesper sparrows were also observed across the cropfields; however, they appeared to avoid the woodland edge and generally used the center of the field (Figure 35). They were observed in ten cropfields, with an overall mean of 72.3 m from the grassland edge, and at a minimum distance of 44.6 m from the woodland edge (Table 30).

DISCUSSION

Most of the species detected using cropfields in our study were found at low abundances, resulting in small sample sizes and large standard errors. According to Best et al. (1995), the majority of birds observed in cropfields were classified as rare or occasional visitors. Agricultural practices such as planting, tilling, and chemical applications can create disturbances that alters habitat, damages nests, and deters use of cropfields (Rodenhouse and Best 1983, Best and Hill 1986).

Roughly 75% of grassland-dependent birds in our study (grasshopper sparrow, dickcissel, meadowlark) were observed within 65 m of the grassland edge; 75% of the five most abundant birds in CRP grasslands (grasshopper sparrow, dickcissel, meadowlark, red-winged blackbird, brown-headed cowbird) were observed within 100 m of the grassland edge. Foraging distances, however, appeared to be species-specific, dependent on particular life history traits. Grasshopper sparrows were a relatively timid species in that they rarely left the protective cover of their native habitat to forage into cropfields. Our results are supported by Best et al. (1995) who compiled data from 60 sources and determined that grasshopper sparrows were a rare species in cropfields (0-5 observations / census / 100 ha).

Dickcissels and meadowlarks had similar mean foraging distances into cropfields, but their foraging patterns varied. Although we had few observations of meadowlarks, they preferred to remain more consistently near the grassland habitat and avoided using cropfields near the woodland edge; an observation also observed by Fitzmaurice (1995) and Sunderman (1995). Dickcissels were frequently detected in cropfields, and were observed at greater distances from the grassland edge. They were observed using cropfields close to the woodland edge, and therefore appeared not to be constrained by the woodland. Dickcissels were also observed using old corn stalks from the previous year to perch on and sing from, potentially increasing the inhabitable area of the cropfield. Using the woodland edge and old corn stalks to perch may have facilitated the dickcissels use of cropfields.

Although meadowlarks avoided using cropfields adjacent to woodlands, like the dickcissel, they have been observed perching in windbreaks (Johnson and Beck 1988). Species may use woodland edges to scan cropfields for predators or potential feeding sites, or use them to seek cover from predation. This may help explain the pattern observed in dickcissels and meadowlarks, where they appeared to fly further into cropfields that were shorter in width (Figure 26: ≤175 m, Figure 28: ≤150). Perhaps narrower cropfields allow species to seek cover in either direction (towards grassland or woodland edge) if necessary, allowing them to use more of the cropfield. When foraging in larger fields (e.g., >200 m), these birds would not be able to forage as far into cropfields because of the greater distances they would have to travel to reach the safety of either edge.

Red-winged blackbirds and brown-headed cowbirds are habitat generalists that are able to exploit many different habitats, including rowcrops and woodlands (Stauffer and Best 1980, Best et a. 1995, Yasukawa and Searcy 1995). Their ubiquitous nature allows them to have unrestricted use of much of the cropfield; however, their mean overall distances at each site remained consistently closer to the grassland edge (within ~120 m).

Lark sparrows and vesper sparrows nest in rowcrops, and can therefore be found scattered across cropfields. Whereas species nesting in CRP fields exhibited general trends (at all of the study sites) of foraging at proximate distances from the grassland edge, lark sparrows and vesper sparrows followed no such pattern. Lark sparrows were commonly observed across the entire field, whereas vesper sparrows seemed to prefer to remain near the center of the cropfield, away from the edges. These tendencies appear related to their specific habitat preferences. Lark sparrows are common inhabitants of grasslands, cropfields, and woodland edges (Rising 1974, Prescott 1997; cited in Dechant et al. 2002), conversely vesper sparrows prefer open habitats with short, sparse vegetation and little cover (Wiens 1969, Sample 1989).

Other factors such as species of crop, amount of crop residue, and bird densities in adjacent grasslands can also influence the abundance and location of grassland birds in cropfields. Species of crop planted was the best model for explaining the variation observed in abundances for several species, but the relationship was only significant for the red-winged blackbird. Estimates for red-winged blackbirds in sorghum fields were high, but this may have been a consequence of water rather than of crop. Our study consisted of only one sorghum field, which was also the only study site near a large cattle pond, therefore it may have been the water source, and not the crop, that attracted the larger numbers of red-winged blackbirds to the site.

Crop residue in fields may have also influenced bird use. Dickcissels, vesper sparrows, and lark sparrows were observed singing from old corn stalks remaining from the previous year; a behavior previously detected in vesper sparrows (Rodenhouse and Best 1983; 1994). Birds may prefer to forage in cropfields with greater amounts of residue because of the available perches, better protective cover, and greater arthropod abundance (Dambach 1948, Edwards and Lofty 1969; cited in Rodenhouse and Best 1983, Basore et al. 1986, Rodenhouse and Best 1994). The amount of crop residue in fields is mainly determined by the species of crop grown, and the tillage practice employed (Edwards and Lofty 1969; cited in Rodenhouse and Best 1994).

The abundance of dickcissels, grasshopper sparrows, and western meadowlarks in cropfields have also been associated with the amount of grassland in the surrounding landscape (Best et al. 2001). We also found evidence of this, but only with the grasshopper sparrow. Grasshopper sparrow abundance in cropfields was closely associated with their densities in the adjacent CRP grasslands. In Chapter 1, we determined that grasshopper sparrows in CRP grasslands respond positively to the amount of grassland in the landscape at the 2000 m scale. Therefore, grasshopper sparrow abundance in cropfields was related to the composition of the surrounding landscape. Differences in study designs and objectives may account for the inconsistent results observed between our study and that of Best et al. (2001). Where our study used landscapes with a gradient from high (51%) to low (7%) amounts of grassy cover in the surrounding landscape, Best et al. (2001) used three representative landscape scenarios consisting of approximately 1.84%, 3.24%, and 13.19% CRP grassland. Best et al. (2001)

had very low percentages of CRP, which essentially tested the effect of having or not having CRP in the surrounding landscape, whereas our study focused on the effect of having low to high amounts of CRP.

CONCLUSION

One important question is how large cropfields should be to facilitate bird foraging on potential crop pests and yet be reasonable as an agricultural field size. Best et al. (1990) addressed this issue by suggesting an optimal cropfield size of 4 hectares so that most of the field would consist of 'perimeter' habitat within 50 m of the nearest edge, the area where most of the foraging occurred. Our study focused on foraging patterns of birds associated with CRP grasslands, and the potential constraint of woody-edge avoidance, to determine the optimal cropfield size to facilitate use and optimize pest suppression by birds.

Because lark sparrows and vesper sparrows use cropfields as breeding habitat, they would most likely not be as constrained by the size of a cropfield as other species may be. Red-winged blackbirds and brown-headed cowbirds were also observed across much of the cropfields but their use of fields appeared to be limited by their preference to remain within ~120 m of the grassland edge. Dickcissels were mainly found within 80 m of the grassland edge, but appeared to fly further into cropfields that were ≤175 m in width. Meadowlarks generally preferred to remain within 60 m of the grassland edge, though they also exhibited a possible trend of flying further into cropfields with narrower widths (≤150 m). Although meadowlarks have been observed using woody edges to perch, woodlands may have served as a constraint to foraging meadowlarks in cropfields because we had no observations within 44 m of the woodland edge. Grasshopper sparrows rarely used cropfields and remained within 11.5 m of the grassland edge, therefore their requirements were not instructive in determining the optimum cropfield size for birds.

Red-winged blackbirds, brown-headed cowbirds, dickcissels, and meadowlarks all demonstrated limitations in using cropfields, particularly the latter two. Approximately 75% of these species were observed within 100 m of the grassland edge. Woodland avoidance by grassland birds has been observed in previous studies (50 m: Fitzmaurice 1995, Sunderman 1995), as well as in our own (meadowlarks: 44 m). Taking into account the foraging patterns of these four species including maximum use areas and woodland avoidance, we believe that cropfields with widths of ~150-175 m would maximize cropfield use and optimize pest suppression by birds.

A width of ~150-175 m would encourage dickcissels and meadowlarks to use more of the cropfield by providing proximal protective cover from both edges, and would allow for potential woodland avoidance by grassland birds (~50 m) when foraging in cropfields. It would also enhance pest suppression through the foraging of CRP grassland birds within 100 m of the grassland edge (Figure 23b), and the foraging of woodland birds from the opposite edge. Though the focus of our study was not on the foraging patterns of woodland birds, our observations of species such as the Baltimore oriole and American robin (Figures 36-37) supports the assertion by Best et al. (1990), Fitzmaurice (1995), and Sunderman (1995) that woodland birds forage primarily within ~50 m of the woodland edge.

Our results document the foraging patterns and woodland edge avoidance of CRP grassland birds in adjacent cropfields. Optimal cropfield size of ~150-175 m across facilitates cropfield use by birds associated with CRP grasslands, potentially benefiting both insect pest suppression and grassland bird conservation.

LITERATURE CITED

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

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

Beecher, N. A., R. J. Johnson, J. R. Brandle, R. M. Case, and L. J. Young. 2002. Agroecology of birds in organic and nonorganic farmland. Conservation Biology 16:1620-1631.

Benton, T. G., D. M. Bryant, L. Cole, and H. Q. P. Crick. 2002. Linking agricultural practice to insect and bird populations: A historical study over three decades. Journal of Applied Ecology 39:673-687.

Best, L. B., and B. J. Hill. 1986. Conservation tillage: ecological traps for nesting birds? Wildlife Society Bulletin 14:308-317.

Best, L . B., R. C. Whitmore, and G. M. Booth. 1990. Use of Cornfields by Birds during the Breeding Season: The importance of edge habitat. American Midland Naturalist 123:84-99.

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

Best, L. B., T. M. Bergin, and K. E. Freemark. 2001. Influence of landscape composition on bird use of rowcrop fields. Journal of Wildlife Management 65:442-449.

Coppedge, B. R., D. M. Engle, R. E. Masters, and M. S. Gregory. 2001. Avian response to landscape change in fragmented Southern Great Plains grasslands. Ecological Applications 11:47-59.

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

Dechant, J. A., M. L. Sondreal, D. H. Johnson, L. D. Igl, C. M. Goldade, a. L. Zimmerman, and B. R. Euliss. 2002. Effects of management practices on grassland birds: Western Meadowlark. Northern Prairie Wildlife Research Center, Jamestown, ND. 33 pages.

Dambach, C. A. 1948. A study of the ecology and economic value of crop field borders. Biological Science Series 2. Graduate School Studies. Ohio State University Press, Columbus. 205 pages.

Dolbeer, R. A. 1990. Ornithology and integrated pest management: The Red-winged Blackbird (*Agelaius phoeniceus*). Ibis 132:309-322.

Edwards, C. A., and J. R. Lofty. 1969. The influence of agricultural practice on soil micro-arthropod populations, p. 237-247 (J. G. Sheals, ed.). The soil ecosystem: Systematic aspects of the environment, organisms and communities. Systematics Association Publishing (No. 8). 247 pages.

Environmental Systems Research Institute (ESRI). 2004. ArcGIS. Version 9.0. Environmental Systems Research Institute, Redlands, California, USA.

Gough, G.A., Sauer, J.R., Iliff, M. Patuxent Bird Identification Infocenter. 1998. Version 97.1. Patuxent Wildlife Research Center, Laurel, MD.

Grant, T. A., E. Madden, and G. B. Berkey. 2004. Tree and shrub invasion in northern mixed-grass prairie: Implications for breeding grassland birds. Wildlife Society Bulletin 32:807-818.

Fitzmaurice, R. L. 1995. Avian use of riparian corridors and adjacent cropland in east-central Nebraska. MS Thesis. University of Nebraska-Lincoln, Nebraska, 77 pages.

Helzer, C. J. 1996. The effects of wet meadow fragmentation on grassland birds. M. S. thesis. University of Nebraska-Lincoln, Nebraska. 65 pages.

Henningsen, J. C., and L. B. Best. 2005. Grassland bird use of riparian filter strips in Southeast Iowa. Journal of Wildlife Management 69:198-210.

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

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

Johnson, D. H., and M. D. Schwartz. 1993. The Conservation Reserve Program and grassland birds. Conservation Biology 7:934-937.

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

Johnson, R. J., and M. M. Beck. 1988. Influences of shelterbelts on wildlife management and biology. Agriculture, Ecosystems and Environment 22:301-335.

Kemp, J. C., and G. W. Barrett. 1989. Spatial patterning: Impact of uncultivated corridors on arthropod populations within soybean agroecosystems. Ecology 70:114-128.

Kirk, D. A, M. D. Evenden, and P. Mineau. 1996. Past and current attempts to evaluate the role of birds as predators of insect pests in temperate agriculture. Current Ornithology 13:175-269.

O'Leary, C. H. and D. W. Nyberg. 2000. Treelines between fields reduce the density of grassland birds. Natural Areas Journal 20:243-249.

Prescott, D. R. C. 1997. Avian communities and NAWMP habitat priorities in the northern prairie biome of Alberta. NAWMP-029. Land Stewardship Centre of Canada, St. Albert, Alberta. 41 pages.

Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. DeSante. 1993. Handbook of field methods for monitoring landbirds. U.S. Department of Agriculture, U. S. Forestry Service, Pacific Southwest Research Station, General Technical Report PSW-GTR-144. Albany, California, USA.

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

Rising, J. D. 1974. The status and faunal affinities of the summer birds of western Kansas. University of Kansas Science Bulletin 50:347-388.

Robbins, C. S. 1981. Bird activity levels related to weather. Pages 52-57 in C. J. Ralph, J. M. Scott, editors. Studies in Avian Biology Number 6: Estimating numbers at terrestrial birds. Proceedings of an International Symposium, cooper Ornithological Society, Asilomar, California, USA.

Rodenhouse, N. L., and L. B. Best. 1983. Breeding ecology of Vesper Sparrows in corn and soybean fields. American Midland Naturalist 110:265-275.

Rodenhouse, N. L., and L. B. Best. 1994. Foraging patterns of Vesper Sparrows (*Pooecetes gramineus*) breeding in cropland. American Midland Naturalist 131:196-206.

Sample, D. W. 1989. Grassland birds in southern Wisconsin: habitat preference, population trends, and response to land use changes. M.S. thesis. University of Wisconsin, Madison, Wisconsin. 588 pages.

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

SAS Institute Incorporated. 2003. SAS/STAT User's Guide, Version 9.1. SAS Institute, Cary, NC, USA.

Stauffer, D. f. and L. B. Best. 1980. Habitat selection by birds of riparian communities: Evaluating effects of habitat alterations. Journal of Wildlife Management 44:1-15.

Sunderman, N. J. 1995. Avian use of field windbreaks, herbaceous fencerows, and associated cropfields in east central Nebraska. MS Thesis, University of Nebraska-Lincoln, Nebraska, 108 pages.

United States Department of Agriculture (USDA), Economic Research Service. 2005. Washington, D.C. Http://www.ers.usda.gov/statefacts/NE.HTM. Accessed January 2006.

Wiens, J. A. 1969. An approach to the study of ecological relationships among grassland birds. Ornithological Monographs 8:1-93.

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

Yasukawa, K., and W. A. Searcy. 1995. Red-winged Blackbird (*Agelaius phoeniceus*). In *The Birds of North America*, No. 184 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

Table 1. Size and location of the fifteen study sites in southeastern Nebraska, 2005-2006.

Site #	CRP Size (ha)	County
3	10.82	Johnson
4	14.67	Butler
6	14.43	Butler
8	10.77	Johnson
9	10.50	Gage
10	17.00	Pawnee
12	13.22	Jefferson
13	24.65	Saline
14	13.99	Johnson
15	11.79	Richardson
16	11.75	Lancaster
20	11.75	Seward
23	15.61	Johnson
24	15.10	Butler
25	14.86	Seward

Table 2. Model selection from Program DISTANCE to determine the best density estimation for each species per year.

2005		
Species	**Model Name**	**ΔAIC**
Grasshopper Sparrow	Global Detection	0
	Site-specific Detection	1.38
Dickcissel	Site-specific Detection	0
	Global Detection	85.79
Meadowlark	Site-specific Detection	0
	Global Detection	34.16
Red-winged Blackbird	Site-specific Detection	0
	Global Detection	5.32

2006		
Species	**Model Name**	**ΔAIC**
Grasshopper Sparrow	Site-specific Detection	0
	Global Detection	6.17
	Detection Method	9.54
	Observer Effect	10.23
Dickcissel	Site-specific Detection	0
	Detection Method	45.24
	Observer Effect	59.33
	Global Detection	67.24
Meadowlark	Site-specific Detection	0
	Detection Method	27.81
	Observer Effect	29.57
	Global Detection	30.75
Red-winged Blackbird	Site-specific Detection	0
	Observer Effect	27.45
	Global Detection	34.21
	Detection Method	36.01

Table 3. Density estimates for each species* per year from study sites in southeastern Nebraska, 2005-2006.

	GRSP		DICK		MEAD		RWBL		BHCO	
Site	**2005**	**2006**	**2005**	**2006**	**2005**	**2006**	**2005**	**2006**	**2005**	**2006**
3	0.0587	0.0760	1.2542	0.5744	0.0093	0.0206	0.1158	0.0570	0.1409	0.1048
4	0.3378	0.2452	0.1536	0.1165	0.0421	0.0260	0.0046	0.0000	0.0000	0.0359
6	0.0734	0.0374	0.7021	0.4870	0.0000	0.0000	0.0000	0.0000	0.0000	0.0245
8	0.6022	0.1786	0.0152	0.0873	0.0031	0.0018	0.0000	0.0016	0.0163	0.0359
9	0.0000	0.0000	0.7767	0.5765	0.0062	0.0000	0.0764	0.0415	0.0367	0.0635
10	0.1028	0.0242	0.1189	0.5568	0.1222	0.0866	0.0641	0.2089	3.3992	0.0045
12	0.0000	0.0227	0.5369	0.5132	0.0093	0.0091	0.0763	0.1055	0.0204	0.0336
13	0.0734	0.2167	0.1408	0.1922	0.0062	0.0110	0.0046	0.0000	0.0000	0.5188
14	0.1322	0.2527	0.2299	0.1773	0.0671	0.0018	0.0414	0.0624	0.1643	0.1258
15	0.1909	0.1372	0.2802	0.1006	0.0125	0.0361	0.0321	0.0160	0.0867	0.0443
16	0.1175	0.0889	0.4598	0.2218	0.0249	0.0018	0.0000	0.0138	0.1489	0.0151
20	0.2056	0.1181	0.1325	0.2283	0.0312	0.0622	0.0000	0.0000	0.0226	0.0000
23	0.0000	0.0043	0.5485	0.1164	0.0374	0.0706	0.0733	0.0447	0.0690	0.0894
24	0.3525	0.1653	0.2845	0.3079	0.0000	0.0037	0.0000	0.0000	0.0714	0.0000
25	0.3965	0.0694	0.7196	0.0931	0.0031	0.0018	0.0000	0.0000	0.0041	0.0204

* GRSP=Grasshopper Sparrow, DICK=Dickcissel, MEAD=Meadowlarks, RWBL=Red-winged Blackbird, BHCO=Brown-headed Cowbird.

Table 4. Independent variables used in the analysis of grassland bird densities in CRP grasslands, southeastern Nebraska, 2005-2006. Variable code descriptions are found in Table 5.

	Variables																								
Species	% Grass 500	% Grass 1000	% Grass 2000	% Pasture 500	% Pasture 1000	% Pasture 2000	% Wood 500	% Wood 1000	% Wood 2000	Connect 500	Connect 1000	Connect 2000	Shape 2000	Tree	Area	VOR	Litter depth	% Forb	% Bareground	% Deadgrass	GRSP	DICK	MEAD	RWBL	Community
Grasshopper Sparrow	x	x	x	x	x	x				x	x	x	x	x	x	x	x	x							x
Dickcissel	x	x	x	x	x	x				x	x	x	x	x	x	x	x	x							
Meadowlark	x	x	x	x	x	x				x	x	x	x	x	x	x	x	x							
Red-winged Blackbird	x	x	x	x	x	x				x	x	x	x	x	x	x	x	x							
Brown-headed Cowbird	x	x	x	x	x	x	x	x	x					x	x						x	x	x	x	x
Northern Bobwhite	x	x	x							x	x	x	x	x	x	x	x	x							
Lark Sparrow	x	x	x	x	x	x				x	x	x	x	x	x	x	x	x	x						
Ring-necked Pheasant	x	x	x							x	x	x	x	x	x	x	x	x							
Field Sparrow	x	x	x	x	x	x				x	x	x	x	x	x	x	x	x							
Common Yellowthroat	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x							
Bobolink	x	x	x	x	x	x				x	x	x	x	x	x	x	x	x		x					
Sedge Wren	x	x	x							x	x	x	x	x	x	x	x	x							
Vesper Sparrow	x	x	x	x	x	x				x	x	x	x	x	x	x	x	x	x						

Table 5. Explanation of codes used in the analysis of grassland birds in southeastern Nebraska, 2005-2006.

Variable	**Code**
% grassland in the landscape, 500 m scale	% Grass 500
% grassland in the landscape, 1000 m scale	% Grass 1000
% grassland in the landscape, 2000 m scale	% Grass 2000
% pasture in the landscape, 500 m scale	% Pasture 500
% pasture in the landscape, 1000 m scale	% Pasture 1000
% pasture in the landscape, 2000 m scale	% Pasture 2000
% woodland in the landscape, 500 m scale	% Wood 500
% woodland in the landscape, 1000 m scale	% Wood 1000
% woodland in the landscape, 2000 m scale	% Wood 2000
Connectance index, 500 m scale	Connect 500
Connectance index, 1000 m scale	Connect 1000
Connectance index, 2000 m scale	Connect 2000
Area-weighted mean shape index, 2000 m scale	Shape 2000
Perpendicular distance to nearest treeline	Tree
Area of study site (grassland patch)	Area
Visual Obstruction Reading	VOR
Litter depth	Litter depth
Ground cover: percent dead grass	% Deadgrass
Ground cover: percent forbs	% Forb
Ground cover: percent bare ground	% Bareground
Grasshopper Sparrow density	GRSP
Dickcissel density	DICK
Meadowlark density	MEAD
Red-winged Blackbird density	RWBL

Table 6. Twenty-five avian species observed using CRP grasslands in southeastern Nebraska, 2005-2006.

Common Name	**Abbreviation**	**Scientific Name**
Grasshopper Sparrow*	GRSP	*Ammodramus savannarum*
Dickcissel*	DICK	*Spiza americana*
Meadowlark (Eastern / Western)*	MEAD	*Sturnella (magna / neglecta)*
Red-winged Blackbird*	RWBL	*Agelaius phoeniceus*
Brown-headed Cowbird*	BHCO	*Molothrus ater*
Bobolink*	BOBO	*Dolichonyx oryzivorus*
American Goldfinch	AMGO	*Carduelis tristis*
Field Sparrow*	FISP	*Spizella pusilla*
Lark Sparrow*	LASP	*Chondestes grammacus*
Vesper Sparrow*	VESP	*Pooecetes gramineus*
Sedge Wren*	SEWR	*Cistothorus platensis*
Common Yellowthroat*	COYE	*Geothlypis trichas*
Upland Sandpiper	UPSA	*Bartramia longicauda*
Northern Bobwhite *	NOBO	*Colinus virginianus*
Ring-necked Pheasant*	RNPH	*Phasianus colchicus*
Wild Turkey	WITU	*Meleagris gallopavo*
Morning Dove	MODO	*Zenaida macroura*
Eastern Kingbird	EAKI	*Tyrannus tyrannus*
Baltimore Oriole	BAOR	*Icterus galbula*
Orchard Oriole	OROR	*Icterus spurius*
Blue Jay	BLJA	*Cyanocitta cristata*
Eastern Towhee	EATO	*Pipilo erythrophthalmus*
Brown Thrasher	BRTH	*Toxostoma rufum*
Northern Flicker	NOFL	*Colaptes auratus*
Red-headed Woodpecker	RHWO	*Melanerpes erythrocephalus*

* Indicates species that were analyzed in this study

Table 7. Vegetation sampling[a] results for fifteen study sites in southeastern Nebraska, 2005-2006.

	VOR		Live Height (cm)		Dead Height (cm)		Litter Depth (cm)		Treeline Distance (m)	
Site	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
3	6.54	6.35	83.75	77.17	88.33	76.33	2.33	1.75	88.80	88.80
4[b]	*	3.48	*	44.83	*	37.25	*	1.17	314.10	314.10
6	7.21	8.71	147.50	107.42	84.67	122.00	2.50	7.50	329.95	329.95
8	3.88	3.40	40.42	50.42	51.83	36.75	1.50	2.58	224.02	224.02
9	8.17	9.35	141.33	94.58	45.42	34.42	1.42	0.00	608.94	608.94
10	2.81	6.13	30.00	91.00	27.33	50.92	0.00	1.17	322.28	322.28
12	6.60	7.56	98.42	99.75	106.50	93.25	5.17	5.92	481.10	481.10
13	3.75	3.50	44.92	56.17	39.25	47.50	0.92	1.17	295.54	295.54
14	4.02	4.06	41.42	48.83	52.17	33.42	1.33	0.25	222.98	222.98
15	4.63	4.15	49.58	53.83	48.50	38.67	3.58	4.42	471.71	471.71
16	5.69	4.52	76.33	66.17	121.83	75.25	1.83	4.17	155.35	155.35
20	4.52	4.40	48.75	62.58	59.25	34.58	2.83	2.33	526.45	526.45
23	5.73	5.52	90.75	78.58	127.25	42.67	5.83	3.67	231.20	231.20
24	6.19	5.38	96.92	85.33	87.75	95.92	2.42	4.75	98.87	98.87
25	5.10	3.33	72.42	56.17	81.92	22.25	1.33	0.00	152.84	152.84

[a] VOR=visual obstruction reading, Live Height=tallest live vegetation, Dead Height=tallest dead vegetation, Litter Depth=depth of the litter, Treeline Distance=perpendicular distance to nearest treeline
[b] Vegetation could not be sampled because of the unexpected introduction of cattle onto the site.

Table 8. Vegetation sampling results using a Daubenmire frame for each site during the 2005 and 2006 breeding seasons.

2005	% Standing		Percent Coverage (non-overlapping: = 100%)					Percent Coverage (overlapping: > 100%)				
Site	Live	Dead	Grass	Forb	Woody	Bare Ground	Litter	Grass	Forb	Woody	Bare Ground	Litter
3	84.42	15.58	59.79	26.25	2.50	13.33	2.50	59.79	30.21	2.50	17.29	2.50
4	*	*	*	*	*	*	*	*	*	*	*	*
6	89.58	10.42	58.96	11.46	2.50	19.38	11.46	58.96	13.33	2.50	21.25	12.50
8	60.42	39.58	85.21	5.63	2.50	2.50	8.54	85.21	5.63	2.50	2.50	12.71
9	97.75	2.25	51.88	21.46	2.50	28.54	11.67	51.88	23.33	2.50	28.54	13.75
10	93.58	6.42	56.67	20.42	2.50	16.67	2.50	56.67	22.29	2.50	22.29	2.50
12	86.25	13.75	79.38	9.58	2.50	2.50	14.79	79.38	9.58	2.50	2.50	28.96
13	76.25	23.75	47.92	37.50	2.50	6.67	5.63	50.00	37.50	2.50	7.71	8.54
14	71.67	28.33	74.38	11.46	7.50	5.63	3.54	74.38	11.46	7.50	6.67	3.54
15	49.58	50.42	71.88	4.58	2.50	2.50	12.50	71.88	4.58	2.50	2.50	12.50
16	77.08	22.92	59.79	8.54	3.54	5.63	16.67	59.79	8.54	3.54	5.63	23.33
20	65.00	35.00	82.29	5.42	2.50	2.50	5.63	82.29	5.42	2.50	2.50	15.63
23	77.08	22.92	71.46	5.42	2.50	2.50	15.83	71.46	5.42	2.50	2.50	34.17
24	83.58	16.42	75.63	6.46	2.50	2.50	13.54	75.63	8.54	2.50	2.50	40.00
25	77.67	22.33	70.00	7.50	2.50	4.58	19.58	70.00	7.50	2.50	4.58	33.33

2006	% Standing		Percent Coverage (non-overlapping: = 100%)					Percent Coverage (overlapping: > 100%)				
Site	Live	Dead	Grass	Forb	Woody	Bare Ground	Litter	Grass	Forb	Woody	Bare Ground	Litter
3	87.08	12.92	55.00	43.96	2.50	4.58	8.75	50.00	46.88	2.50	6.46	16.67
4	77.50	22.50	46.25	9.58	2.50	9.38	39.58	46.25	9.58	2.50	9.38	51.25
6	76.67	23.33	58.75	24.17	2.50	9.38	10.42	56.67	26.04	2.50	11.25	29.17
8	71.67	28.33	51.88	8.33	2.50	2.50	36.67	51.88	8.33	2.50	2.50	54.17
9	94.58	5.42	69.79	6.46	2.50	26.04	2.50	69.79	10.63	2.50	46.25	2.50
10	75.42	24.58	47.92	16.25	2.50	5.42	35.83	47.92	16.25	2.50	5.42	52.29
12	87.50	12.50	61.67	18.54	2.50	2.50	20.21	61.67	18.54	6.46	2.50	43.75
13	66.25	33.75	42.71	21.25	2.50	8.33	26.04	42.71	23.33	2.50	8.33	41.25
14	88.75	11.25	34.17	33.75	2.50	33.13	7.50	34.17	33.75	2.50	41.04	9.38
15	73.33	26.67	64.17	2.50	2.50	2.50	35.83	64.17	2.50	2.50	2.50	54.17
16	83.75	16.25	61.67	8.54	2.50	3.54	32.50	61.67	8.54	2.50	3.54	48.13
20	74.17	25.83	53.75	8.54	2.50	2.50	30.42	53.75	9.58	2.50	2.50	52.08
23	88.75	11.25	67.08	5.63	2.50	2.50	20.42	65.00	5.63	2.50	2.50	32.08
24	90.42	9.58	70.63	9.58	2.50	2.50	19.79	60.00	9.58	2.50	2.50	49.38
25	90.42	9.58	33.13	5.63	2.50	38.75	2.50	33.13	5.63	2.50	41.04	5.42

Table 9. Percentages of land cover categories within a 500, 1000, and 2000 m buffer surrounding each study site for the 2005 and 2006 breeding seasons.

2005

500 m buffer															
Sites	**6**	**12**	**10**	**14**	**13**	**25**	**15**	**4**	**23**	**24**	**16**	**9**	**20**	**8**	**3**
Total Grassland	8%	11%	13%	14%	17%	17%	20%	21%	22%	24%	30%	32%	40%	45%	46%
Total Pastureland	4%	19%	22%	8%	31%	26%	9%	19%	20%	26%	14%	14%	33%	13%	22%
Total Woodland	14%	14%	15%	26%	5%	24%	18%	22%	10%	24%	24%	9%	6%	23%	16%
Total Cropland	71%	54%	48%	51%	44%	30%	51%	36%	44%	23%	30%	43%	11%	17%	14%
Total Misc.	2%	2%	2%	2%	3%	3%	2%	2%	4%	3%	2%	2%	10%	2%	3%
Grassland Rank[a]	1	1	2	2	2	2	3	3	3	4	5	5	5	5	5

1000 m buffer															
Sites	**6**	**12**	**13**	**24**	**14**	**25**	**10**	**9**	**15**	**4**	**16**	**23**	**20**	**8**	**3**
Total Grassland	7%	10%	11%	13%	15%	18%	19%	20%	22%	23%	26%	27%	30%	45%	51%
Total Pastureland	8%	24%	25%	29%	10%	28%	13%	18%	16%	15%	27%	13%	37%	20%	20%
Total Woodland	10%	10%	5%	25%	23%	18%	14%	15%	19%	14%	21%	12%	11%	13%	11%
Total Cropland	73%	54%	56%	30%	48%	32%	48%	44%	41%	46%	24%	43%	11%	20%	15%
Total Misc.	3%	2%	3%	3%	3%	3%	7%	3%	2%	1%	2%	5%	10%	2%	2%
Grassland Rank	1	1	1	2	2	3	3	3	3	4	4	4	5	5	5

2000 m buffer															
Sites	**6**	**12**	**24**	**14**	**13**	**9**	**23**	**10**	**15**	**4**	**20**	**25**	**16**	**3**	**8**
Total Grassland	8%	9%	14%	16%	18%	18%	22%	23%	24%	24%	24%	26%	28%	34%	36%
Total Pastureland	14%	18%	28%	16%	23%	15%	14%	34%	19%	13%	34%	24%	22%	33%	20%
Total Woodland	7%	7%	20%	23%	7%	9%	8%	13%	15%	12%	13%	20%	14%	10%	8%
Total Cropland	69%	64%	34%	43%	49%	55%	51%	27%	41%	46%	22%	28%	32%	20%	35%
Total Misc.	3%	2%	4%	3%	3%	2%	5%	3%	1%	5%	7%	2%	3%	3%	1%
Grassland Rank	1	1	2	2	3	3	3	4	4	4	4	4	5	5	5

[a] Ranking system devised to simplify chart by grouping grassland percentages into five categories: Rank 1= 0-12%, Rank 2 = 13-17%, Rank 3 = 18-22%, Rank 4 = 23-27%, Rank 5 = ≥28%.

Table 9. Continued. Percentages of land cover categories within a 500, 1000, and 2000 m buffer surrounding each study site for the 2005 and 2006 breeding seasons.

2006

500 m buffer															
Sites	**6**	**10**	**14**	**23**	**25**	**4**	**13**	**12**	**15**	**16**	**24**	**9**	**3**	**8**	**20**
Total Grassland	7%	13%	14%	16%	17%	21%	21%	22%	22%	30%	31%	34%	44%	45%	49%
Total Pastureland	6%	22%	8%	20%	27%	19%	26%	19%	9%	14%	22%	18%	24%	13%	24%
Total Woodland	14%	15%	26%	10%	24%	22%	5%	14%	18%	24%	24%	9%	16%	23%	6%
Total Cropland	71%	48%	51%	50%	30%	36%	44%	43%	49%	30%	22%	37%	14%	17%	11%
Total Misc.	2%	2%	2%	4%	3%	2%	4%	2%	2%	2%	2%	2%	3%	2%	10%
Grassland Rank [a]	1	2	2	2	2	3	3	3	3	5	5	5	5	5	5

1000 m buffer															
Sites	**6**	**12**	**14**	**10**	**24**	**25**	**13**	**15**	**4**	**23**	**16**	**9**	**20**	**8**	**3**
Total Grassland	6%	15%	16%	17%	17%	18%	19%	22%	24%	25%	26%	26%	42%	47%	48%
Total Pastureland	9%	24%	10%	15%	27%	28%	21%	16%	15%	13%	26%	21%	26%	20%	24%
Total Woodland	10%	10%	23%	14%	25%	18%	5%	19%	14%	12%	22%	15%	11%	13%	11%
Total Cropland	73%	49%	48%	48%	29%	32%	52%	41%	45%	45%	24%	35%	11%	18%	15%
Total Misc.	3%	2%	3%	7%	2%	3%	3%	2%	1%	5%	2%	4%	10%	2%	3%
Grassland Rank	1	2	2	2	2	3	3	3	4	4	4	4	5	5	5

2000 m buffer															
Sites	**6**	**12**	**24**	**14**	**10**	**13**	**23**	**4**	**9**	**25**	**15**	**16**	**20**	**3**	**8**
Total Grassland	6%	10%	15%	16%	21%	21%	24%	25%	25%	26%	27%	28%	29%	35%	42%
Total Pastureland	15%	18%	28%	16%	36%	21%	14%	14%	16%	23%	19%	22%	29%	33%	20%
Total Woodland	7%	7%	20%	23%	13%	7%	8%	12%	9%	20%	15%	15%	13%	10%	8%
Total Cropland	69%	63%	33%	42%	27%	48%	50%	45%	48%	28%	37%	32%	22%	18%	29%
Total Misc.	3%	2%	4%	3%	3%	2%	5%	5%	3%	3%	1%	3%	7%	4%	1%
Grassland Rank	1	1	2	2	3	3	4	4	4	4	4	5	5	5	5

[a] Ranking system devised to simplify chart by grouping grassland percentages into five categories: Rank 1= 0-12%, Rank 2 = 13-17%, Rank 3 = 18-22%, Rank 4 = 23-27%, Rank 5 = ≥28%.

Table 10. Grassland percentages including and excluding (-a/w) alfalfa and wheat fields for both the 2005 and 2006 seasons.

2005

Sites	500 m	500 m (-a/w)	1000 m	1000 m (-a/w)	2000 m	2000 m (-a/w)
3	46%	38%	51%	46%	34%	32%
4	21%	21%	23%	22%	24%	21%
6	8%	8%	7%	5%	8%	6%
8	45%	45%	45%	45%	36%	36%
9	32%	32%	20%	19%	18%	13%
10	13%	13%	19%	18%	23%	22%
12	11%	11%	10%	6%	9%	6%
13	17%	6%	11%	5%	18%	13%
14	14%	5%	15%	12%	16%	14%
15	20%	20%	22%	22%	24%	23%
16	30%	30%	26%	25%	28%	25%
20	40%	40%	30%	30%	24%	22%
23	22%	16%	27%	23%	22%	18%
24	24%	19%	13%	10%	14%	12%
25	17%	15%	18%	16%	26%	25%

Rank[a]						
Sites	500 m	500 m (-a/w)	1000 m	1000 m (-a/w)	2000 m	2000 m (-a/w)
3	5	5	5	5	5	5
4	3	3	4	3	4	3
6	1	1	1	1	1	1
8	5	5	5	5	5	5
9	5	5	3	3	3	2
10	2	2	3	3	4	3
12	1	1	1	1	1	1
13	2	1	1	1	3	2
14	2	1	2	1	2	2
15	3	3	3	3	4	4
16	5	5	4	4	5	4
20	5	5	5	5	4	3
23	3	2	4	4	3	3
24	4	3	2	1	2	1
25	2	2	3	2	4	4

[a] Ranking system devised to simplify chart by grouping grassland percentages into five categories: Rank 1= 0-12%, Rank 2 = 13-17%, Rank 3 = 18-22%, Rank 4 = 23-27%, Rank 5 = ≥28%.

Table 10. Continued. Grassland percentages including and excluding (-a/w) alfalfa and wheat fields for both the 2005 and 2006 seasons.

2006

Sites	500 m	500 m (-a/w)	1000 m	1000 m (-a/w)	2000 m	2000 m (-a/w)
3	44%	39%	48%	46%	35%	32%
4	21%	21%	24%	22%	25%	21%
6	7%	7%	6%	4%	6%	4%
8	45%	45%	47%	45%	42%	36%
9	34%	17%	26%	11%	25%	11%
10	13%	13%	17%	16%	21%	19%
12	22%	11%	15%	7%	10%	7%
13	21%	3%	19%	4%	21%	13%
14	14%	5%	16%	11%	16%	13%
15	22%	20%	22%	17%	27%	21%
16	30%	25%	26%	24%	28%	24%
20	49%	49%	42%	42%	29%	26%
23	16%	16%	25%	23%	24%	17%
24	31%	26%	17%	13%	15%	13%
25	17%	15%	18%	16%	26%	24%

Rank[a]						
Sites	500 m	500 m (-a/w)	1000 m	1000 m (-a/w)	2000 m	2000 m (-a/w)
3	5	5	5	5	5	5
4	3	3	4	3	4	3
6	1	1	1	1	1	1
8	5	5	5	5	5	5
9	5	2	4	1	4	1
10	2	2	2	2	3	3
12	3	1	2	1	1	1
13	3	1	3	1	3	2
14	2	1	2	1	2	2
15	3	3	3	2	4	3
16	5	4	4	4	5	4
20	5	5	5	5	5	4
23	2	2	4	4	4	2
24	5	4	2	2	2	2
25	3	2	3	2	4	4

[a] Ranking system devised to simplify chart by grouping grassland percentages into five categories: Rank 1= 0-12%, Rank 2 = 13-17%, Rank 3 = 18-22%, Rank 4 = 23-27%, Rank 5 = ≥28%.

Table 11. Number of observations for each species per site during the 2005-2006 breeding seasons. Species names and abbreviations are located in Table 6.

		Site															
Species	**Year**	**3**	**4**	**6**	**8**	**9**	**10**	**12**	**13**	**14**	**15**	**16**	**20**	**23**	**24**	**25**	**Total**
GRSP	2005	4	23	5	41	0	7	0	5	9	13	4	18	0	24	27	180
	2006	6	35	5	28	0	5	4	22	33	28	6	18	2	24	10	226
DICK	2005	60	22	40	3	61	26	50	21	27	35	26	23	31	38	41	504
	2006	66	32	58	17	97	77	84	51	42	24	45	48	38	60	23	762
MEAD	2005	3	7	0	1	2	10	3	2	10	4	0	9	5	0	1	57
	2006	5	6	0	1	0	14	5	6	1	15	1	17	13	2	1	87
BOBO	2005	0	4	0	2	0	0	0	1	0	0	0	0	0	0	0	7
	2006	0	1	0	0	0	3	0	15	0	0	0	0	3	0	0	22
RWBL	2005	21	1	0	0	8	7	11	1	6	7	0	0	16	0	0	78
	2006	22	0	0	1	13	52	22	0	15	5	2	0	28	0	0	160
SEWR	2005	3	0	0	0	0	0	5	0	0	0	0	0	7	0	0	15
	2006	0	0	3	0	0	0	4	0	0	0	0	0	0	2	0	9
AMGO	2005	2	2	0	0	0	4	3	0	0	1	1	0	1	0	2	16
	2006	0	0	3	0	1	3	4	0	2	0	2	0	0	0	0	15
COYE	2005	8	0	13	0	2	0	9	2	0	0	12	0	4	0	0	50
	2006	7	0	20	4	0	0	13	6	0	0	1	0	5	3	0	59
FISP	2005	0	1	3	1	0	0	0	1	0	0	1	1	0	1	1	10
	2006	1	0	9	5	0	0	0	0	1	1	2	0	0	2	1	22
BHCO	2005	18	0	0	4	9	8	5	0	7	13	4	2	4	4	1	79
	2006	21	9	5	7	28	2	10	31	43	14	2	5	19	0	5	201
NOBO	2005	1	0	0	0	1	1	0	0	0	0	1	4	0	0	0	8
	2006	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3
RNPH	2005	2	2	1	0	1	0	0	0	0	0	1	1	1	0	0	9
	2006	1	2	0	0	1	1	1	2	0	0	0	0	0	0	0	8

Table 11. Continued. Number of observations for each species per site during the 2005-2006 breeding seasons. Species names and abbreviations are located in Table 6.

		Sites															
Species	Year	3	4	6	8	9	10	12	13	14	15	16	20	23	24	25	Total
LASP	2005	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
	2006	1	0	0	0	1	2	0	0	0	0	1	0	0	0	3	8
WITU	2005	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	8
	2006[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EAKI	2005	4	1	0	0	1	2	2	4	0	4	1	5	0	4	2	30
	2006	5	3	1	3	2	3	1	3	2	5	3	4	0	2	25	62
VESP	2005	0	0	0	0	1	2	0	0	0	0	0	0	1	0	0	4
	2006	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	3
BAOR	2005	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	2006	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3
MODO	2005	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
	2006	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	3
X	2005	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	4
	2006[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLJA	2005[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
EATO	2005[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2006	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
BRTH	2005[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2006	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	2
NOFL	2005[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2006	0	0	0	0	0	0	1	0	1	0	0	0	2	0	0	4

[a]Indicates that no observations were made for the species that year

Table 11. Continued. Number of observations for each species per site during the 2005-2006 breeding seasons. Species names and abbreviations are located in Table 6.

		Sites														
Species	**Year**	**3**	**4**	**6**	**8**	**9**	**10**	**12**	**13**	**14**	**15**	**16**	**20**	**23**	**24**	**25**	**Total**
OROR	2005[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2006	4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	5
RHWO	2005[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
UPSA	2005[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2006	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
TOTAL		270	152	166	119	229	238	241	173	200	169	118	160	180	168	147	2730

[a]Indicates that no observations were made for the species that year

Table 12. Best-fit ($\Delta i = 0$) and alternative ($\Delta i < 4$) models for the Grasshopper Sparrow, southeastern Nebraska, 2005-2006.

GRASSHOPPER SPARROW

Model	Ki [a]	ΔAICc [b]	Wi [c]
% Grass 2000 + Year	4	0.0	0.3192
Year (null model)	3	1.2	0.1758
% Grass 2000 + % Pasture 2000 + Year	5	2.5	0.0896
% Pasture 1000 + Year	4	2.9	0.0749
% Grass 500 + Year	4	3.7	0.0502
% Grass 1000 + Year	4	3.9	0.0454
% Pasture 2000 + Year	4	3.9	0.0454
% Pasture 500 + Year	4	4.1	0.0411
VOR + Year	4	4.2	0.0391

Variables	$\hat{\bar{\theta}}$ [d]	$\hat{se}(\hat{\theta})$ [e]	Σwi [f]
% Grass 2000	0.2557	0.1896	0.4088
Year (null model)[g]	0.0098	0.0120	0.1758
% Pasture 2000	-0.0153	0.0183	0.1350
% Pasture 1000	0.0337	0.1835	0.0890
% Grass 1000	0.0135	0.0172	0.0595
% Grass 500	0.0151	0.0183	0.0539
% Pasture 500	0.0017	0.0184	0.0448
VOR	-0.0015	0.0015	0.0404

[a] Number of parameters in each model
[b] Difference between the best model and alternative models
[c] Weight of model: estimated probability of being the best model
[d] Model averaged estimator: estimate of variable's effect (slope)
[e] Unconditional standard error
[f] Parameter weights
[g] Year model results represent an estimate for the null model alone, it is not a parameter estimate

Table 13. Best-fit ($\Delta i = 0$) and alternative ($\Delta i < 4$) models for the Dickcissel, southeastern Nebraska, 2005-2006.

DICKCISSEL

Model	**Ki** [a]	**ΔAICc** [b]	***Wi*** [c]
% Grass 2000 + VOR + Year	5	0.0	0.3334
VOR + Year	4	0.1	0.3239
% Grass 1000 + VOR + Year	5	0.5	0.2596
% Grass 500 + VOR + Year	5	2.9	0.0782

Variables	$\hat{\bar{\theta}}$ [d]	$\hat{se}(\hat{\theta})$ [e]	Σwi [f]
VOR	0.1207	0.0221	0.9951
% Grass 2000	0.2382	0.2158	0.3242
% Grass 1000	0.1337	0.1241	0.2599
% Grass 500	0.0194	0.0291	0.0784

[a] Number of parameters in each model
[b] Difference between the best model and alternative models
[c] Weight of model: estimated probability of being the best model
[d] Model averaged estimator: estimate of variable's effect (slope)
[e] Unconditional standard error
[f] Parameter weights

Table 14. Best-fit ($\Delta i = 0$) and alternative ($\Delta i < 4$) models for the Meadowlark, southeastern Nebraska, 2005-2006.

MEADOWLARK

Model	**Ki** [a]	**ΔAICc** [b]	***Wi*** [c]
Year (null model)	3	0.0	0.5731
% Pasture 2000 + Year	4	2.4	0.1720
% Pasture 1000 + Year	4	3.3	0.1097

Variables	$\hat{\bar{\theta}}$ [d]	$\hat{se}(\hat{\theta})$ [e]	Σwi [f]
Year (null model)[g]	0.0009	0.0067	0.5731
% Pasture 2000	0.0276	0.0269	0.1800
% Pasture 1000	-0.0148	0.0160	0.1144

[a] Number of parameters in each model
[b] Difference between the best model and alternative models
[c] Weight of model: estimated probability of being the best model
[d] Model averaged estimator: estimate of variable's effect (slope)
[e] Unconditional standard error
[f] Parameter weights
[g] Year model results represent an estimate for the null model alone, it is not a parameter estimate

Table 15. Best-fit ($\Delta i = 0$) and alternative ($\Delta i < 4$) models for the Red-winged Blackbird, southeastern Nebraska, 2005-2006.

RED-WINGED BLACKBIRD

Model	***Ki*** [a]	**ΔAICc** [b]	***Wi*** [c]
Year (null model)	3	0.0	0.5172
% Pasture 1000 + Year	4	2.5	0.1477
% Pasture 2000 + Year	4	3.3	0.0990

Variables	$\hat{\bar{\theta}}$ [d]	$\hat{se}(\hat{\theta})$ [e]	Σwi [f]
Year (null model)[g]	-0.0011	0.0095	0.5172
% Pasture 1000	-0.0307	0.0325	0.1549
% Pasture 2000	0.0187	0.0221	0.1097

[a] Number of parameters in each model
[b] Difference between the best model and alternative models
[c] Weight of model: estimated probability of being the best model
[d] Model averaged estimator: estimate of variable's effect
[e] Unconditional standard error
[f] Parameter weights
[g] Year model results represent an estimate for the null model alone, it is not a parameter estimate

Table 16. Best-fit ($\Delta i = 0$) and alternative ($\Delta i < 4$) models for the Brown-headed Cowbird, southeastern Nebraska, 2005-2006.

BROWN-HEADED COWBIRD

Model	***Ki*** [a]	**ΔAICc** [b]	***Wi*** [c]
Meadowlark + Year	4	0.0	0.9777

Variables	$\hat{\bar{\theta}}$ [d]	$\hat{se}(\hat{\theta})$ [e]	Σwi [f]
Meadowlark	12.1585	3.0194	0.9777

[a] Number of parameters in each model
[b] Difference between the best model and alternative models
[c] Weight of model: estimated probability of being the best model
[d] Model averaged estimator: estimate of variable's effect
[e] Unconditional standard error
[f] Parameter weights

Table 17. Best-fit ($\Delta i = 0$) and alternative ($\Delta i < 4$) models for the Northern Bobwhite, southeastern Nebraska, 2005-2006.

NORTHERN BOBWHITE

Model	*Ki* [a]	ΔAICc [b]	*Wi* [c]
% Grass 500 + Year	3	0.0	0.5953
% Grass 1000 + Year	3	2.0	0.2217

Variables	Relationship	$\hat{\theta}$ [d]	$\hat{se}(\hat{\theta})$ [e]	Odds [f]
% Grass 500	+	8.0861	4.6123	3249.07
% Grass 1000	+	2.5654	2.2876	13.0064

[a] Number of parameters in each model
[b] Difference between the best model and alternative models
[c] Weight of model: estimated probability of being the best model
[d] Model averaged estimator: estimate of variable's effect
[e] Unconditional standard error
[f] Odds of presence

Table 18. Best-fit ($\Delta i = 0$) and alternative ($\Delta i < 4$) models for the Lark Sparrow, southeastern Nebraska, 2005-2006.

LARK SPARROW

Model	*Ki* [a]	ΔAICc [b]	*Wi* [c]
% Pasture 2000 + Year	3	0.0	0.3158
Litter Depth + Year	3	0.5	0.2442
% Bareground + Year	3	2.8	0.0767
Year (null model)	2	3.5	0.0556

Variables	Relationship	$\hat{\theta}$ [d]	$\hat{se}(\hat{\theta})$ [e]	Odds [f]
% Pasture 2000	+	6.0643	5.0723	430.2392
Litter-Depth	-	-0.1862	0.1739	0.8301
% Bareground	+	0.0046	0.0051	1.0047
Year (null model) [g]	-	-0.1041	0.1180	0.9011

[a] Number of parameters in each model
[b] Difference between the best model and alternative models
[c] Weight of model: estimated probability of being the best model
[d] Model averaged estimator: estimate of variable's effect
[e] Unconditional standard error
[f] Odds of presence
[g] Year model results represent an estimate for the null model alone, it is not a parameter estimate

Table 19. Best-fit ($\Delta i = 0$) and alternative ($\Delta i < 4$) models for the Ring-necked Pheasant, southeastern Nebraska, 2005-2006.

RING-NECKED PHEASANT

Model	Ki [a]	ΔAICc [b]	Wi [c]
VOR + Year	3	0.0	0.3408
Shape 2000 + Year	3	0.5	0.2607
Year (null model)	2	3.0	0.0772

Variables	Relationship	$\bar{\hat{\theta}}$ [d]	$\hat{se}(\hat{\theta})$ [e]	Odds[f]
VOR	+	0.1959	0.1595	1.2164
Shape 2000	-	-0.7482	0.6728	0.4732
Year (null model)[g]	+	0.0091	0.0588	1.0091

[a] Number of parameters in each model
[b] Difference between the best model and alternative models
[c] Weight of model: estimated probability of being the best model
[d] Model averaged estimator: estimate of variable's effect
[e] Unconditional standard error
[f] Odds of presence
[g] Year model results represent an estimate for the null model alone, it is not a parameter estimate

Table 20. Best-fit ($\Delta i = 0$) and alternative ($\Delta i < 4$) models for the Field Sparrow, southeastern Nebraska, 2005-2006.

FIELD SPARROW

Model	Ki [a]	ΔAICc [b]	Wi [c]
Trees	3	0.0	0.3595
Shape 2000	3	1.4	0.1805
% Pasture 1000	3	2.5	0.1033
Year (null model)	2	3.4	0.0641
Connect 500	3	3.5	0.0616

Variables	Relationship	$\bar{\hat{\theta}}$ [d]	$\hat{se}(\hat{\theta})$ [e]	Odds[f]
Trees	-	-0.0023	0.0018	0.9977
Shape 2000	+	0.4745	0.4608	1.6072
% Pasture 1000	+	1.0754	1.1454	2.9312
Year (null model)[g]	-	-0.0086	0.0483	0.9915
Connect 500	+	0.0055	0.0065	1.0055

[a] Number of parameters in each model
[b] Difference between the best model and alternative models
[c] Weight of model: estimated probability of being the best model
[d] Model averaged estimator: estimate of variable's effect
[e] Unconditional standard error
[f] Odds of presence
[g] Year model results represent an estimate for the null model alone, it is not a parameter estimate

Table 21. Best-fit ($\Delta i = 0$) and alternative ($\Delta i < 4$) models for the Common Yellowthroat, southeastern Nebraska, 2005-2006.

COMMON YELLOWTHROAT

Model	Ki [a]	ΔAICc [b]	*Wi* [c]
% Woody 2000 + Year	3	0.0	0.7489
Litter depth + Year	3	3.6	0.1210

Variables	Relationship	$\hat{\bar{\theta}}$ [d]	$\hat{se}(\hat{\theta})$ [e]	Odds [f]
% Woody 2000	-	-23.0813	10.5175	9.46×10^{-11}
Litter depth	+	0.0807	0.0793	1.0841

[a] Number of parameters in each model
[b] Difference between the best model and alternative models
[c] Weight of model: estimated probability of being the best model
[d] Model averaged estimator: estimate of variable's effect
[e] Unconditional standard error
[f] Odds of presence

Table 22. Best-fit ($\Delta i = 0$) and alternative ($\Delta i < 4$) models for the Bobolink, southeastern Nebraska, 2005-2006.

BOBOLINK

Model	Ki [a]	ΔAICc [b]	*Wi* [c]
Area + Year	3	0.0	0.7403

Variables	Relationship	$\hat{\bar{\theta}}$ [d]	$\hat{se}(\hat{\theta})$ [e]	Odds [f]
Area	+	0.3586	0.2043	1.4313

[a] Number of parameters in each model
[b] Difference between the best model and alternative models
[c] Weight of model: estimated probability of being the best model
[d] Model averaged estimator: estimate of variable's effect
[e] Unconditional standard error
[f] Odds of presence

Table 23. Best-fit ($\Delta i = 0$) and alternative ($\Delta i < 4$) models for the Sedge Wren, southeastern Nebraska, 2005-2006.

SEDGE WREN

Model	Ki [a]	ΔAICc [b]	Wi [c]
Litter depth + Year	3	0.0	0.9968

Variables	Relationship	$\hat{\bar{\theta}}$ [d]	$\hat{se}(\hat{\theta})$ [e]	Odds [f]
Litter depth	+	1.9765	0.9551	7.2172

[a] Number of parameters in each model
[b] Difference between the best model and alternative models
[c] Weight of model: estimated probability of being the best model
[d] Model averaged estimator: estimate of variable's effect
[e] Unconditional standard error
[f] Odds of presence

Table 24. Best-fit ($\Delta i = 0$) and alternative ($\Delta i < 4$) models for the Vesper Sparrow, southeastern Nebraska, 2005-2006.

VESPER SPARROW

Model	Ki [a]	ΔAICc [b]	Wi [c]
% Bareground + Year	3	0.0	0.1610
Year (null model)	2	0.3	0.1385
Trees + Year	3	1.7	0.0686
% Pasture 500 + Year	3	1.9	0.0637
Litter depth + Year	3	2.1	0.0555
VOR + Year	3	2.3	0.0505
Connect 500 + Year	3	2.6	0.0444
Connect 1000 + Year	3	2.6	0.0442
% Grass 2000 + Year	3	2.6	0.0439
Shape 2000 + Year	3	2.7	0.0408
% Pasture 2000 + Year	3	2.7	0.0423
% Grass 500 + Year	3	2.7	0.0423
% Grass 1000 + Year	3	2.7	0.0422
% Forbs + Year	3	2.7	0.0416
% Pasture 1000 + Year	3	2.8	0.0407
Connect 2000 + Year	3	2.8	0.0401
Area + Year	3	2.8	0.0398

Table 24. Continued. Best-fit ($\Delta i = 0$) and alternative ($\Delta i < 4$) models for the Vesper Sparrow, southeastern Nebraska, 2005-2006.

Variables	Relationship	$\hat{\bar{\theta}}$ [d]	$\hat{se}(\hat{\theta})$ [e]	Odds[f]
% Bareground	+	0.0099	0.0103	1.0100
Year (null model)[g]	+	0.0793	0.1545	1.0825
Trees	+	0.0002	0.0003	1.0002
% Pasture 500	+	0.4292	0.6103	1.5360
Litter depth	-	-0.0134	0.0215	0.9867
VOR	-	-0.0112	0.0200	0.9889
Connect 500	-	-0.0015	0.0036	0.9985
Connect 1000	+	0.0035	0.0082	1.0035
% Grass 2000	+	0.1151	0.2811	1.1220
Shape 2000	+	0.1062	0.3111	1.1120
% Pasture 2000	+	0.0604	0.1775	1.0622
% Grass 500	+	0.0582	0.1749	1.0599
% Grass 1000	-	-0.0006	0.0021	0.9994
% Forbs	-	-0.0140	0.0623	0.9861
% Pasture 1000	-	-0.0619	0.2849	0.9400
Connect 2000	+	0.0027	0.0181	1.0027
Area	-	-0.0004	0.0058	0.9996

[a] Number of parameters in each model
[b] Difference between the best model and alternative models
[c] Weight of model: estimated probability of being the best model
[d] Model averaged estimator: estimate of variable's effect
[e] Unconditional standard error
[f] Odds of presence
[g] Year model results represent an estimate for the null model alone, it is not a parameter estimate

Table 25. Cropfield widths and locations of the fifteen study sites in southeastern Nebraska, 2005-2006.

Field Width (m)	Site	County
96	16	Lancaster
102	3	Johnson
113	8	Johnson
117	4	Butler
121	20	Seward
141	24	Butler
145	6	Butler
155	9	Gage
173	10	Pawnee
176	23	Johnson
222	25	Seward
230	13	Saline
253	12	Jefferson
286	14	Johnson
306	15	Richardson

Table 26. Criteria for ranking the non-crop vegetation, insect concentration, and soil moisture of crop fields in southeastern Nebraska, 2005-2006.

Non-crop Vegetation Description[1]	**Rank**
Essentially none	1
Scattered patches	2
Many patches	3
Continuous along at least half of corn rows	4
Continuous along most corn rows	5
Present along and in between most corn rows	6
Dense throughout cornfield	7

Insect Concentration in Crop Fields	**Rank**
0 - 5 insects observed consistently every 3 meters	Low
6 - 15 insects observed consistently every 3 meters	Medium
> 16 insects observed consistently every 3 meters	High

Soil Moisture in Crop Fields	**Rank**
Soil cracked, crumbles easily, dusty, very dry	Dry
Soil slightly spongy, clumps together, moist	Medium
Soil is muddy, sticky, shoes sink in, high water content	Wet

[1] Beecher et al. 2002

Table 27. Thirty-eight avian species observed using cropfields in southeastern Nebraska, 2005-2006.

Common Name	Abbreviation	Scientific Name
Grasshopper Sparrow	GRSP	*Ammodramus savannarum*
Dickcissel	DICK	*Spiza americana*
Meadowlark (Eastern / Western)	MEAD	*Sturnella (magna / neglecta)*
Red-winged Blackbird	RWBL	*Agelaius phoeniceus*
Brown-headed Cowbird	BHCO	*Molothrus ater*
Bobolink	BOBO	*Dolichonyx oryzivorus*
American Goldfinch	AMGO	*Carduelis tristis*
Field Sparrow	FISP	*Spizella pusilla*
Lark Sparrow	LASP	*Chondestes grammacus*
Vesper Sparrow	VESP	*Pooecetes gramineus*
Common Yellowthroat	COYE	*Geothlypis trichas*
Northern Bobwhite	NOBO	*Colinus virginianus*
Ring-necked Pheasant	RNPH	*Phasianus colchicus*
Wild Turkey	WITU	*Meleagris gallopavo*
Morning Dove	MODO	*Zenaida macroura*
Eastern Kingbird	EAKI	*Tyrannus tyrannus*
Baltimore Oriole	BAOR	*Icterus galbula*
Orchard Oriole	OROR	*Icterus spurius*
Blue Jay	BLJA	*Cyanocitta cristata*
Eastern Towhee	EATO	*Pipilo erythrophthalmus*
Brown Thrasher	BRTH	*Toxostoma rufum*
Northern Flicker	NOFL	*Colaptes auratus*
Red-headed Woodpecker	RHWO	*Melanerpes erythrocephalus*
Common Grackle	COGR	*Quiscalus quiscula*
American Robin	AMRO	*Turdus migratorius*
Northern Cardinal	NOCA	*Cardinalis cardinalis*
Eastern Bluebird	EABL	*Sialia sialis*
House Wren	HOWR	*Troglodytes aedon*
Chipping Sparrow	CHSP	*Spizella passerina*
Killdeer	KILL	*Charadrius vociferus*
Gray Catbird	GRCA	*Dumetella carolinensis*
American Crow	AMCR	*Corvus brachyrhynchos*
Horned Lark	HOLA	*Eremophila alpestris*
Indigo Bunting	INBU	*Passerina cyanea*
Red-bellied Woodpecker	RBWO	*Melanerpes carolinus*
European Starling	EUST	*Sturnus vulgaris*
Great Crested Flycatcher	GCFL	*Myiarchus crinitus*
Turkey Vulture	TUVU	*Cathartes aura*

Table 28. Total number of observations for each species per cropfield site during the 2005-2006 breeding seasons. Species names and abbreviations are located in Table 27.

Species	Year	Site															
		3	4	6	8	9	10	12	13	14	15	16	20	23	24	25	Total
GRSP	2005	0	0	0	6	0	0	0	0	0	2	0	0	0	1	2	11
	2006	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	2
DICK	2005	1	2	7	0	5	10	11	0	2	14	0	3	3	1	9	68
	2006	0	0	1	0	21	21	26	1	7	6	0	3	0	1	0	87
MEAD	2005	1	1	1	0	0	0	3	1	2	0	0	0	2	1	0	12
	2006	2	0	0	0	0	2	0	1	0	0	0	0	0	0	0	5
BOBO	2005	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
	2006[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RWBL	2005	2	0	0	0	7	7	5	4	0	3	0	0	25	0	0	53
	2006	15	1	0	0	2	8	30	0	2	5	0	5	23	0	0	91
AMGO	2005	0	0	0	0	3	0	4	0	2	0	0	0	2	0	0	11
	2006[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COYE	2005	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	3
	2006[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FISP	2005	0	0	0	1	0	0	0	0	0	0	3	0	0	3	0	7
	2006	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
BHCO	2005	3	3	20	2	5	1	6	8	6	2	0	6	19	1	8	90
	2006	4	4	7	0	28	4	39	11	24	5	0	3	0	0	4	133
NOBO	2005	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
	2006	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2
RNPH	2005	0	0	0	0	0	0	1	3	1	0	0	0	0	0	0	5
	2006	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	3
LASP	2005	8	8	0	3	0	0	0	0	0	24	3	0	0	8	7	61
	2006	11	1	0	1	3	4	11	4	16	6	11	1	0	10	13	92

[a] Indicates no observations were made for the species that year

Table 28. Continued. Total number of observations for each species per cropfield site during the 2005-2006 breeding seasons. Species names and abbreviations are located in Table 27.

		Site															
Species	**Year**	**3**	**4**	**6**	**8**	**9**	**10**	**12**	**13**	**14**	**15**	**16**	**20**	**23**	**24**	**25**	**Total**
WITU	2005	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3
	2006[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EAKI	2005	2	3	1	2	0	0	4	1	0	1	0	0	5	5	0	24
	2006	1	0	0	1	1	1	13	0	2	4	0	5	0	1	1	30
VESP	2005	0	0	6	2	0	0	0	0	3	0	0	0	3	2	0	16
	2006	0	0	0	0	2	0	3	3	9	0	0	1	0	1	4	23
BAOR	2005	0	0	5	0	1	0	5	0	0	0	1	0	0	0	1	13
	2006	4	0	7	0	0	0	7	0	0	0	0	0	0	0	4	22
BRTH	2005	0	0	0	0	0	0	1	0	0	0	1	2	0	0	1	5
	2006	1	0	0	0	0	0	9	0	0	0	0	0	0	0	0	10
MODO	2005	1	13	0	0	0	0	0	0	0	5	0	1	2	0	0	22
	2006	0	8	2	0	0	0	3	0	1	0	0	1	0	0	0	15
X[b]	2005	3	1	3	1	0	0	3	0	2	1	8	5	0	0	0	27
	2006	1	5	2	0	3	0	1	2	2	0	1	5	0	1	0	23
COGR	2005	2	10	0	0	0	0	0	0	0	3	0	0	0	0	0	15
	2006	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	2
AMRO	2005	2	0	0	0	0	0	0	0	0	0	0	6	0	0	1	9
	2006	0	0	6	0	0	0	7	0	0	1	2	3	0	0	2	21
NOCA	2005	1	0	0	0	0	0	0	0	0	0	2	0	1	0	0	4
	2006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EABL	2005	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
	2006	0	0	0	0	1	0	9	0	2	0	0	2	0	0	0	14

[a] Indicates no observations were made for the species that year
[b] Species that could not be identified

Table 28. Continued. Total number of observations for each species per cropfield site during the 2005-2006 breeding seasons. Species names and abbreviations are located in Table 27.

		Site														
Species	**Year**	**3**	**4**	**6**	**8**	**9**	**10**	**12**	**13**	**14**	**15**	**16**	**20**	**23**	**24**	**25**	**Total**
HOWR	2005	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	2006[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHSP	2005	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	4
	2006	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	5
KILL	2005	0	9	0	0	0	0	0	0	0	0	0	2	0	4	0	15
	2006	3	0	0	0	0	0	0	2	2	0	0	9	0	0	0	16
CRCA	2005	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	2
	2006	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0	4
BLJA	2005	0	0	0	0	0	0	5	0	0	0	0	0	0	3	0	8
	2006	0	0	0	0	0	0	23	0	0	0	1	0	0	1	1	26
RHWO	2005	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
	2006[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AMCR	2005	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
	2006	0	0	0	0	0	0	0	6	0	1	0	0	0	0	0	7
HOLA	2005	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
	2006	0	0	0	0	1	0	12	0	4	0	0	0	0	0	0	17
INBU	2005	0	0	0	0	0	0	0	0	0	0	2	0	0	3	2	7
	2006	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	3
EATO	2005[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2006	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
NOFL	2005[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2006	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2
RBWO	2005[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2006	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1

[a] Indicates no observations were made for the species that year

Table 28. Continued. Total number of observations for each species per cropfield site during the 2005-2006 breeding seasons. Species names and abbreviations are located in Table 27.

		Site														
Species	**Year**	**3**	**4**	**6**	**8**	**9**	**10**	**12**	**13**	**14**	**15**	**16**	**20**	**23**	**24**	**25**	**Total**
EUST	2005[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2006	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	5
GCFL	2005[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2006	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
OROR	2005[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2006	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
TUVU	2005[a]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2006	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
TOTAL	2005	28	53	45	20	22	18	49	18	20	56	20	25	64	34	31	503
	2006	43	21	26	2	61	43	190	45	68	33	15	51	25	15	29	667

[a] Indicates no observations were made for the species that year

Table 29. Best-fit ($\Delta i = 0$) and alternative ($\Delta i < 4$) models for grasshopper sparrow abundance in cropfields.

GRASSHOPPER SPARROW

Model	**Ki** [a]	**ΔAICc** [b]	***Wi*** [c]
CRP density + Year	4	0.0	1.0000

Variable	$\hat{\bar{\theta}}$ [d]	$\hat{se}(\hat{\theta})$ [e]
CRP density	6.5384	1.0518

[a] Number of parameters in each model
[b] Difference between the best model and alternative models
[c] Weight of model: estimated probability of being the best model
[d] Model averaged estimator: estimate of variable's effect
[e] Unconditional standard error

Table 30. Summary of distances traveled into cropfields by grassland birds in southeastern Nebraska, 2005-2006.

Species	Cropfield Width (m)	Number of Obs.	Distance Traveled From Grassland (m)				Min. Dist. to Treeline (m)
			Min.	Max.	Mean	Overall Min.	
Grasshopper Sparrow	96	0	0.0	0.0	0.0	0.0	101.4
	102	0	0.0	0.0	0.0	**Overall Max.**	
	113	6	1.7	11.4	5.5	58.5	
	117	1	3.2	3.2	3.2	**Overall Mean**	
	121	0	0.0	0.0	0.0	11.5	
	141	1	6.0	6.0	6.0		
	145	0	0.0	0.0	0.0		
	155	0	0.0	0.0	0.0		
	173	0	0.0	0.0	0.0		
	176	0	0.0	0.0	0.0		
	222	2	1.7	13.1	7.4		
	230	0	0.0	0.0	0.0		
	253	0	0.0	0.0	0.0		
	286	1	58.5	58.5	58.5		
	306	2	4.8	29.4	17.1		
Dickcissel	96	0	0.0	0.0	0.0	**Overall Min.**	8.9
	102	1	44.5	44.5	44.5	0.0	
	113	0	0.0	0.0	0.0	**Overall Max.**	
	117	2	24.8	24.8	24.8	250.9	
	121	6	0.5	83.4	29.1	**Overall Mean**	
	141	2	17.6	25.8	21.7	49.1	
	145	8	1.0	21.3	13.4		
	155	26	0.5	131.4	55.3		
	173	31	0.3	164.1	52.9		
	176	3	98.5	141.2	127.0		
	222	9	0.5	75.5	35.3		
	230	1	46.0	46.0	46.0		
	253	37	0.3	184.4	43.7		
	286	9	19.7	55.8	29.8		
	306	20	6.4	250.9	74.2		

Table 30. Continued. Summary of distances traveled into cropfields by grassland birds in southeastern Nebraska, 2005-2006.

Species	Cropfield Width (m)	Number of Obs.	Dist. Traveled From Grassland (m)				Min. Dist. to Treeline (m)
			Min.	Max.	Mean	Overall Min.	
Meadowlark	96	0	0.0	0.0	0.0	0.0	44.4
	102	3	9.9	35.4	18.4	**Overall Max.**	
	113	0	0.0	0.0	0.0	96.6	
	117	1	54.5	54.5	54.5	**Overall Mean**	
	121	0	0.0	0.0	0.0	39.0	
	141	1	96.6	96.6	96.6		
	145	1	37.7	37.7	37.7		
	155	0	0.0	0.0	0.0		
	173	2	9.0	9.0	9.0		
	176	2	73.1	73.7	73.4		
	222	0	0.0	0.0	0.0		
	230	2	60.8	68.2	64.5		
	253	3	2.1	16.7	11.8		
	286	2	52.1	52.1	52.1		
	306	0	0.0	0.0	0.0		

Red-winged Blackbird	96	0	0.0	0.0	0.0	**Overall Min.**	0.5
	102	17	7.5	101.3	53.4	0.0	
	113	0	0.0	0.0	0.0	**Overall Max.**	
	117	1	41.8	41.8	41.8	233.6	
	121	5	38.6	60.8	54.5	**Overall Mean**	
	141	0	0.0	0.0	0.0	79.5	
	145	0	0.0	0.0	0.0		
	155	9	1.0	118.9	87.4		
	173	15	2.4	66.4	45.2		
	176	48	6.3	167.4	106.9		
	222	0	0.0	0.0	0.0		
	230	4	29.6	163.8	93.0		
	253	35	8.1	203.8	67.8		
	286	2	34.1	34.1	34.1		
	306	8	36.3	233.6	101.6		

Table 30. Continued. Summary of distances traveled into cropfields by grassland birds in southeastern Nebraska, 2005-2006.

Species	Cropfield Width (m)	Number of Obs.	Dist. Traveled From Grassland (m)				Min. Dist. to Treeline (m)
			Min.	Max.	Mean	Overall Min.	
Brown-headed Cowbird	96	0	0.0	0.0	0.0	0.0	0.1
	102	7	52.7	92.5	80.4	**Overall Max.**	
	113	2	2.8	83.2	43.0	279.3	
	117	7	7.1	69.5	30.6	**Overall Mean**	
	121	9	13.2	62.9	52.4	75.0	
	141	1	51.3	51.3	51.3		
	145	27	1.0	135.5	69.3		
	155	33	8.2	83.0	42.2		
	173	5	0.7	143.5	83.2		
	176	19	12.7	176.7	100.5		
	222	12	0.7	130.1	32.6		
	230	19	7.6	179.6	106.0		
	253	45	0.9	197.3	71.0		
	286	30	2.6	279.3	110.5		
	306	7	95.8	155.1	105.0		

Lark Sparrow	96	14	2.5	75.6	44.5	**Overall Min.**	0.1
	102	19	1.0	90.9	61.1	0.0	
	113	4	31.1	112.5	79.1	**Overall Max.**	
	117	9	23.3	87.3	41.2	288.3	
	121	1	72.5	72.5	72.5	**Overall Mean**	
	141	18	0.9	140.5	52.5	104.7	
	145	0	0.0	0.0	0.0		
	155	3	123.4	140.9	135.1		
	173	4	8.2	115.8	87.4		
	176	0	0.0	0.0	0.0		
	222	20	14.0	217.3	99.0		
	230	4	90.3	135.4	111.5		
	253	11	5.6	234.1	186.7		
	286	16	8.3	247.1	95.9		
	306	30	64.3	288.3	192.6		

Table 30. Continued. Summary of distances traveled into cropfields by grassland birds in southeastern Nebraska, 2005-2006.

Species	Cropfield Width (m)	Number of Obs.	Dist. Traveled From Grassland (m)				Min. Dist. to Treeline (m)
			Min.	Max.	Mean	Overall Min.	
Vesper Sparrow	96	0	0.0	0.0	0.0	0.0	44.6
	102	0	0.0	0.0	0.0	**Overall Max.**	
	113	2	48.8	62.4	55.6	207.9	
	117	0	0.0	0.0	0.0	**Overall Mean**	
	121	1	1.4	1.4	1.4	72.3	
	141	3	2.2	92.8	62.6		
	145	6	1.0	84.9	36.4		
	155	2	11.6	65.9	38.8		
	173	0	0.0	0.0	0.0		
	176	3	57.8	89.9	75.8		
	222	4	3.7	56.2	31.2		
	230	3	62.3	148.0	119.4		
	253	3	146.7	207.9	174.0		
	286	12	32.0	184.1	82.6		
	306	0	0.0	0.0	0.0		

Table 31. Best-fit ($\Delta i = 0$) and alternative ($\Delta i < 4$) models for dickcissel abundance in cropfields.

DICKCISSEL

Model	Ki [a]	$\Delta AICc$ [b]	Wi [c]
Crop + Year	4	0.0	0.9902

Variables	$\hat{\bar{\theta}}$ [d]	$\hat{se}(\hat{\theta})$ [e]
Soy	0.0000	0.0000
Corn	-2.7424	2.8079
Sorghum	-5.3337	5.4241
Wheat	-7.5135	7.5462

[a] Number of parameters in each model
[b] Difference between the best model and alternative models
[c] Weight of model: estimated probability of being the best model
[d] Model averaged estimator: estimate of variable's effect
[e] Unconditional standard error

Table 32. Best-fit ($\Delta i = 0$) and alternative ($\Delta i < 4$) models for meadowlark abundance in cropfields.

MEADOWLARK

Model	Ki [a]	$\Delta AICc$ [b]	Wi [c]
CRP density + Year	4	0.0	0.6864
Crop + Year	4	2.8	0.1693
Year (null model)	3	3.1	0.1440

Variables	Parameter	$\hat{\bar{\theta}}$ [d]	$\hat{se}(\hat{\theta})$ [e]
CRP density		2.7916	3.6479
Crop + Year	Soy	0.0000	0.0000
	Corn	0.0254	0.0614
	Sorghum	0.0879	0.1331
	Wheat	-0.0451	0.1594
Year (null model)[f]		0.0672	0.0725

[a] Number of parameters in each model
[b] Difference between the best model and alternative models
[c] Weight of model: estimated probability of being the best model
[d] Model averaged estimator: estimate of variable's effect
[e] Unconditional standard error
[f] Year model results represent an estimate for the null model alone, it is not a parameter estimate

Table 33. Best-fit ($\Delta i = 0$) and alternative ($\Delta i < 4$) models for red-winged blackbird abundance in cropfields.

RED-WINGED BLACKBIRD

Model	Ki [a]	ΔAICc [b]	Wi [c]
Crop + Year	4	0.0	0.9991

Variables	$\hat{\bar{\theta}}$ [d]	$\hat{se}(\hat{\theta})$ [e]
Soy	0.0000	0.0000
Corn	0.4483	2.4736
Sorghum	20.6103	4.7782
Wheat	-3.7916	6.6476

[a] Number of parameters in each model
[b] Difference between the best model and alternative models
[c] Weight of model: estimated probability of being the best model
[d] Model averaged estimator: estimate of variable's effect
[e] Unconditional standard error

Table 34. Best-fit ($\Delta i = 0$) and alternative ($\Delta i < 4$) models for brown-headed cowbird abundance in cropfields.

BROWN-HEADED COWBIRD

Model	Ki [a]	ΔAICc [b]	Wi [c]
Crop + Year	4	0.0	0.9989

Variables	$\hat{\bar{\theta}}$ [d]	$\hat{se}(\hat{\theta})$ [e]
Soy	0.0000	0.0000
Corn	-4.6122	3.7394
Sorghum	-0.0097	7.2232
Wheat	-6.8564	10.0493

[a] Number of parameters in each model
[b] Difference between the best model and alternative models
[c] Weight of model: estimated probability of being the best model
[d] Model averaged estimator: estimate of variable's effect
[e] Unconditional standard error

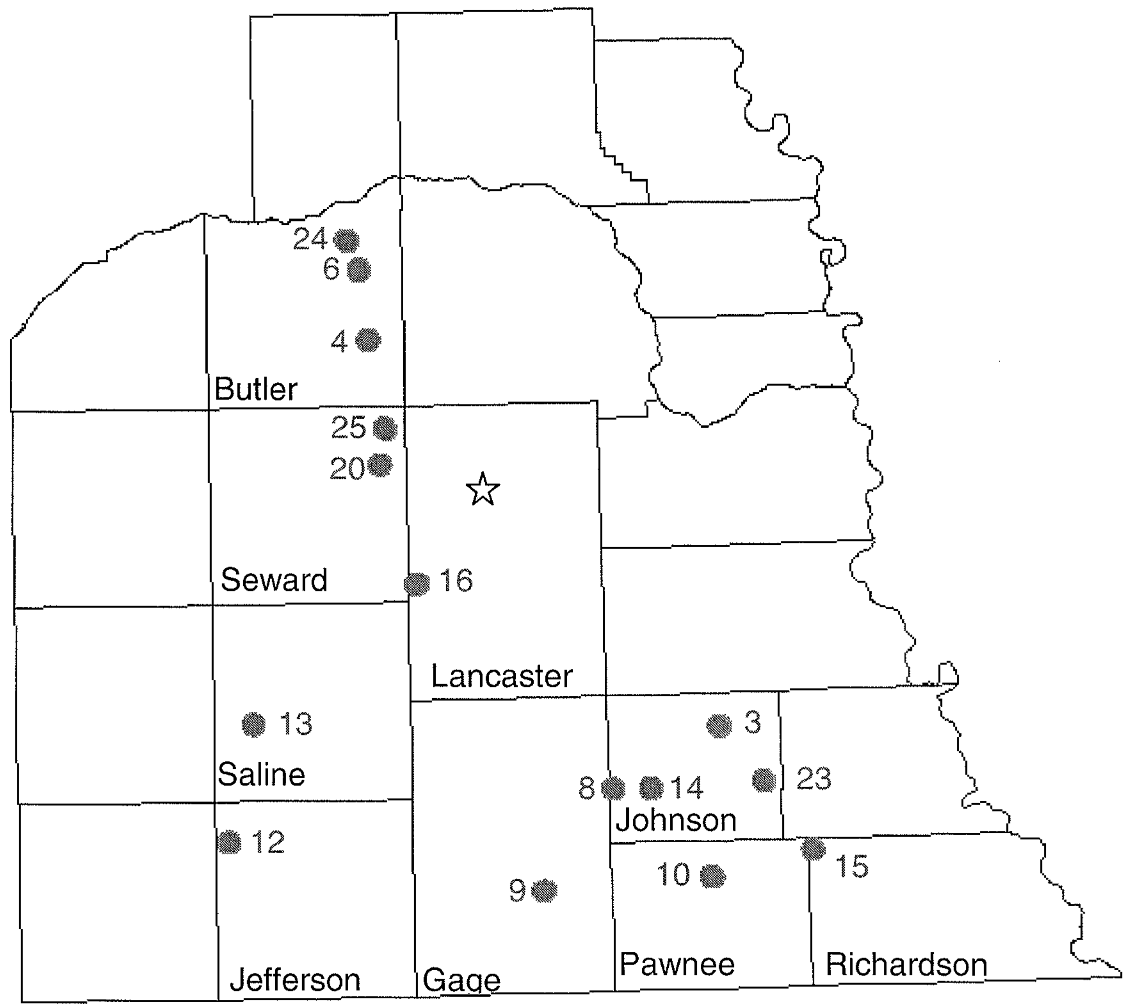
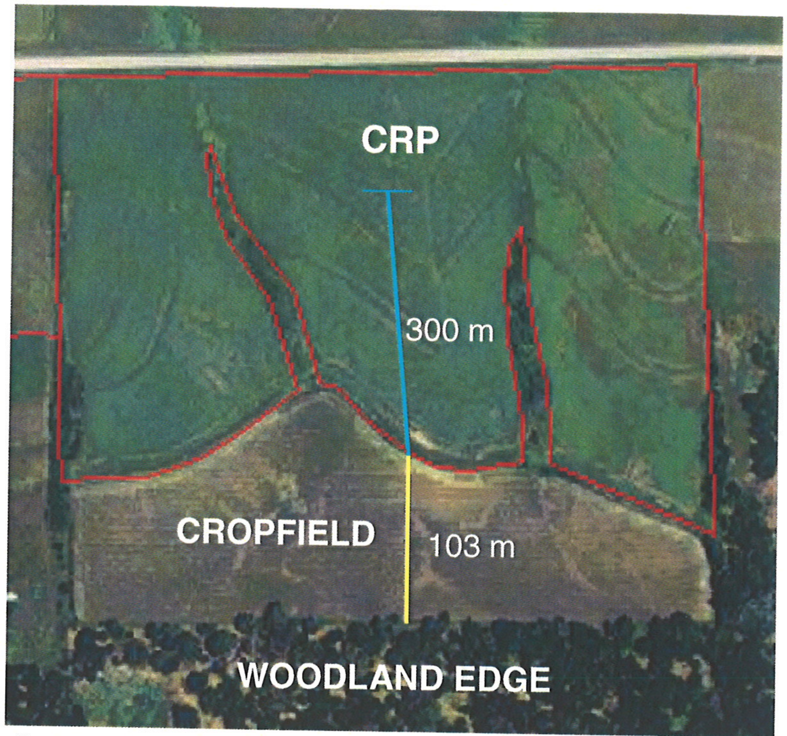


Figure 1. Fifteen study sites located in nine counties in southeastern Nebraska, 2005-2006. The city of Lincoln is indicated by the star to provide a reference point.



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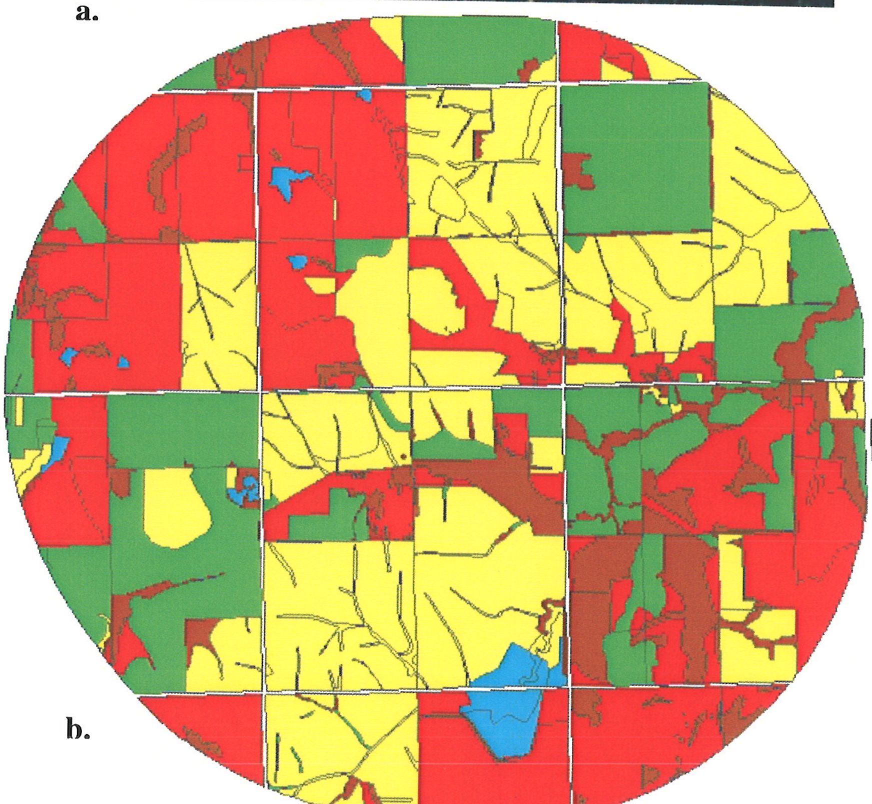

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Figure 2. Study site #3. **a.** Aerial photograph illustrating the CRP grassland (with 300 m line-transect), cropfield (with 103 m transect), and woodland edge. **b.** 2000 m buffer around study site digitized in a GIS. Yellow=Grassland, Red=Pastureland, Brown=Woodland, Green=Cropfields, Blue=Miscellaneous.

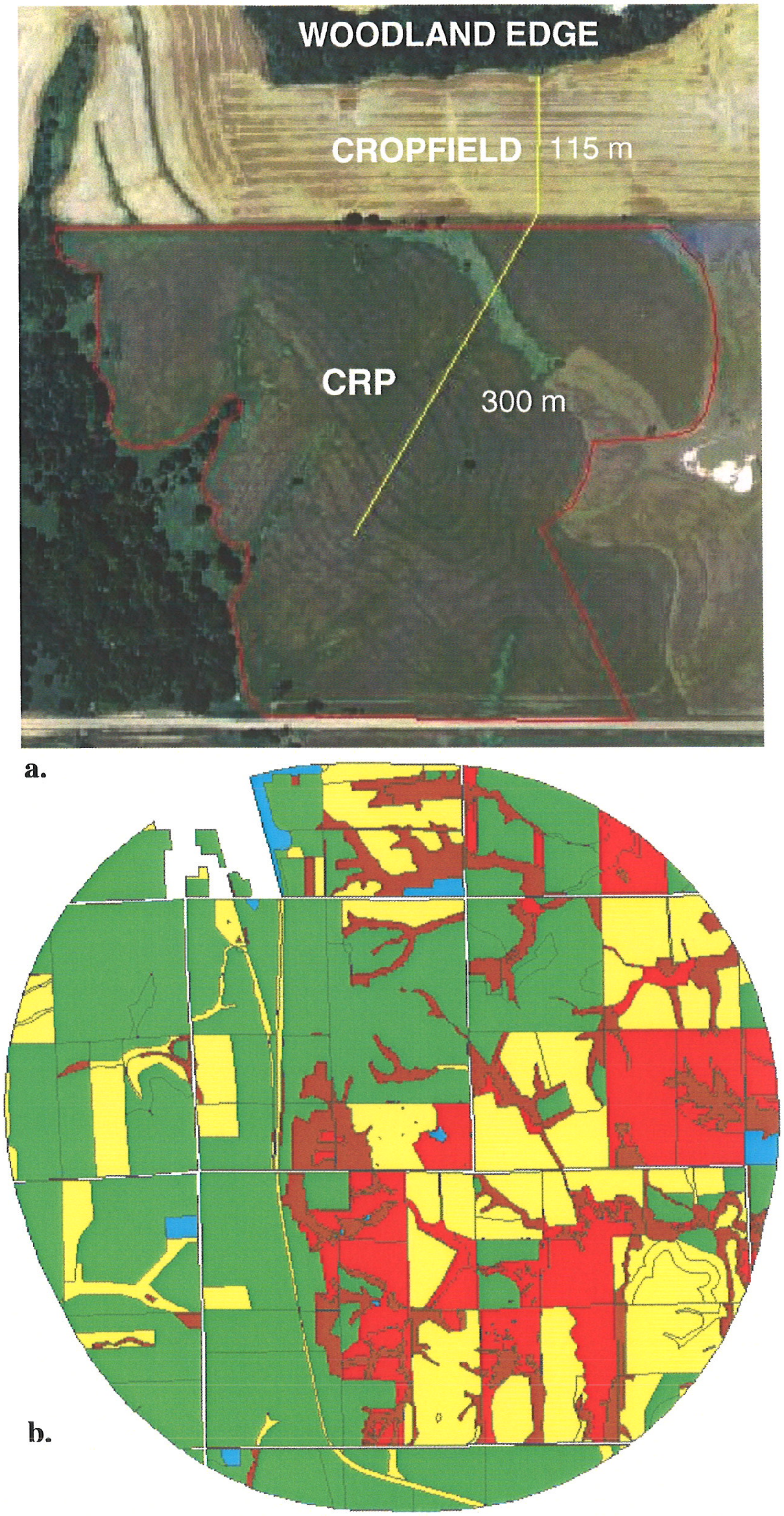
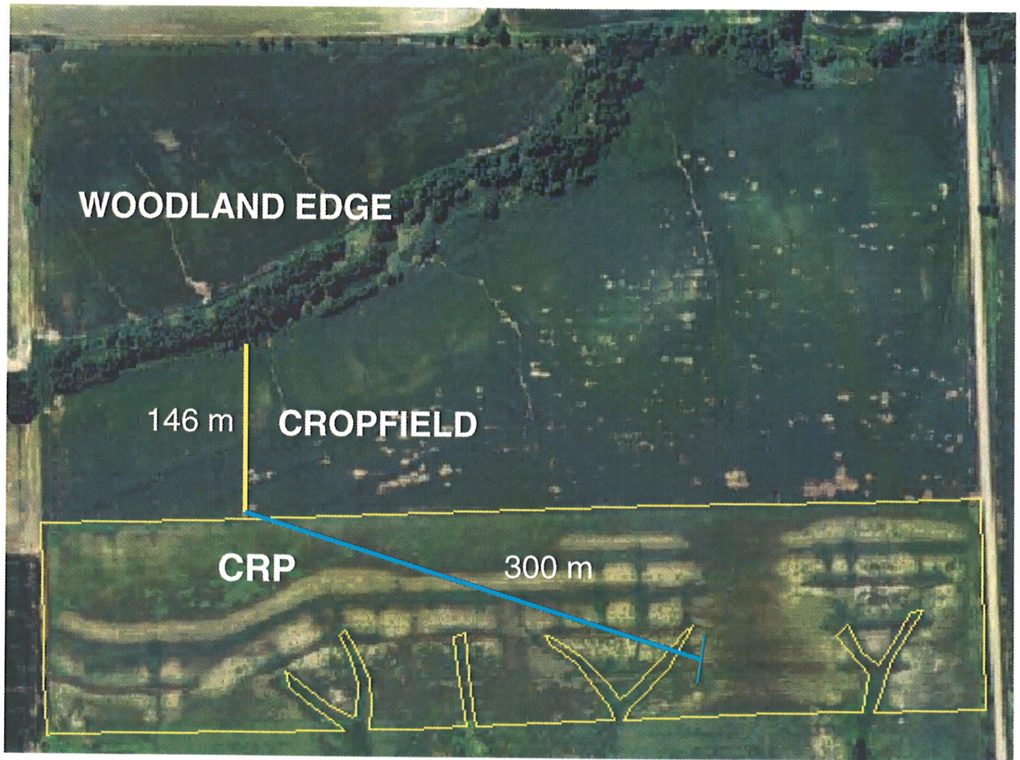


Figure 3. Study site #4. **a.** Aerial photograph illustrating the CRP grassland (with 300 m line-transect), cropfield (with 115 m transect), and woodland edge. **b.** 2000 m buffer around study site digitized in a GIS. Yellow=Grassland, Red=Pastureland, Brown=Woodland, Green=Cropfields, Blue=Miscellaneous.



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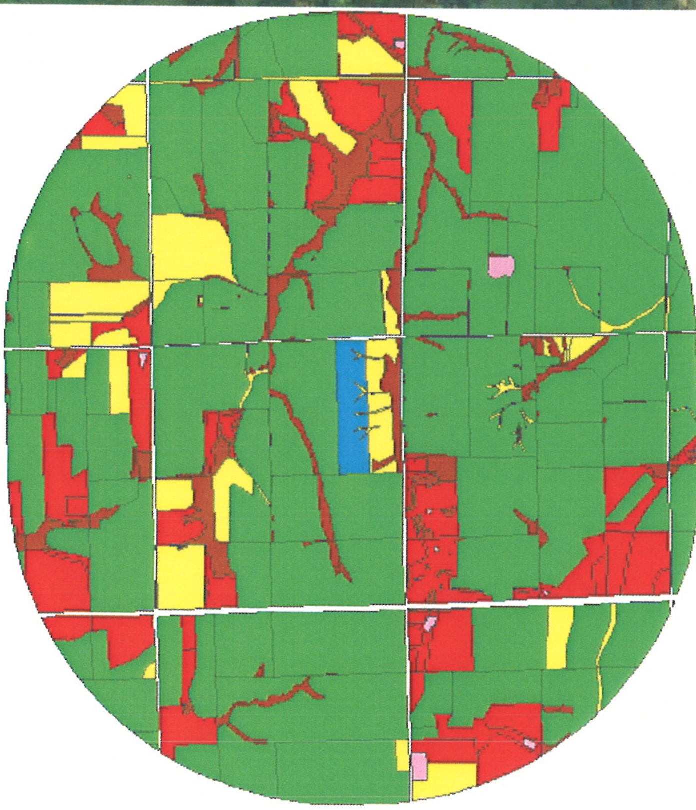

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Figure 4. Study site #6. **a.** Aerial photograph illustrating the CRP grassland (with 300 m line-transect), cropfield (with 146 m transect), and woodland edge. **b.** 2000 m buffer around study site digitized in a GIS. Yellow=Grassland, Red=Pastureland, Brown=Woodland, Green=Cropfields, Blue=Miscellaneous.

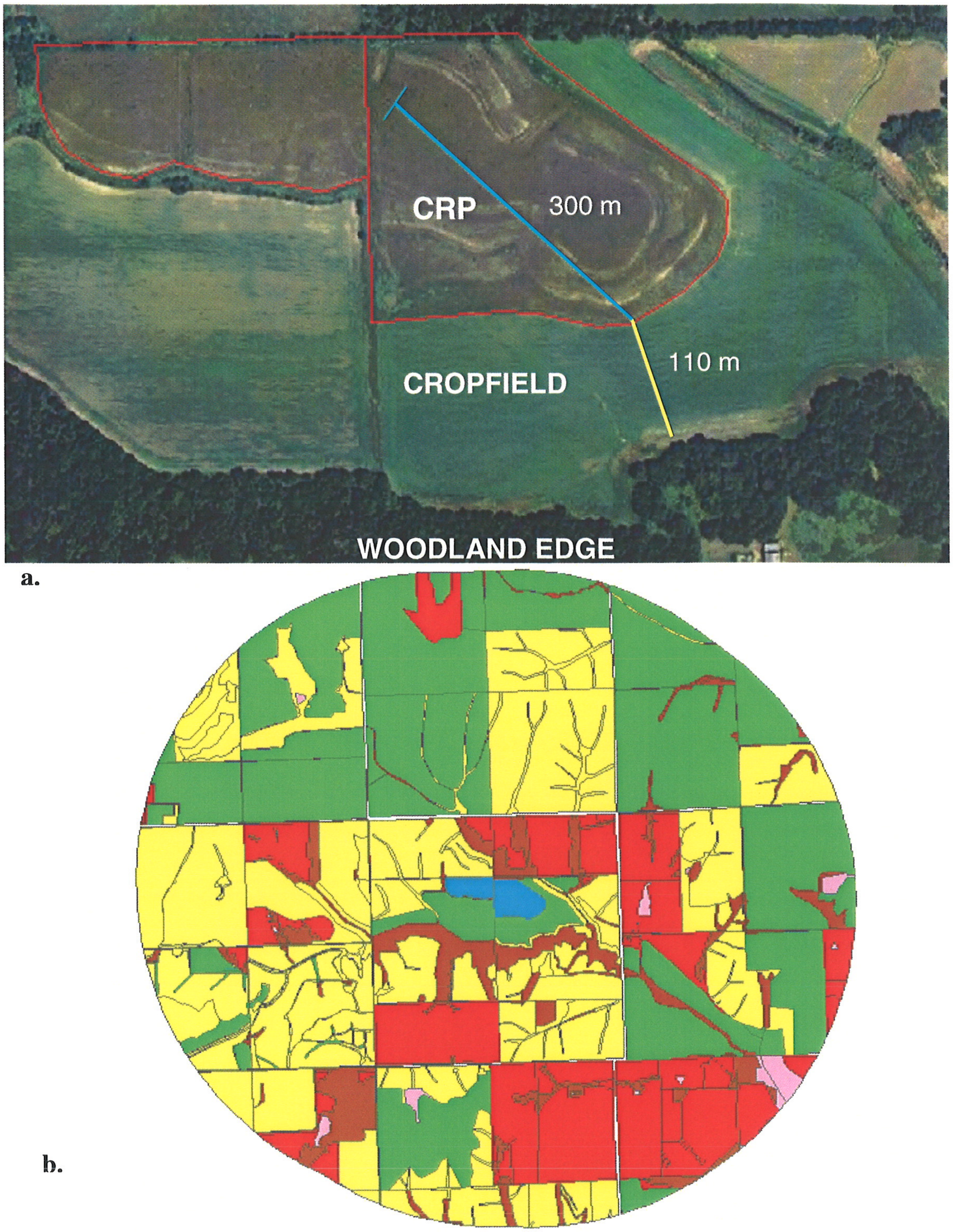

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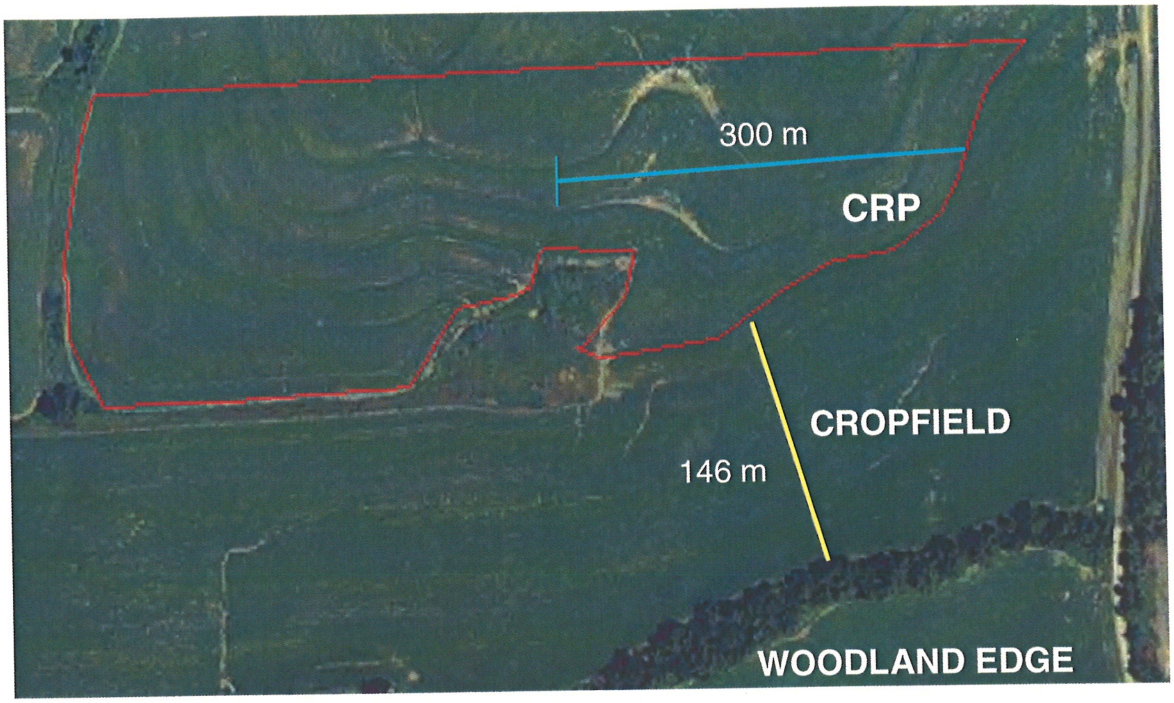
Figure 5. Study site #8. **a.** Aerial photograph illustrating the CRP grassland (with 300 m line-transect), cropfield (with 110 m transect), and woodland edge. **b.** 2000 m buffer around study site digitized in a GIS. Yellow=Grassland, Red=Pastureland, Brown=Woodland, Green=Cropfields, Blue=Miscellaneous.



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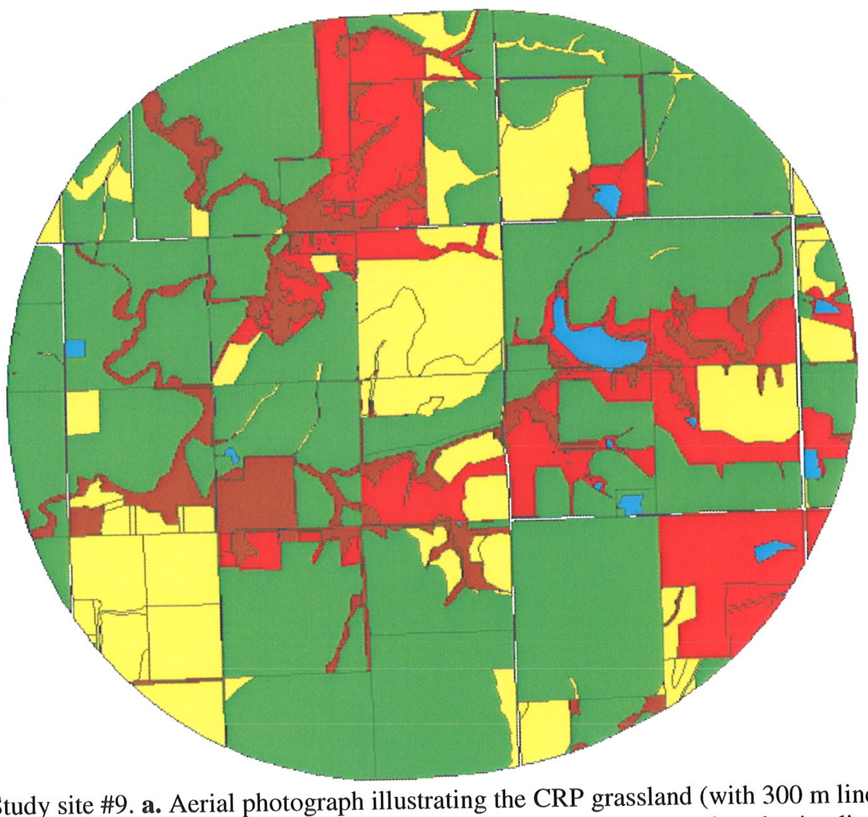


b.

Figure 6. Study site #9. **a.** Aerial photograph illustrating the CRP grassland (with 300 m line-transect), cropfield (with 146 m transect), and woodland edge. **b.** 2000 m buffer around study site digitized in a GIS. Yellow=Grassland, Red=Pastureland, Brown=Woodland, Green=Cropfields, Blue=Miscellaneous.

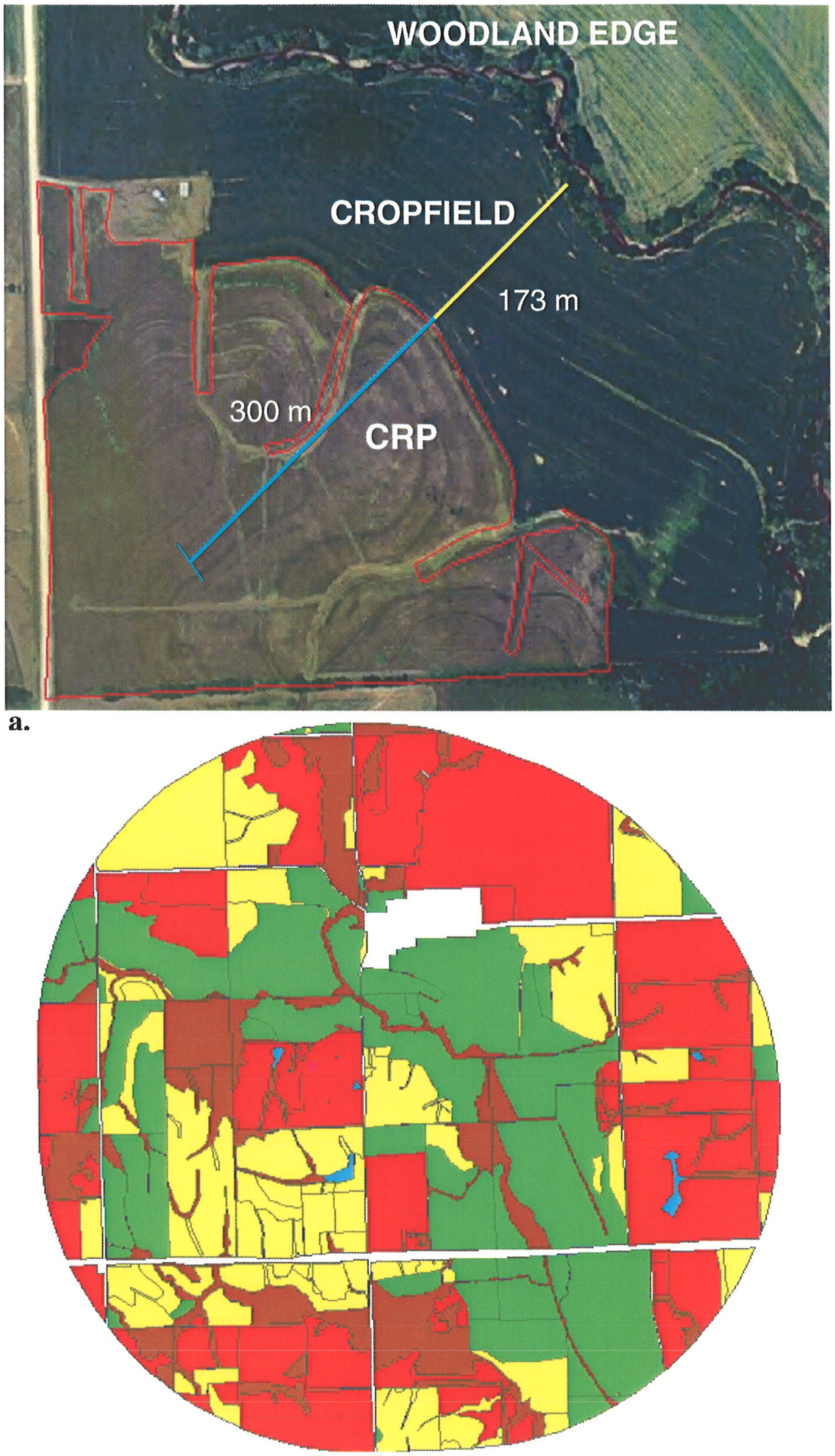
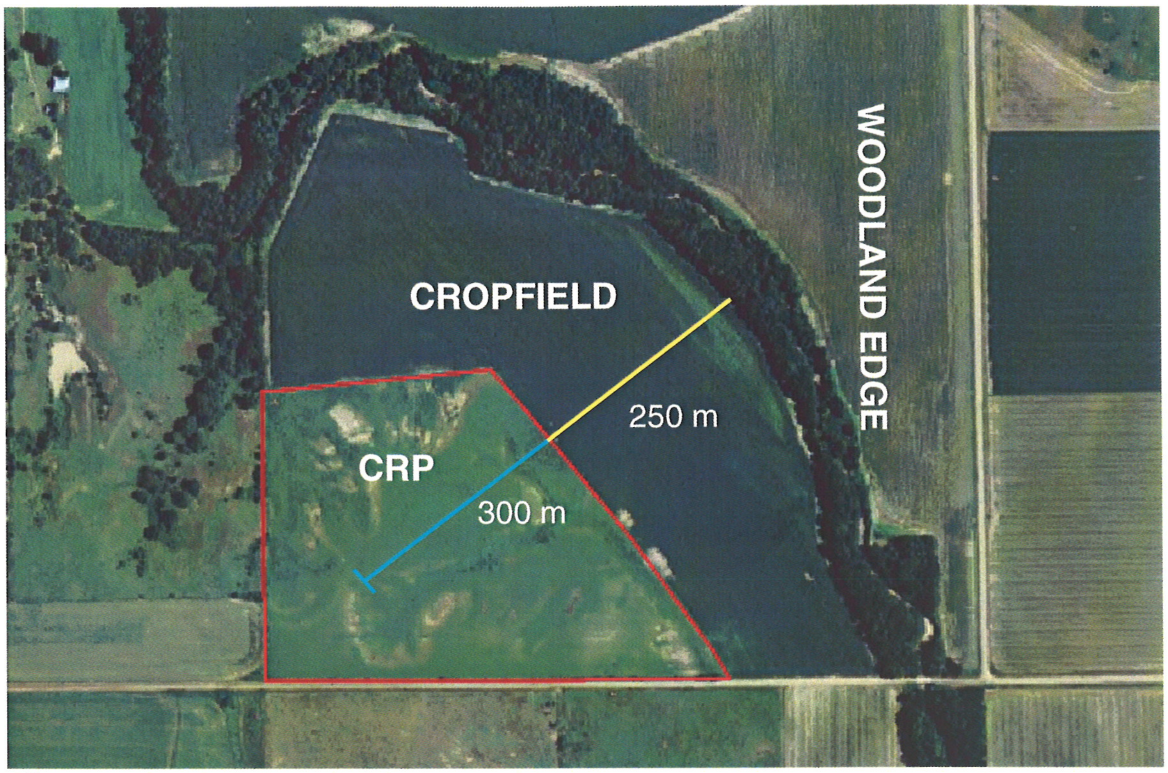


Figure 7. Study site #10. **a.** Aerial photograph illustrating the CRP grassland (with 300 m line-transect), cropfield (with 173 m transect), and woodland edge. **b.** 2000 m buffer around study site digitized in a GIS. Yellow=Grassland, Red=Pastureland, Brown=Woodland, Green=Cropfields, Blue=Miscellaneous.



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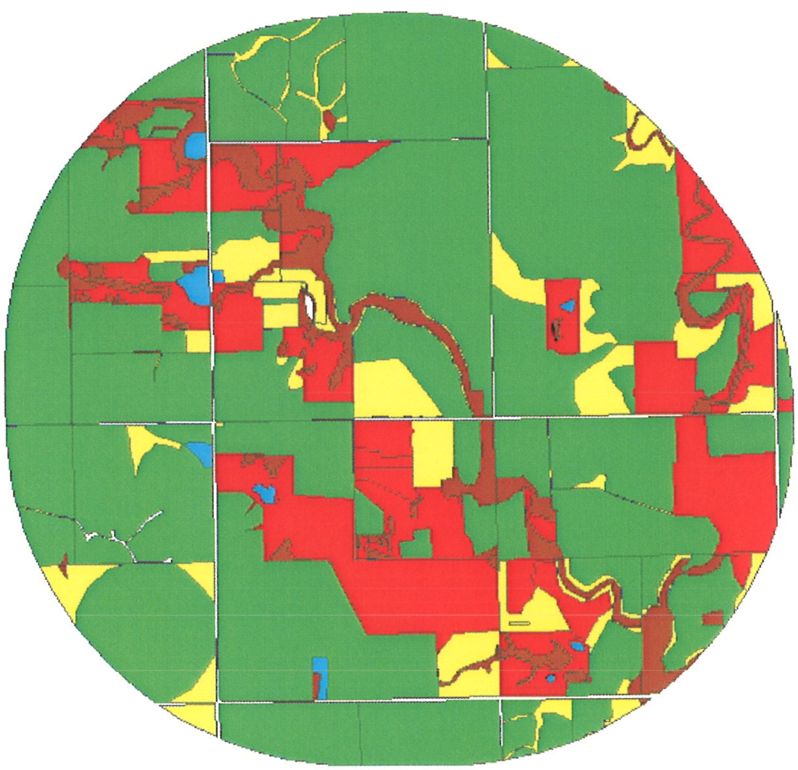
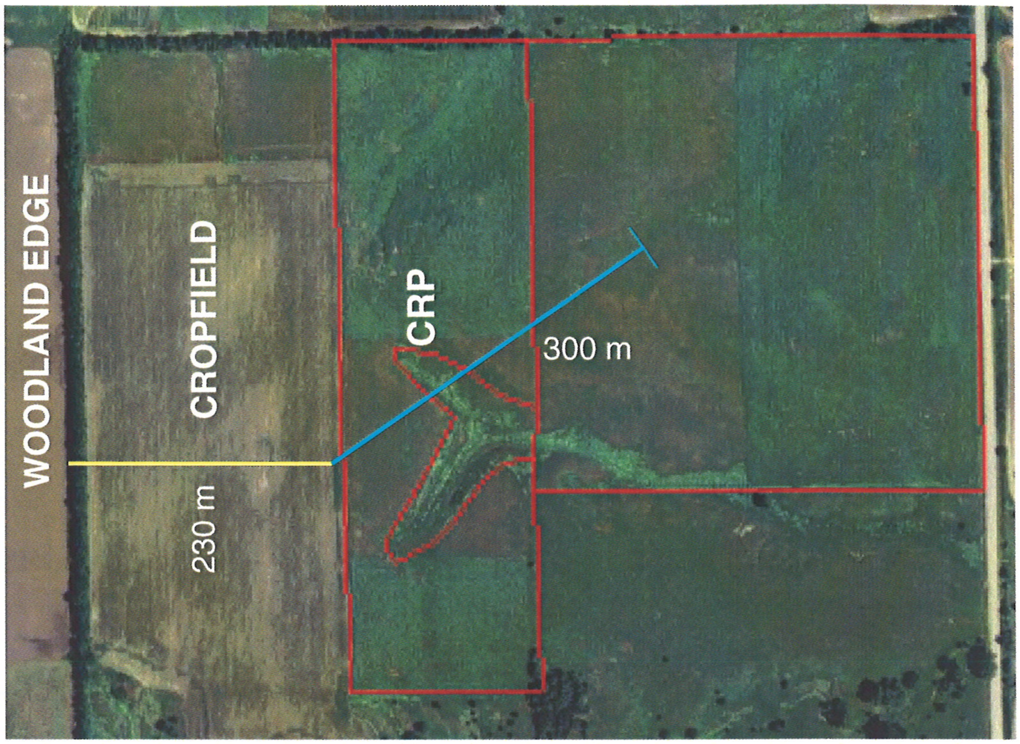


b.

Figure 8. Study site #12. **a.** Aerial photograph illustrating the CRP grassland (with 300 m line-transect), cropfield (with 250 m transect), and woodland edge. **b.** 2000 m buffer around study site digitized in a GIS. Yellow=Grassland, Red=Pastureland, Brown=Woodland, Green=Cropfields, Blue=Miscellaneous.



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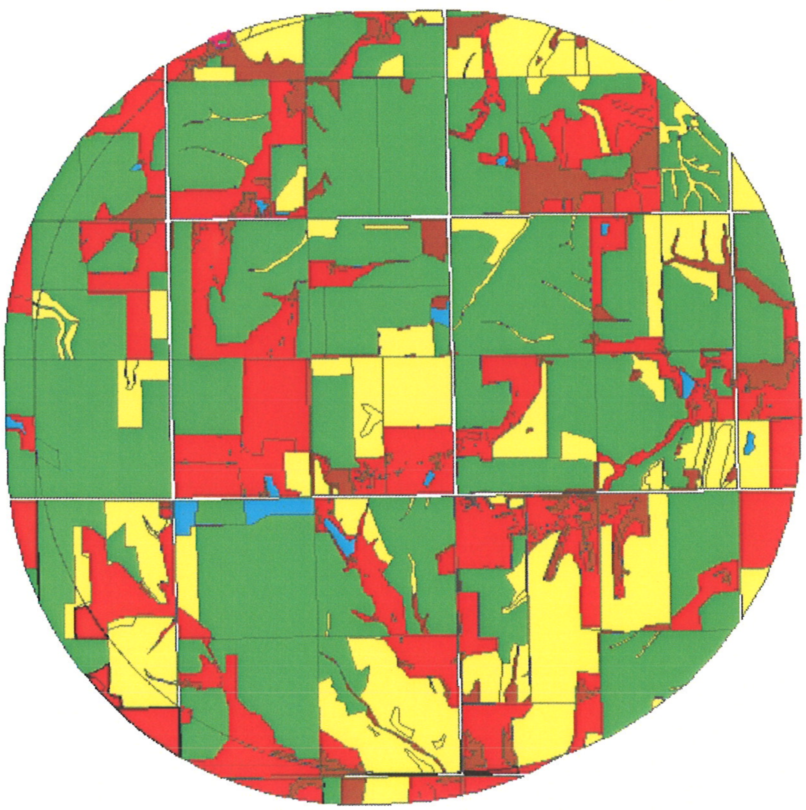

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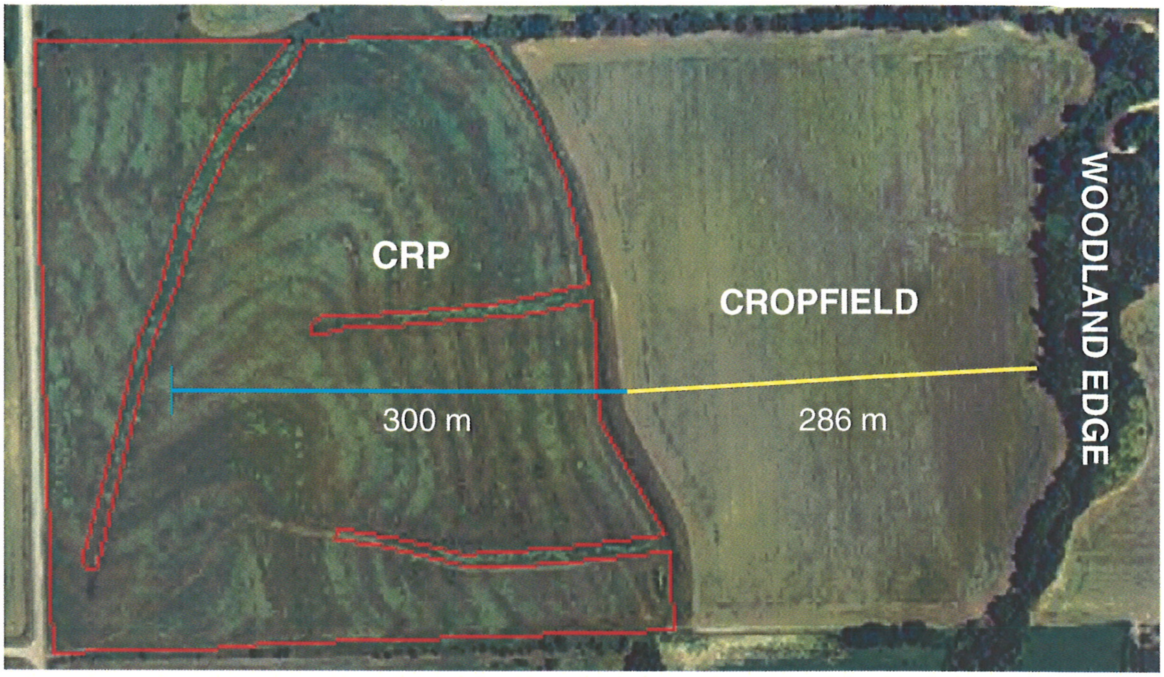
Figure 9. Study site #13. **a.** Aerial photograph illustrating the CRP grassland (with 300 m line-transect), cropfield (with 230 m transect), and woodland edge. **b.** 2000 m buffer around study site digitized in a GIS. Yellow=Grassland, Red=Pastureland, Brown=Woodland, Green=Cropfields, Blue=Miscellaneous.



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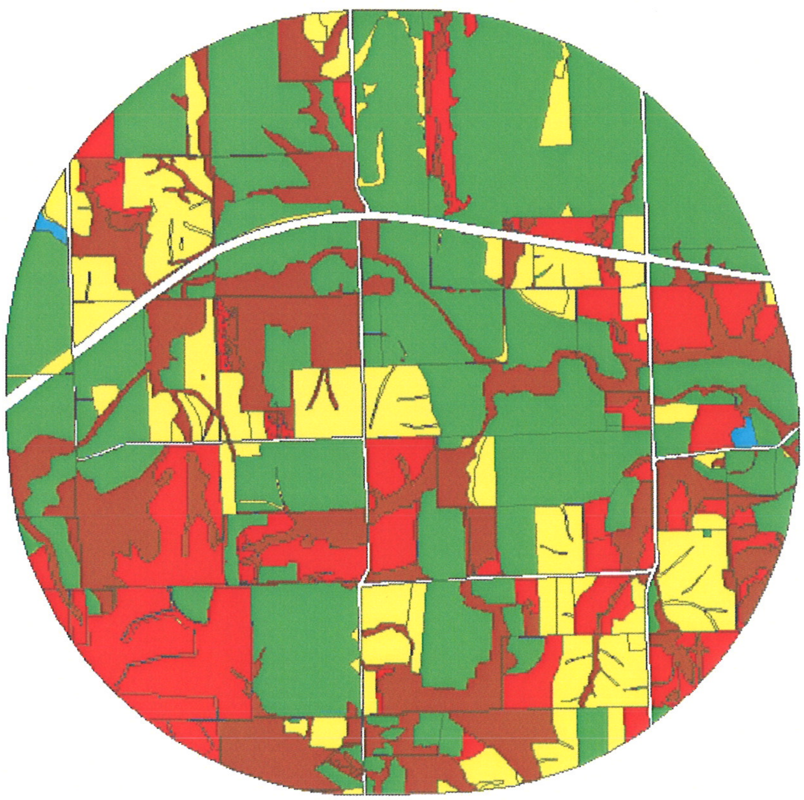
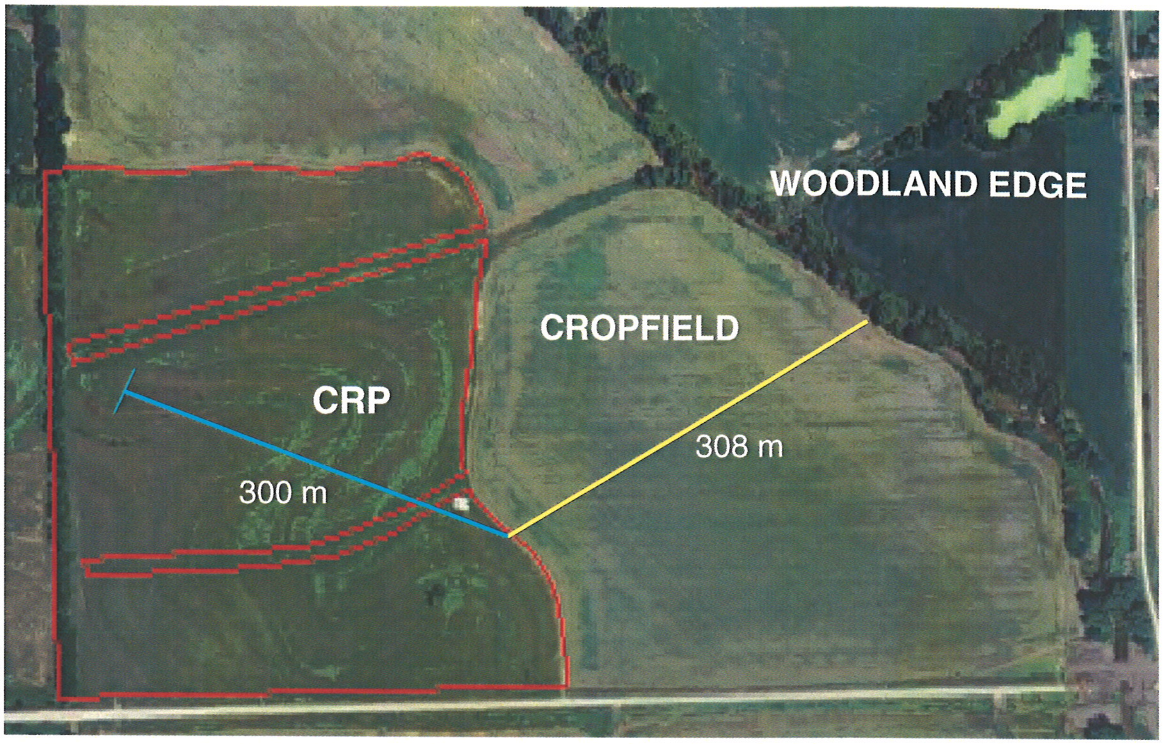


b.

Figure 10. Study site #14. **a.** Aerial photograph illustrating the CRP grassland (with 300 m line-transect), cropfield (with 286 m transect), and woodland edge. **b.** 2000 m buffer around study site digitized in a GIS. Yellow=Grassland, Red=Pastureland, Brown=Woodland, Green=Cropfields, Blue=Miscellaneous.



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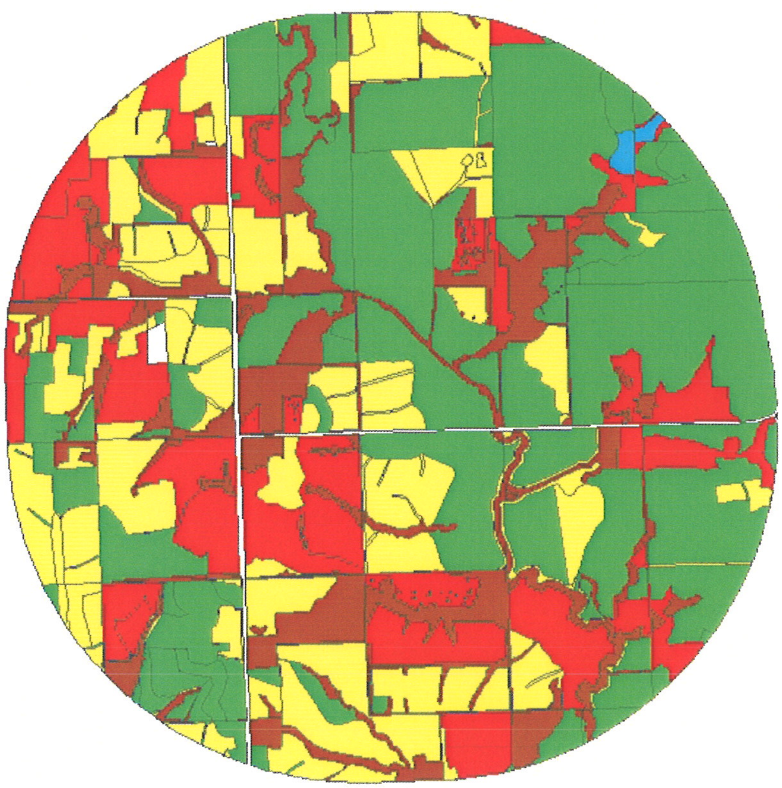
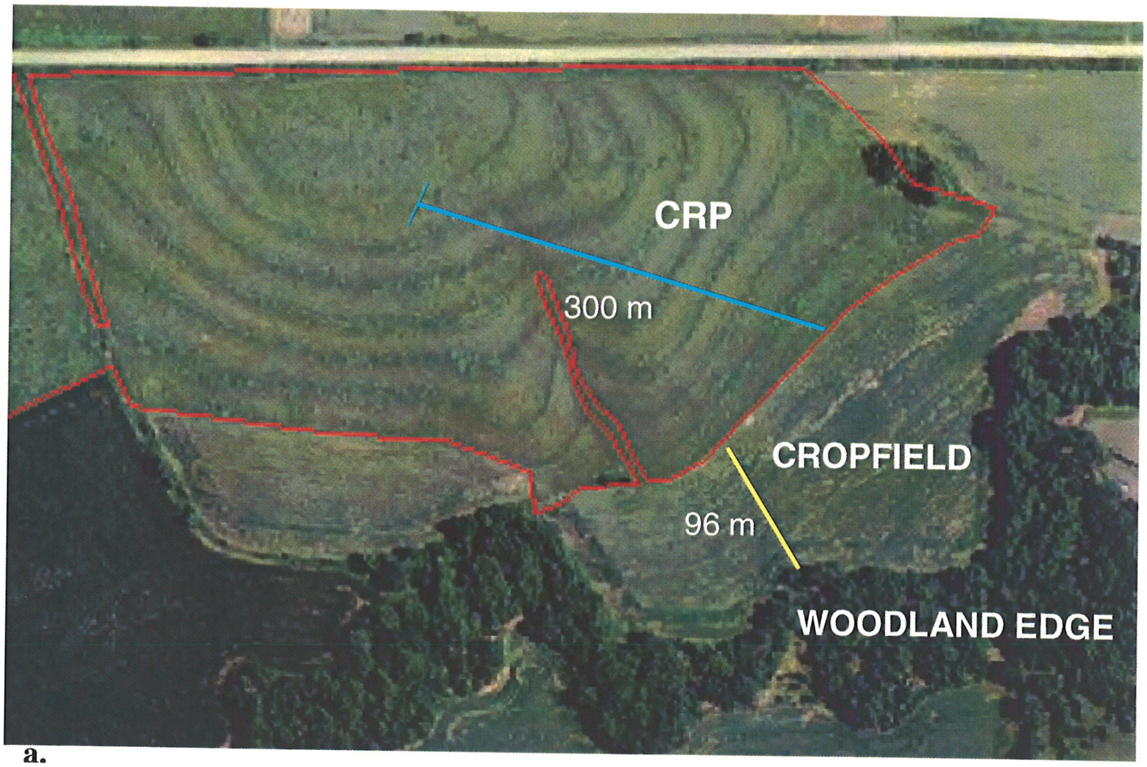


b.

Figure 11. Study site #15. **a.** Aerial photograph illustrating the CRP grassland (with 300 m line-transect), cropfield (with 308 m transect), and woodland edge. **b.** 2000 m buffer around study site digitized in a GIS. Yellow=Grassland, Red=Pastureland, Brown=Woodland, Green=Cropfields, Blue=Miscellaneous.



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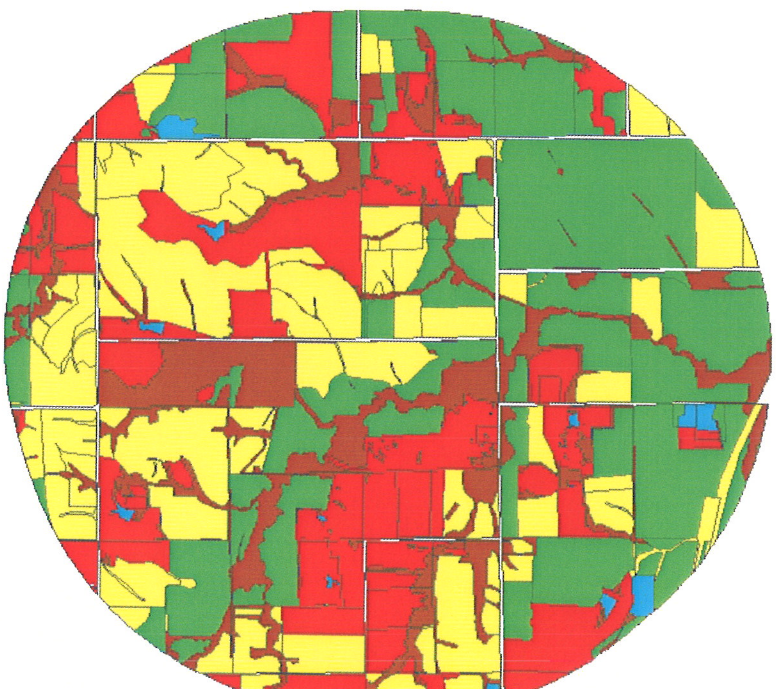
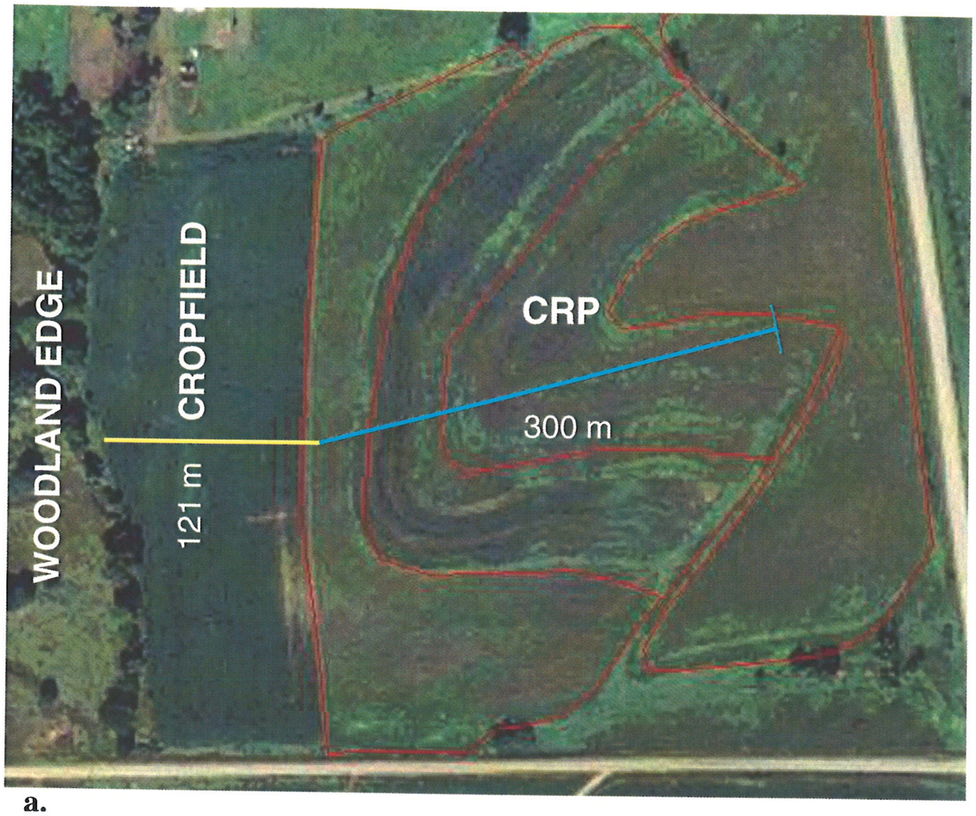


b.

Figure 12. Study site #16. **a.** Aerial photograph illustrating the CRP grassland (with 300 m line-transect), cropfield (with 96 m transect), and woodland edge. **b.** 2000 m buffer around study site digitized in a GIS. Yellow=Grassland, Red=Pastureland, Brown=Woodland, Green=Cropfields, Blue=Miscellaneous.



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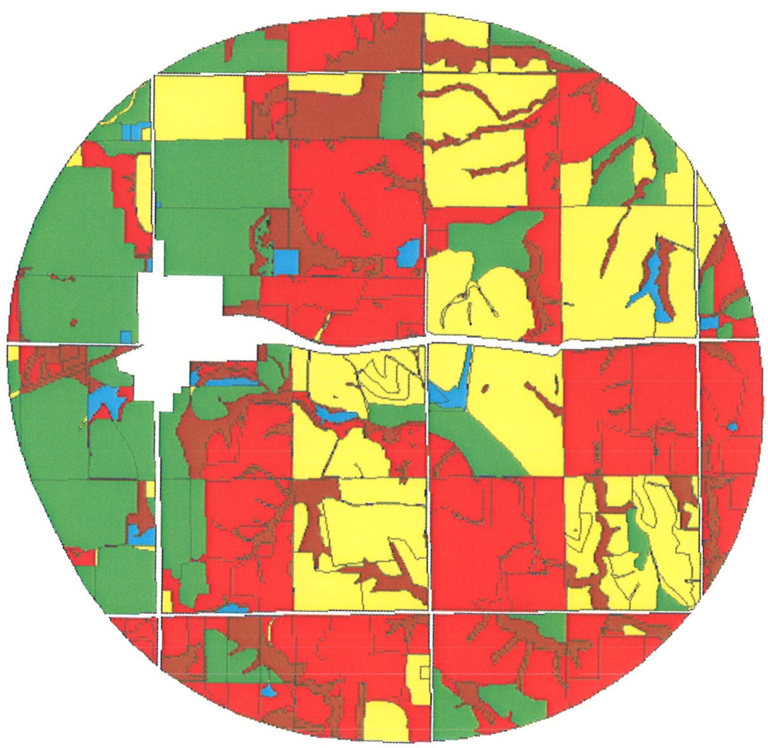

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Figure 13. Study site #20. **a.** Aerial photograph illustrating the CRP grassland (with 300 m line-transect), cropfield (with 121 m transect), and woodland edge. **b.** 2000 m buffer around study site digitized in a GIS. Yellow=Grassland, Red=Pastureland, Brown=Woodland, Green=Cropfields, Blue=Miscellaneous.

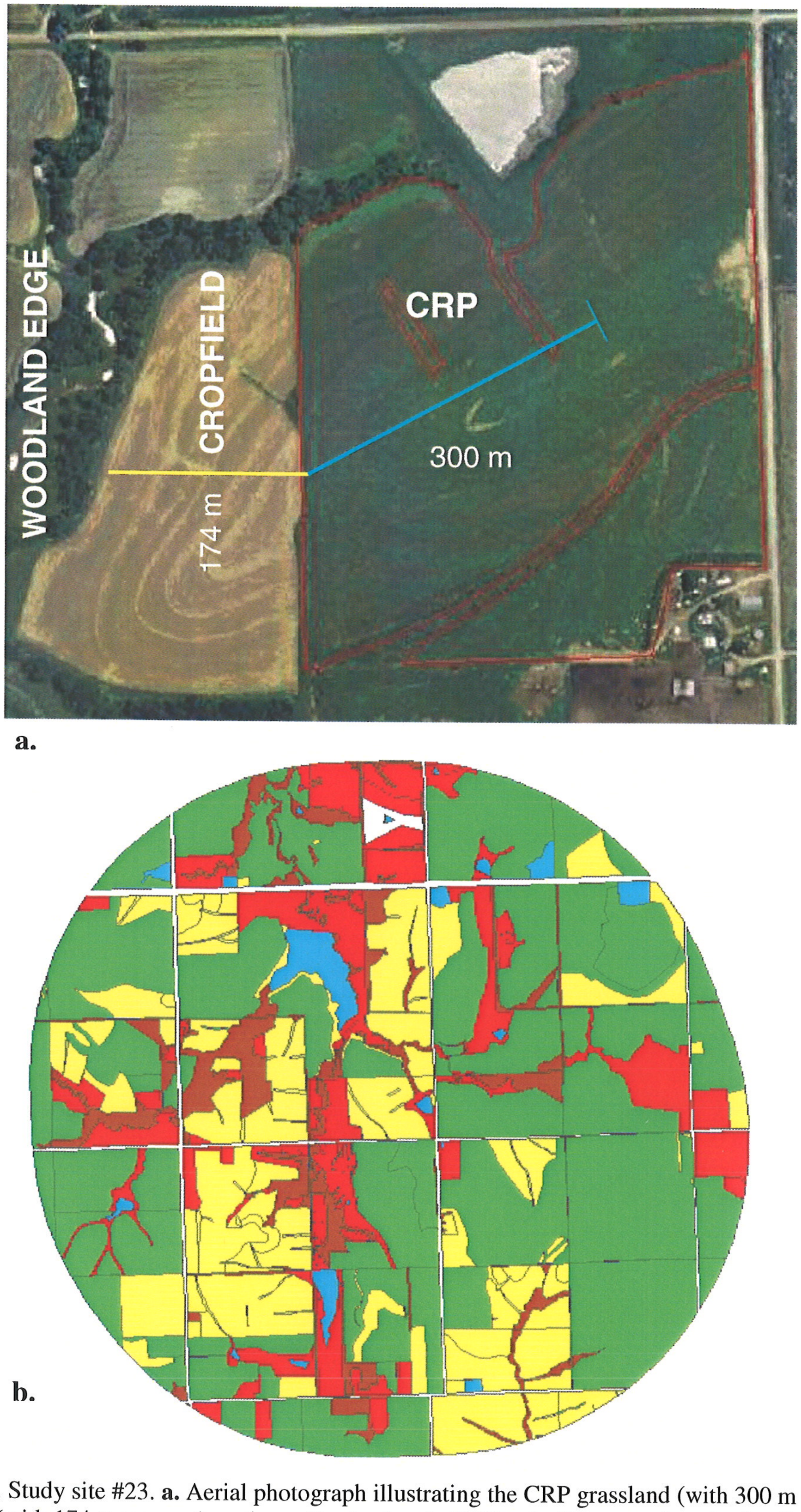
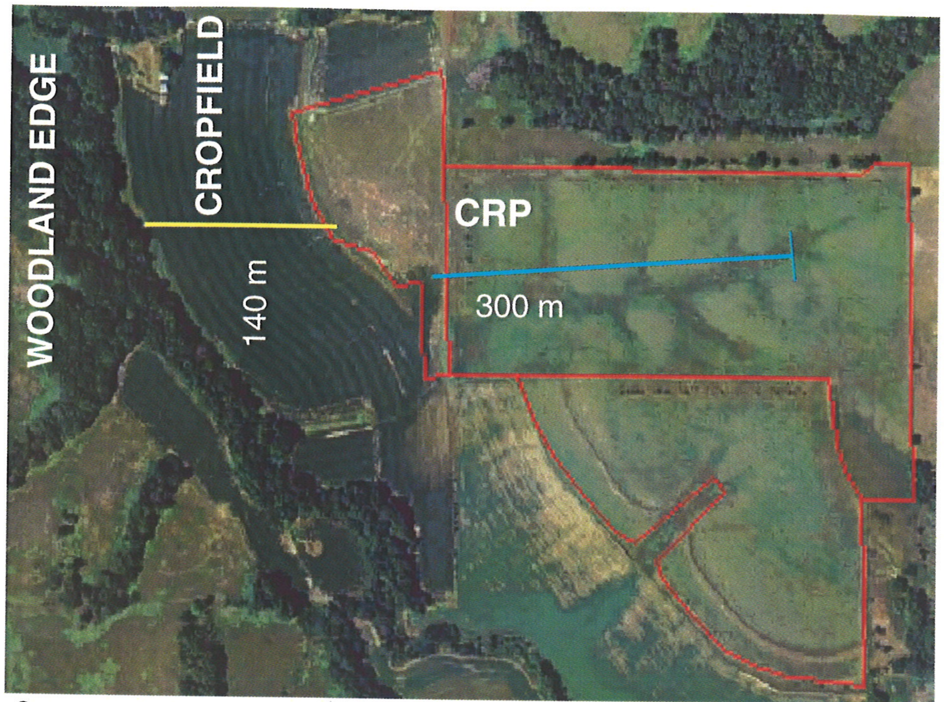


Figure 14. Study site #23. **a.** Aerial photograph illustrating the CRP grassland (with 300 m line-transect), cropfield (with 174 m transect), and woodland edge. **b.** 2000 m buffer around study site digitized in a GIS. Yellow=Grassland, Red=Pastureland, Brown=Woodland, Green=Cropfields, Blue=Miscellaneous.



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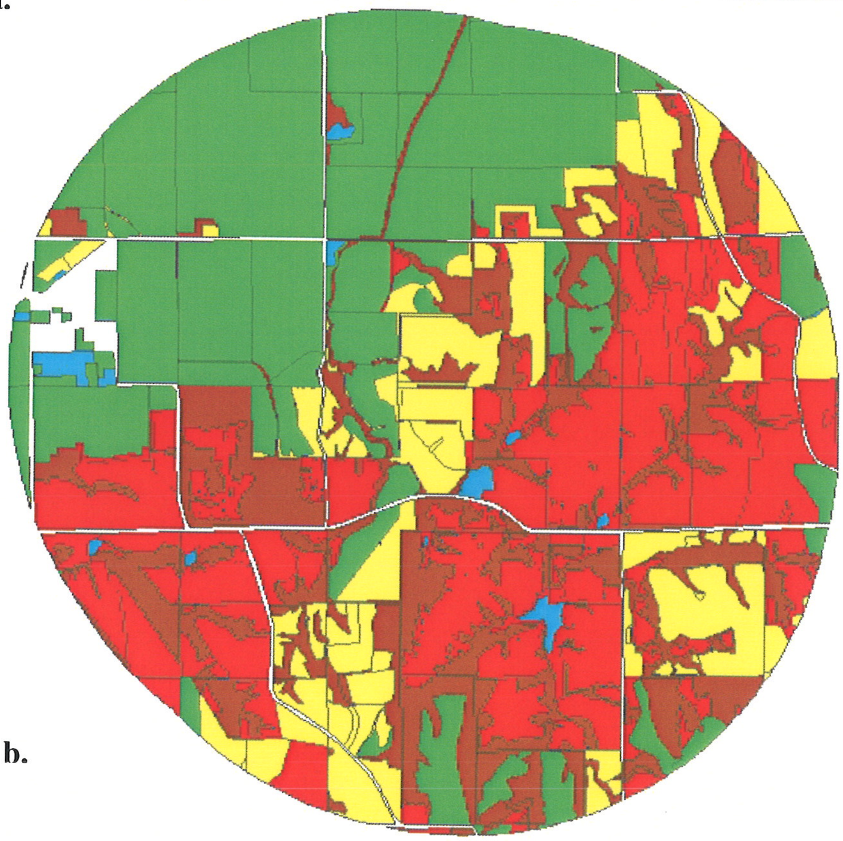
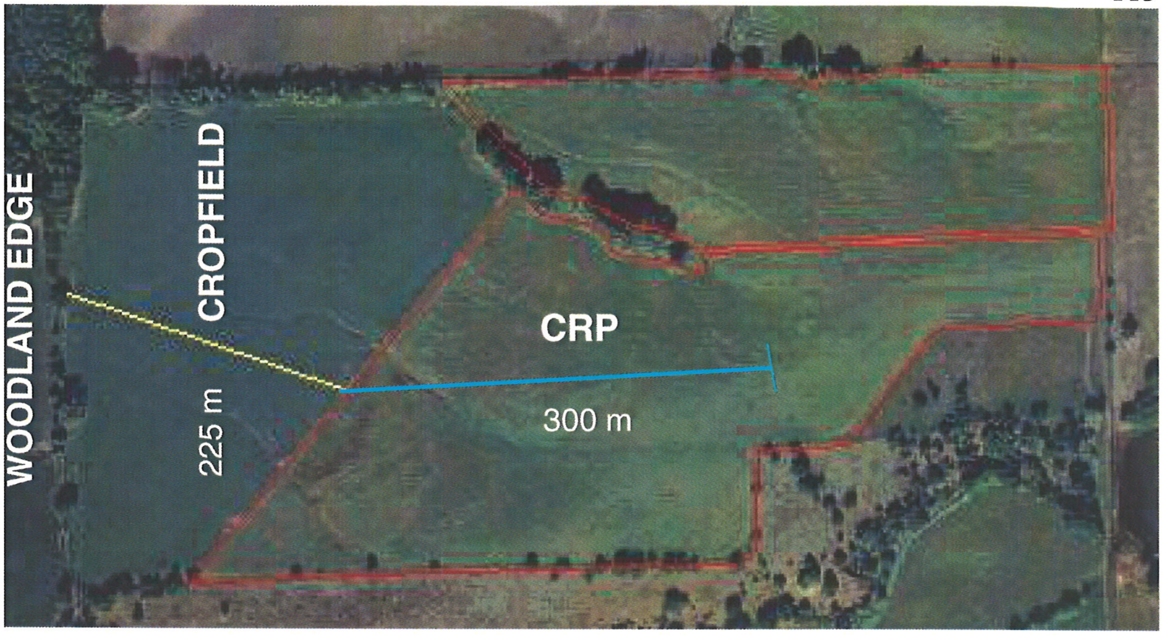


b.

Figure 15. Study site #24. **a.** Aerial photograph illustrating the CRP grassland (with 300 m line-transect), cropfield (with 140 m transect), and woodland edge. **b.** 2000 m buffer around study site digitized in a GIS. Yellow=Grassland, Red=Pastureland, Brown=Woodland, Green=Cropfields, Blue=Miscellaneous.



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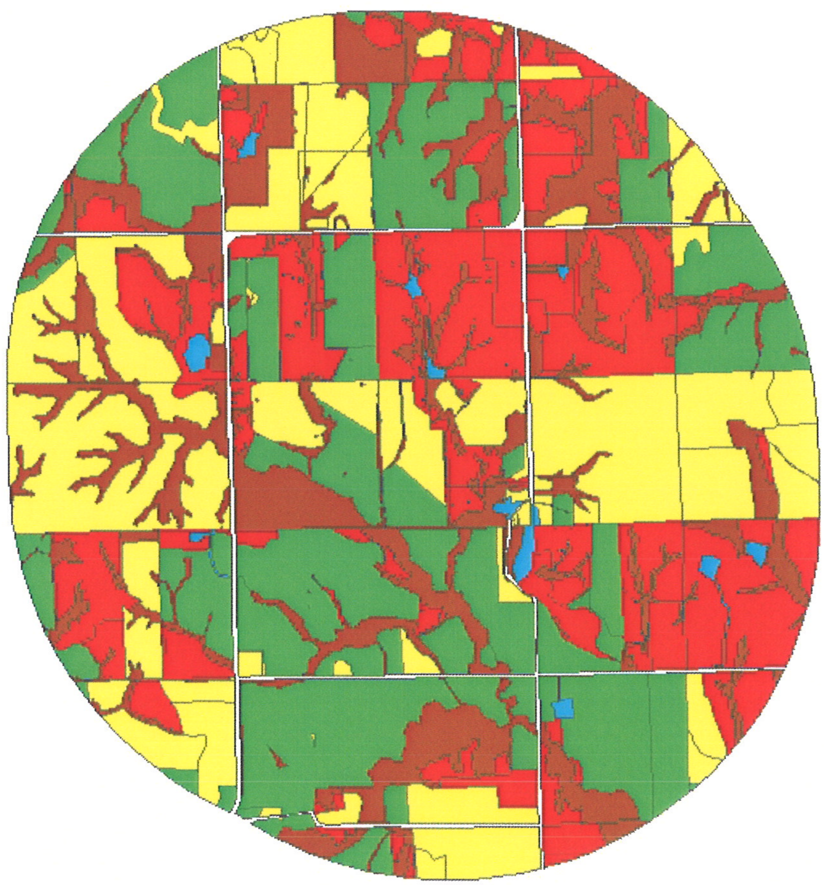


Figure 16. Study site #25. **a.** Aerial photograph illustrating the CRP grassland (with 300 m line-transect), cropfield (with 225 m transect), and woodland edge. **b.** 2000 m buffer around study site digitized in a GIS. Yellow=Grassland, Red=Pastureland, Brown=Woodland, Green=Cropfields, Blue=Miscellaneous.

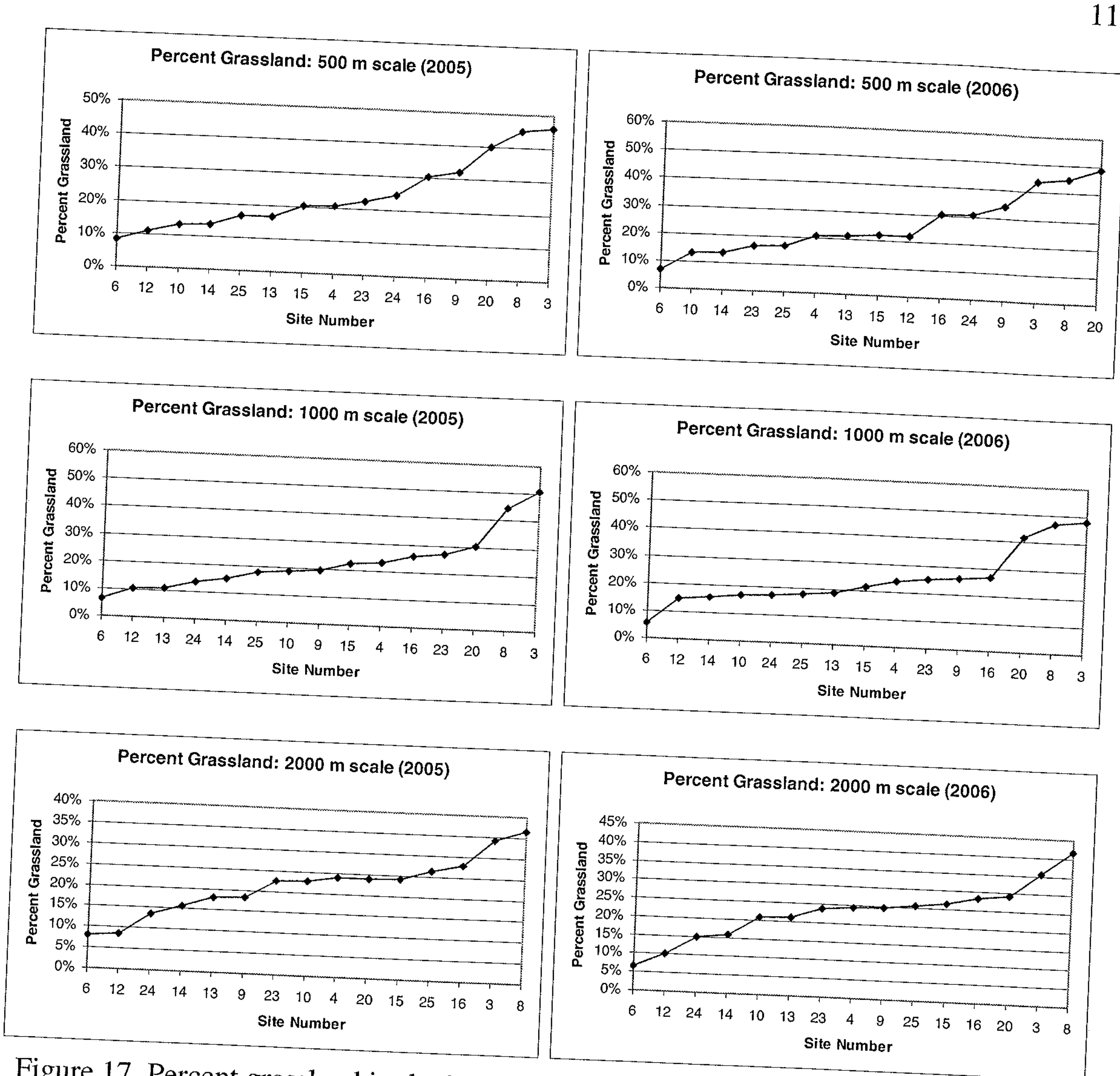


Figure 17. Percent grassland in the landscape at the 500, 1000, 2000 m scales, arranged from low to high for the fifteen study sites in southeastern Nebraska, 2005-2006.

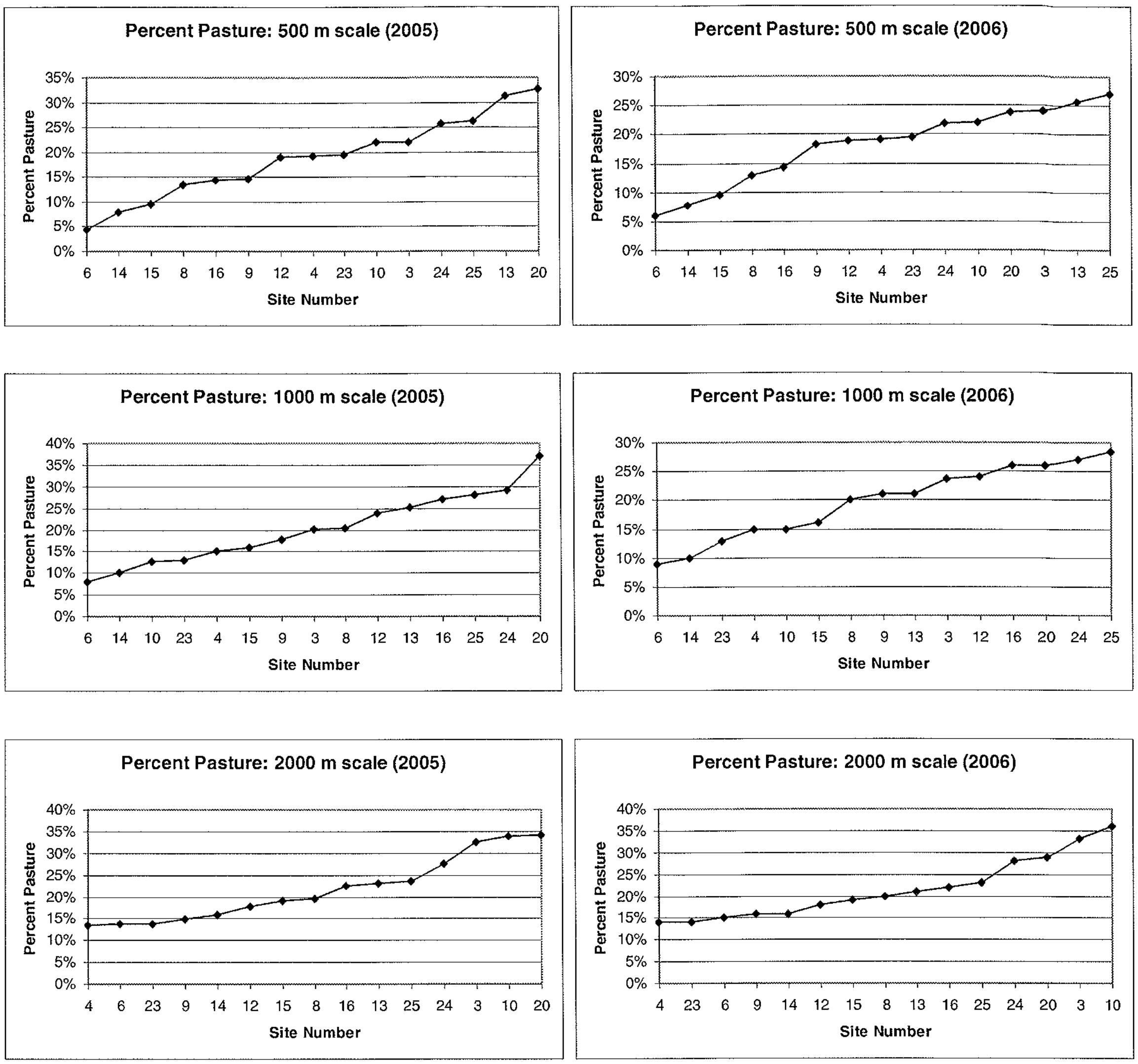


Figure 18. Percent pastureland in the landscape at the 500, 1000, and 2000 m scales, arranged from low to high for the fifteen study sites in southeastern Nebraska, 2005-2006.

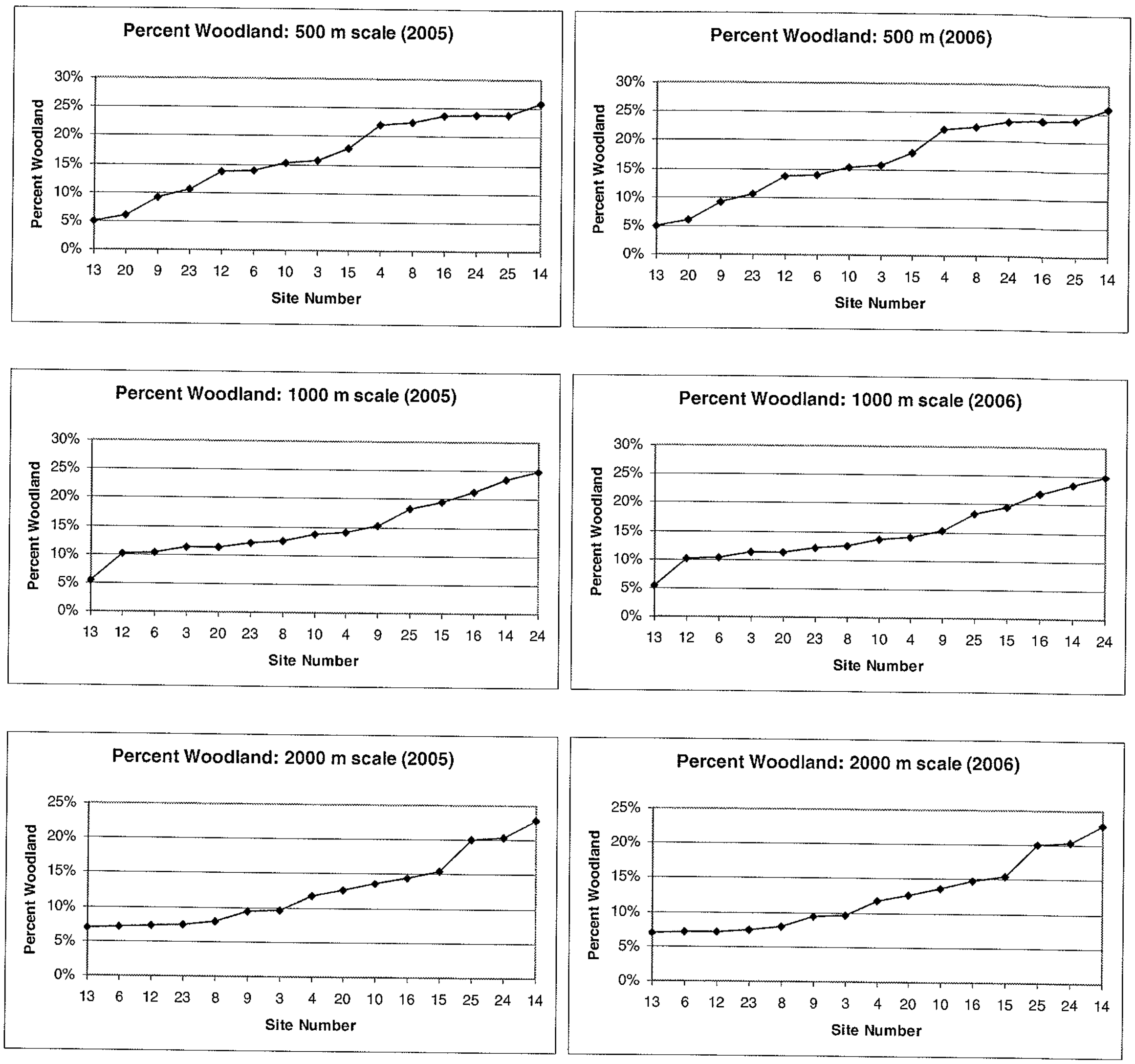


Figure 19. Percent woodland in the landscape at the 500, 1000, 2000 m scales, arranged from low to high for the fifteen study sites in southeastern Nebraska, 2005-2006.

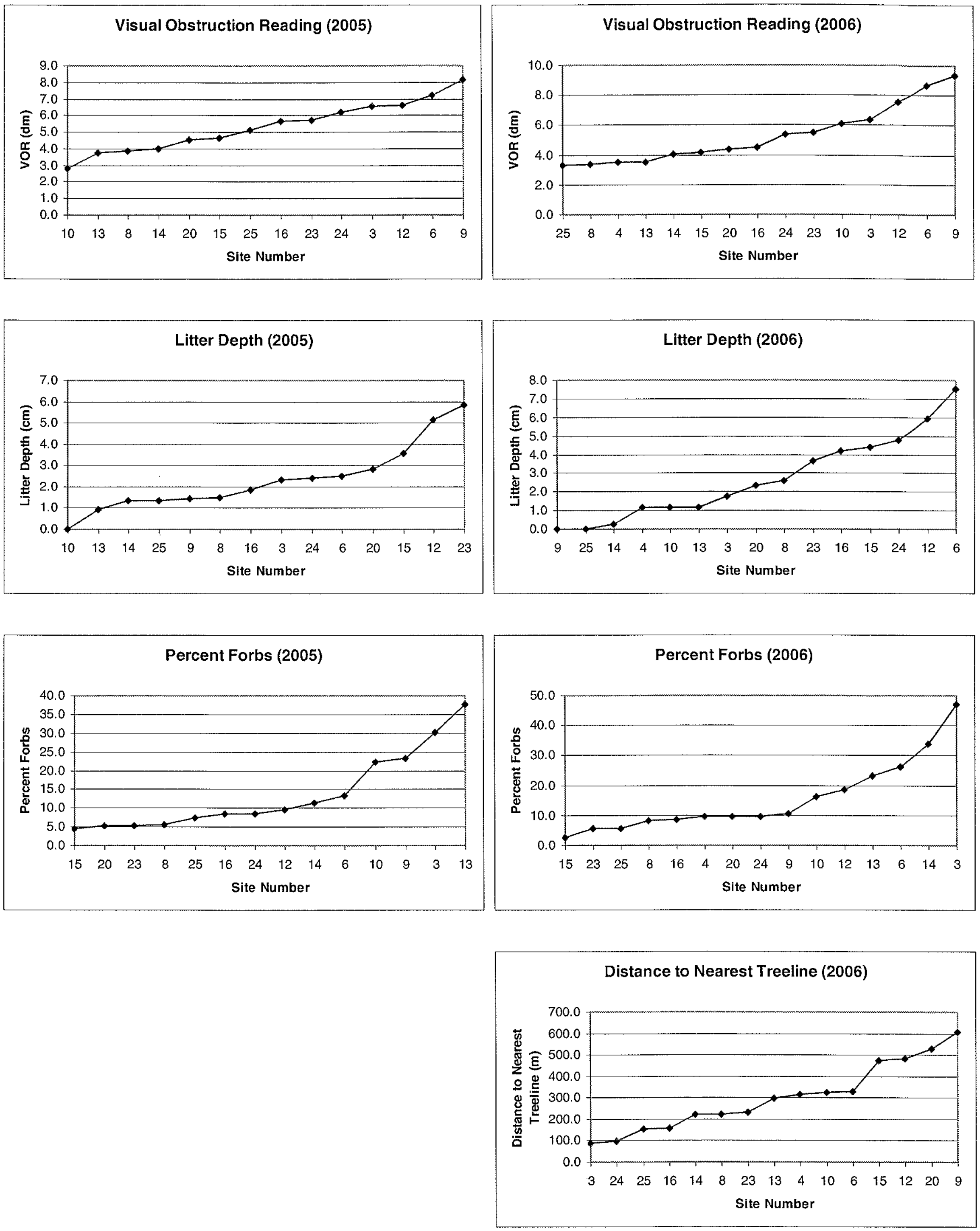


Figure 20. Local vegetation variables measured at each site arranged from low to high for the fifteen study sites in southeastern Nebraska, 2005-2006.

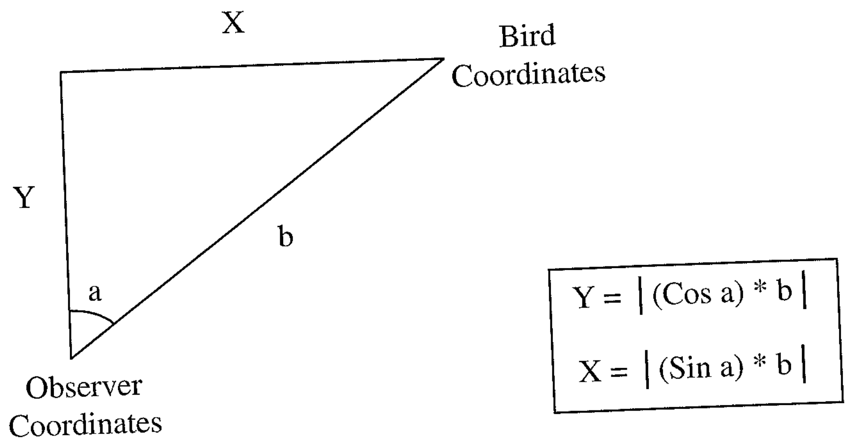


Figure 21. Calculations used to determine exact location of birds in cropfield, with 'a' representing the angle and 'b' denoting the distance to each bird.

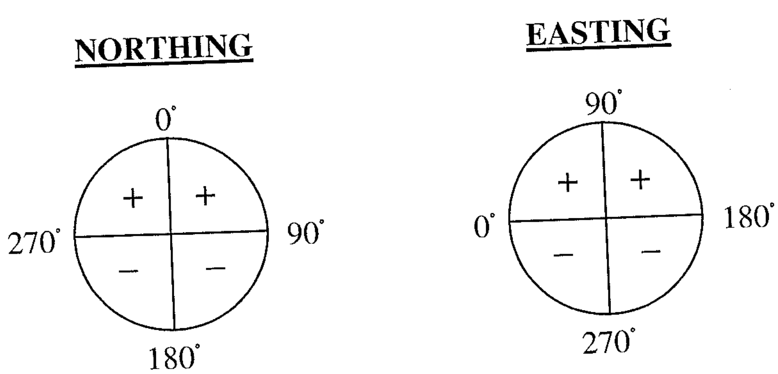
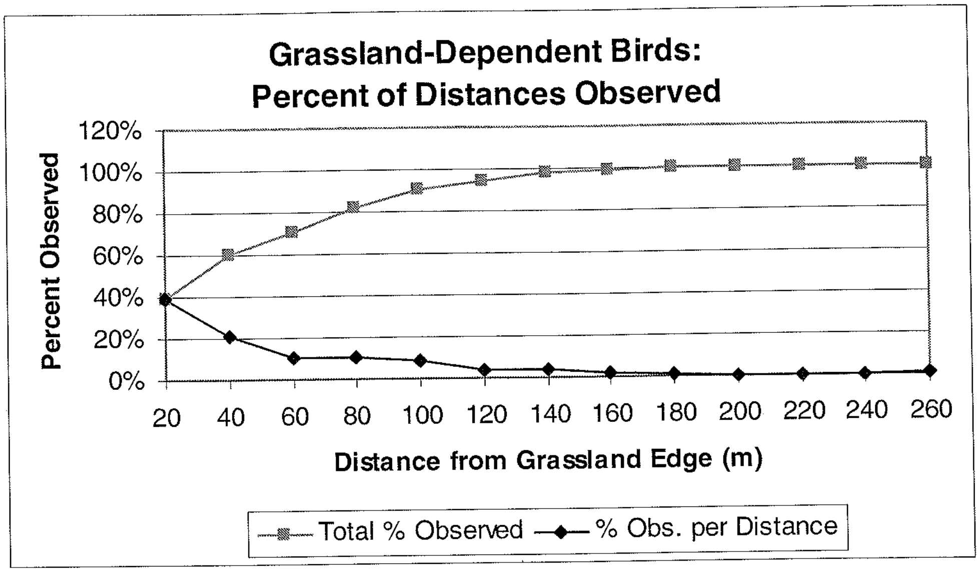


Figure 22. Diagram to facilitate the conceptualization of degree changes in the Universal Transverse Mercator northing and easting coordinate system.



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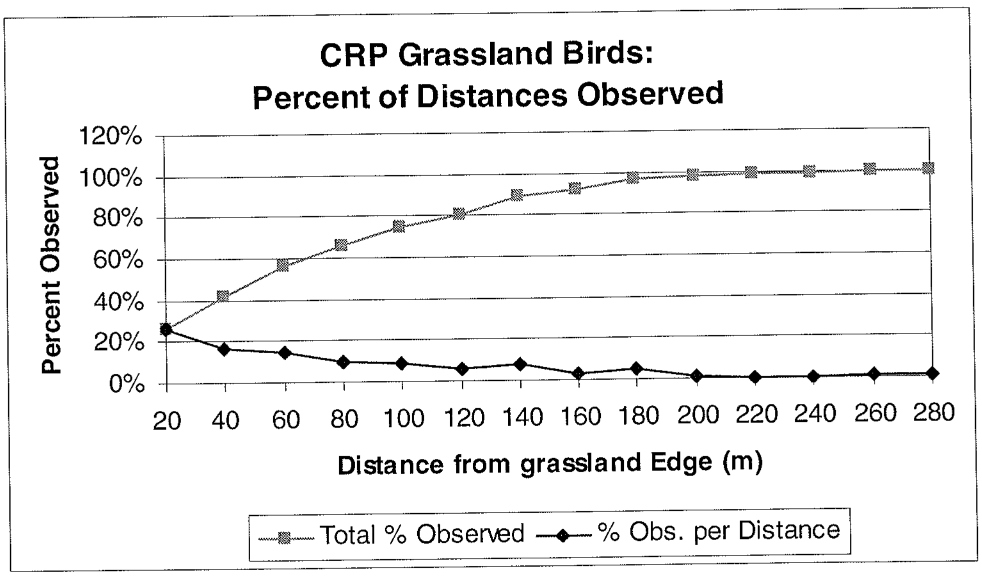

b.

Figure 23. **a.** Percentage of distances flown from grassland edges into cropfields by grassland-dependent birds (grasshopper sparrow, dickcissel, meadowlark) in southeastern Nebraska, 2005-2006. Both the individual percentages for each increment of distance, and the total percentages are illustrated. **b.** Same figure illustrating distances of birds commonly associated with CRP grasslands (grasshopper sparrow, dickcissel, meadowlark, red-winged blackbird, brown-headed cowbird).

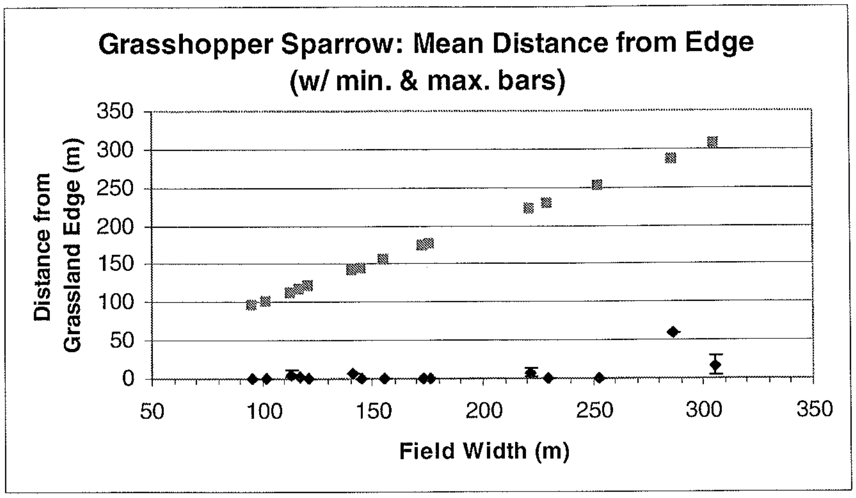

Figure 24. Minimum, maximum, and mean distances (diamonds) flown by grasshopper sparrows from grassland edges into cropfields for fifteen study sites in southeastern Nebraska, 2005-2006. Linear gradient (squares) represent the woodland edge to illustrate the maximum width of each study site. Sites with no observations are depicted by a mean (diamond) of 0 m.

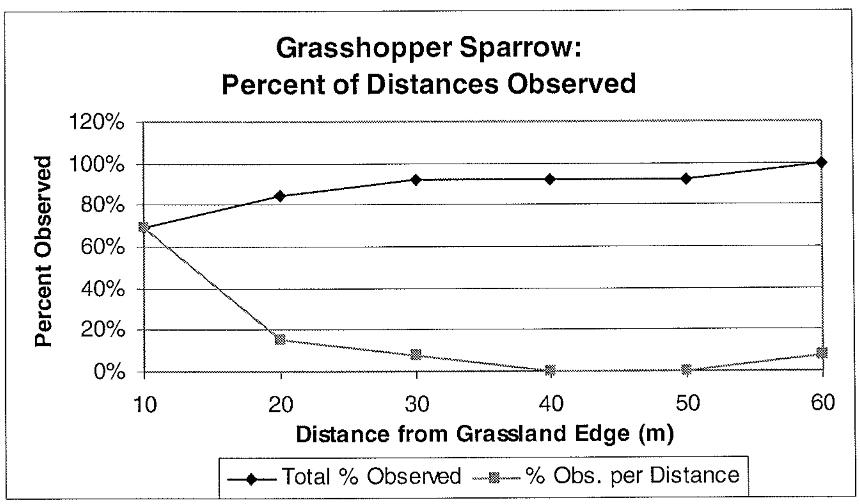

Figure 25. Percentage of distances flown from grassland edges into cropfields by grasshopper sparrows in southeastern Nebraska, 2005-2006. Both the individual percentages for each increment of distance, and the total percentages are illustrated.

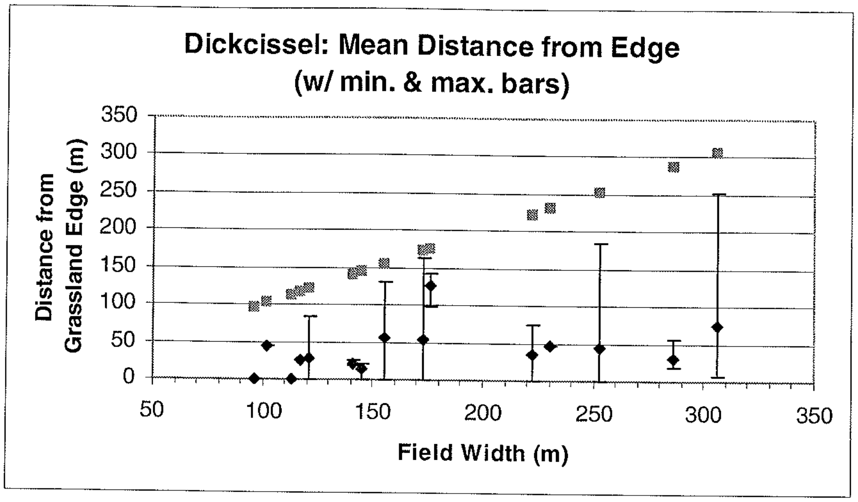

Figure 26. Minimum, maximum, and mean distances (diamonds) flown by dickcissels from grassland edges into cropfields for fifteen study sites in southeastern Nebraska, 2005-2006. Linear gradient (squares) represent the woodland edge to illustrate the maximum width of each study site. Sites with no observations are depicted by a mean (diamond) of 0 m.

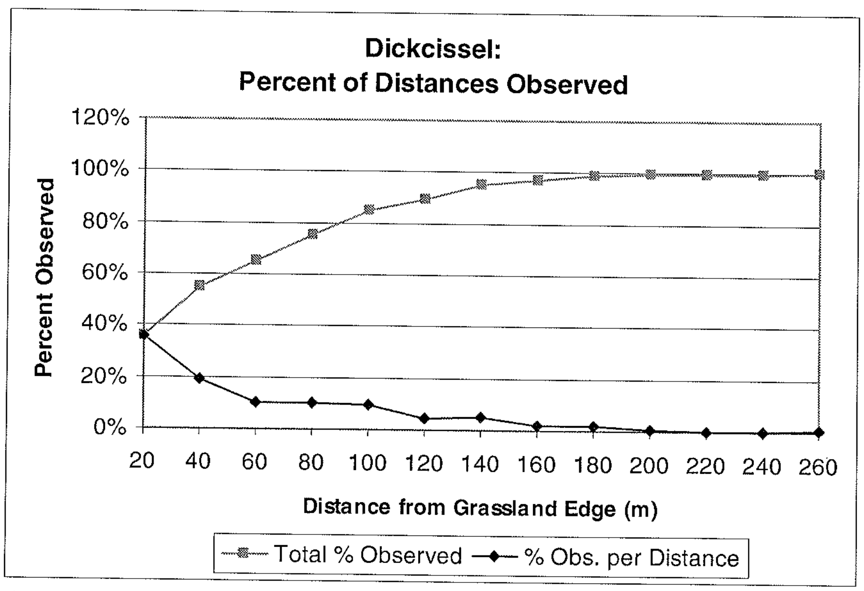

Figure 27. Percentage of distances flown from grassland edges into cropfields by dickcissels in southeastern Nebraska, 2005-2006. Both the individual percentages for each increment of distance, and the total percentages are illustrated.

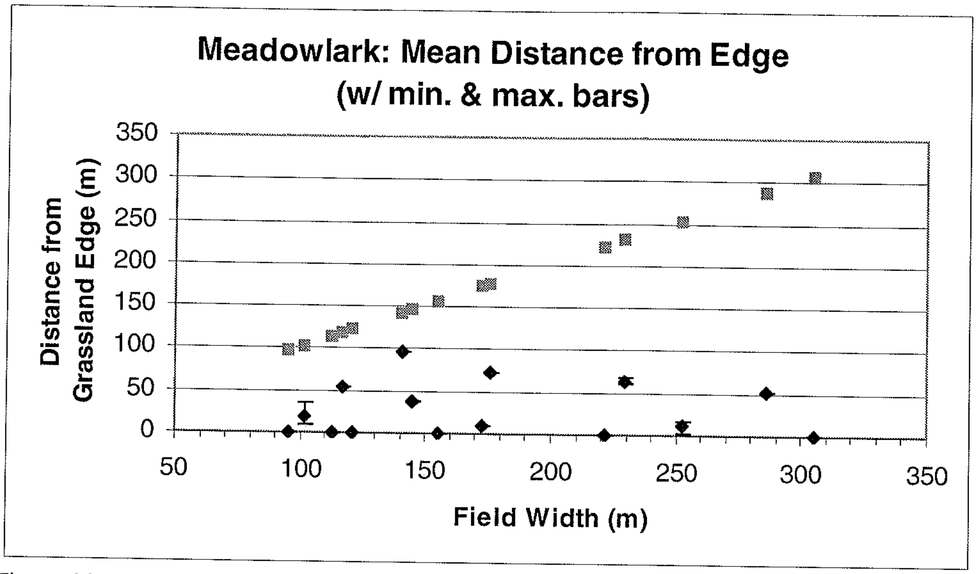

Figure 28. Minimum, maximum, and mean distances (diamonds) flown by meadowlarks from grassland edges into cropfields for fifteen study sites in southeastern Nebraska, 2005-2006. Linear gradient (squares) represent the woodland edge to illustrate the maximum width of each study site. Sites with no observations are depicted by a mean (diamond) of 0 m.

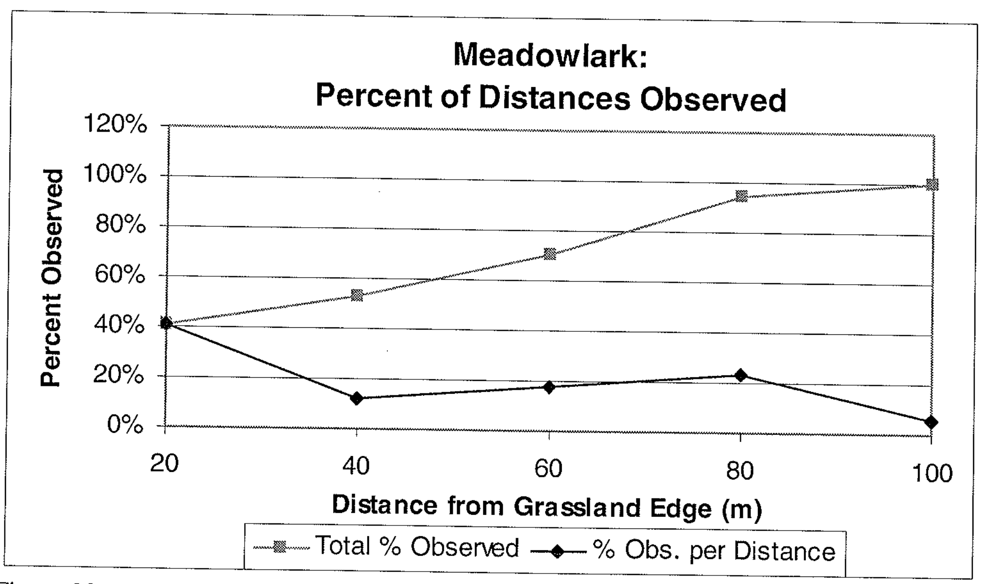

Figure 29. Percentage of distances flown from grassland edges into cropfields by meadowlarks in southeastern Nebraska, 2005-2006. Both the individual percentages for each increment of distance, and the total percentages are illustrated.

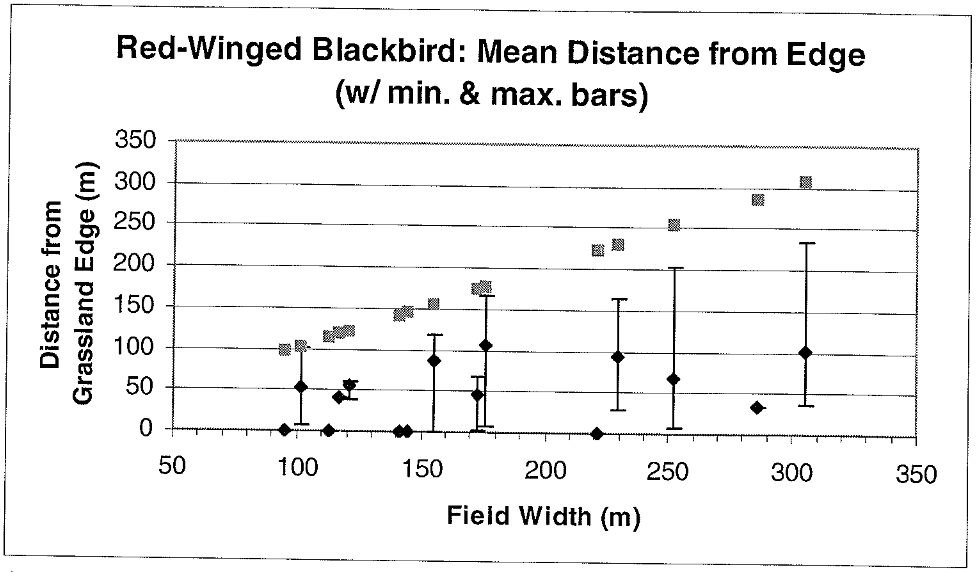

Figure 30. Minimum, maximum, and mean distances (diamonds) flown by red-winged blackbirds from grassland edges into cropfields for fifteen study sites in southeastern Nebraska, 2005-2006. Linear gradient (squares) represent the woodland edge to illustrate the maximum width of each study site. Sites with no observations are depicted by a mean (diamond) of 0 m.

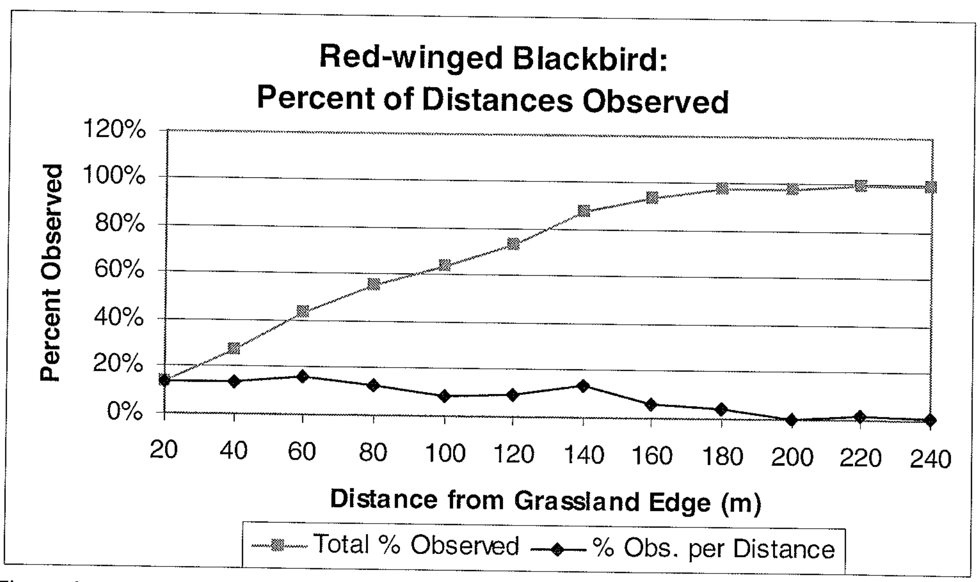

Figure 31. Percentage of distances flown from grassland edges into cropfields by red-winged blackbirds in southeastern Nebraska, 2005-2006. Both the individual percentages for each increment of distance, and the total percentages are illustrated.

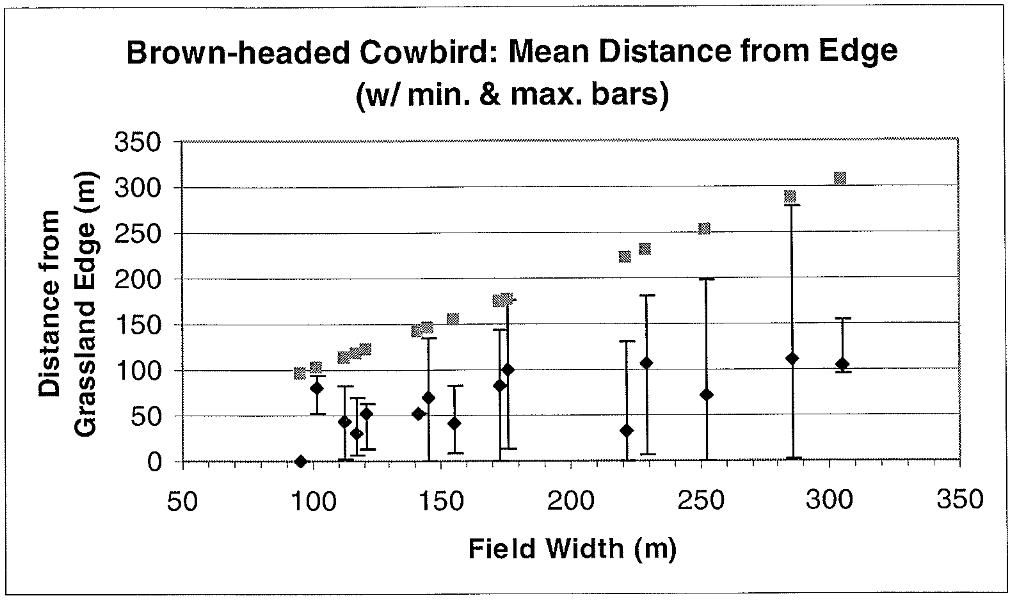

Figure 32. Minimum, maximum, and mean distances (diamonds) flown by brown-headed cowbirds from grassland edges into cropfields for fifteen study sites in southeastern Nebraska, 2005-2006. Linear gradient (squares) represent the woodland edge to illustrate the maximum width of each study site. Sites with no observations are depicted by a mean (diamond) of 0 m.

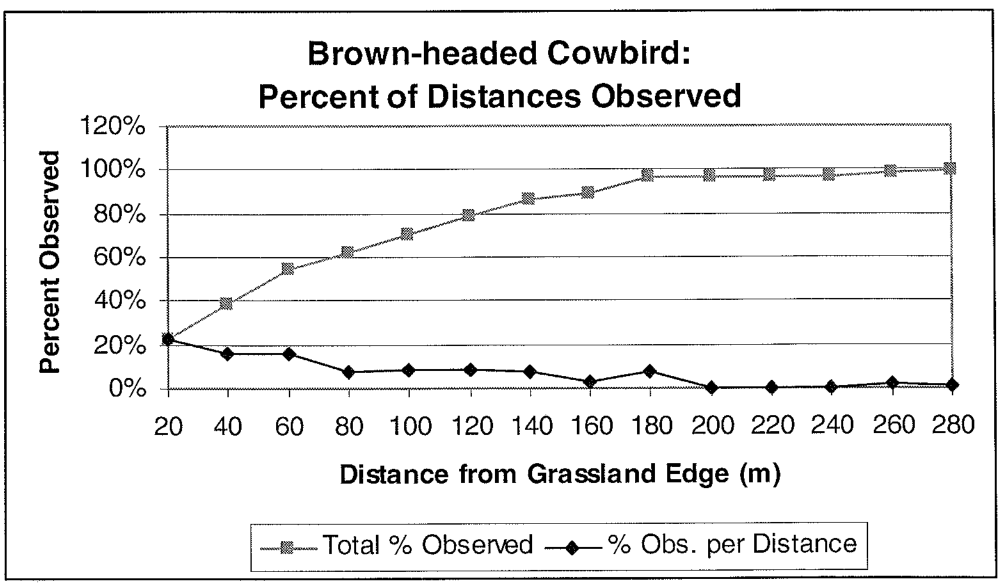

Figure 33. Percentage of distances flown from grassland edges into cropfields by brown-headed cowbirds in southeastern Nebraska, 2005-2006. Both the individual percentages for each increment of distance, and the total percentages are illustrated.

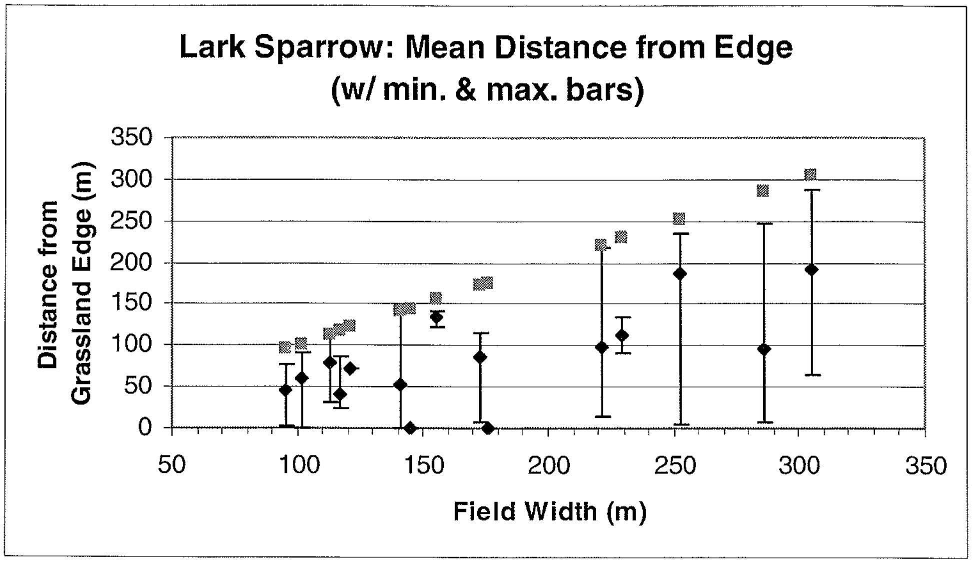

Figure 34. Minimum, maximum, and mean distances (diamonds) flown by lark sparrows from grassland edges into cropfields for fifteen study sites in southeastern Nebraska, 2005-2006. Linear gradient (squares) represent the woodland edge to illustrate the maximum width of each study site. Sites with no observations are depicted by a mean (diamond) of 0 m.

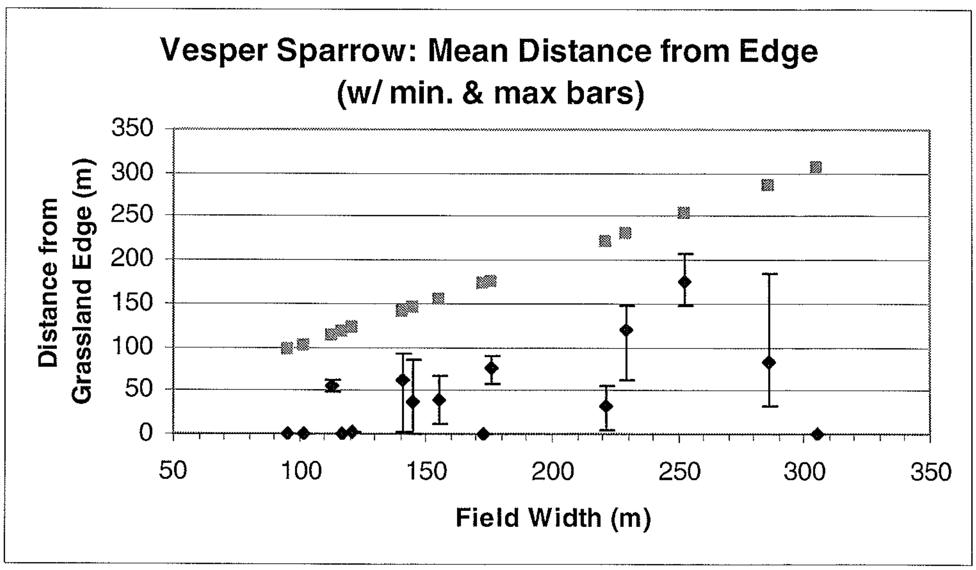

Figure 35. Minimum, maximum, and mean distances (diamonds) flown by vesper sparrows from grassland edges into cropfields for fifteen study sites in southeastern Nebraska, 2005-2006. Linear gradient (squares) represent the woodland edge to illustrate the maximum width of each study site. Sites with no observations are depicted by a mean (diamond) of 0 m.

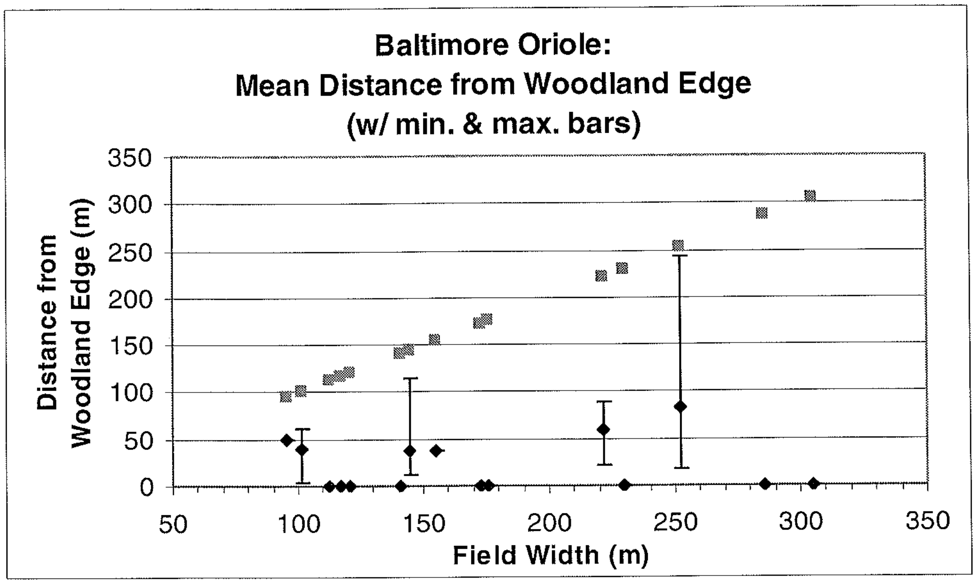

Figure 36. Minimum, maximum, and mean distances (diamonds) flown by Baltimore orioles from woodland edges into cropfields for fifteen study sites in southeastern Nebraska, 2005-2006. Linear gradient (squares) represent the grassland edge to illustrate the maximum width of each study site. Sites with no observations are depicted by a mean (diamond) of 0 m.

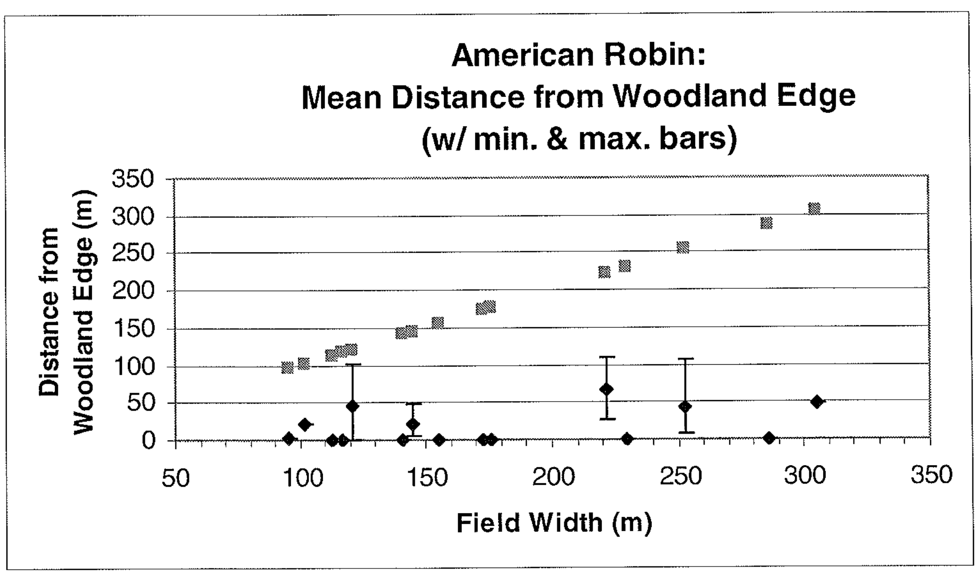

Figure 37. Minimum, maximum, and mean distances (diamonds) flown by American robins from woodland edges into cropfields for fifteen study sites in southeastern Nebraska, 2005-2006. Linear gradient (squares) represent the grassland edge to illustrate the maximum width of each study site. Sites with no observations are depicted by a mean (diamond) of 0 m.