1998

# Assemblages of grassland birds as indicators of environmental condition

Sharon Freshman Browder

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# ASSEMBLAGES OF GRASSLAND BIRDS AS INDICATORS OF ENVIRONMENTAL CONDITION

By

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B.S., Texas A&M University, College Station, 1988

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requirements for the degree of

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I developed four regression models that predict an index of grassland integrity using the presence or abundance of bird species in the Prairie Pothole Region of North Dakota. The index is based on proportions of cover types and the relationships of these cover types to grassland birds. Species abundance data were obtained from three-minute roadside point counts at 905 points in 44, 4050-ha study plots in 1995 and 1996. Species were recorded in each of four quadrants at each point. Cover types were identified by digital aerial photography and quantified using GIS. Species selected for analysis included all grassland species ($n = 11$) that occurred in at least 15 quadrants, and all other species ($n = 39$) that occurred in at least 1% of 6772 quadrants. Logistic regression identified 386 statistically significant relationships between species and cover types at 200 m and 400 m scales. I used two thirds of the data to construct the four linear regression models (presence and abundance models at 200 m and 400 m scales). Final models included 12 species that were statistically significant ($\alpha \leq 0.05$) in all four models. Cross-validation tests using the remaining third of the data indicate that the index predicts grassland integrity consistently. The presence of those species associated with woody vegetation or cropland, combined with the absence of many grassland-dependent species, can provide a measure of grassland integrity. Although identifying regional associations of species with cover types is labor-intensive, such indices can be applied relatively inexpensively to monitor grassland integrity over a large geographic area by applying them to abundance data currently collected by the Breeding Bird Survey.

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# SECTION I

## Introduction

### Background

Declines in populations of grassland birds in North American have been even more precipitous than those of birds in forests and other biomes (Robbins et al. 1986, Droege and Sauer 1994, Knopf 1994). Many resident species nesting in grasslands and scrublands showed consistent population declines between 1966 and 1988 (Droege and Sauer 1990). This trend has been particularly evident in the Great Plains, which was once the largest contiguous grassland area in North America. Lark Buntings (*Calamospiza melancocorys*) and Grasshopper Sparrows (*Ammodramus savannarum*) declined on average by >4% annually from 1966 to 1990. Clay-colored Sparrows (*Spizella pallida*), Bobolinks (*Dolichonyx oryzivorus*), and Baird's Sparrows (*Ammodramus bairdii*) declined by >2% annually, and Dickcissels (*Spiza americana*) declined by >1% annually (Johnson and Schwartz 1993a). Most North American grassland species both breed and winter on this continent (Johnsgard 1979), so these declines must be a function of processes occurring only in North America (Knopf 1994).

Declines in grassland birds have been attributed to extensive and continuing conversion of grasslands to cropland and to increasingly intensive agricultural practices (Herkert 1991, Bollinger and Gavin 1992). Native grasslands in North America have been altered to a greater degree than any other biome, including forests (U.S. Department of Agriculture 1987, Smith et al. 1994). Most grassland losses have been in the form of tillage for croplands. In North Dakota, nearly 70% of the total land area is composed of cropland. Most of the remaining grasslands, approximately 26% of North Dakota's total land area, is pastureland and rangeland (U.S. Department of Commerce 1994). Grassland conversion also has been accompanied by the wholesale destruction of wetlands (Dahl et al. 1991), negatively affecting species associated with wetlands. Additionally, widespread planting of trees in the Great Plains (Baer 1989) has changed avian species composition by creating suitable habitats for woodland and edge species (Martin and Vohs 1978, Martin 1980).

Wide-scale grassland conversion is particularly detrimental to grassland birds for several reasons. Most grassland conversions permanently eliminate the vegetation on which many grassland species depend for breeding or wintering habitat. Disturbances to croplands, and birds using them, occur several times each year as fields are tilled, planted, sprayed, and harvested. Few converted grasslands are maintained in permanent cover, and then only if they are used as pasture or are enrolled in an agricultural subsidy program such as the

Conservation Reserve Program (CRP). Often only small patches of grassland remain in agricultural landscapes, and such remnant grasslands usually are hayed or heavily grazed (Stewart 1975). Conversion of hayfields from grass to alfalfa, earlier hay-cropping dates, and earlier rotation of hayfields to other crops are probably contributing to declines of grassland birds (Bollinger and Gavin 1992). Heavily grazed grasslands support fewer avian species than those that are lightly or moderately grazed (Kantrud 1981). Additionally, small patches of grassland are often more attractive to edge species than to grassland species. Some species of grassland birds do not breed in small patches of grassland (Herkert 1991), and others suffer relatively high rates of nest predation and brood parasitism in small tracts (Johnson and Temple 1990).

Growing concern for the effects of wide-scale anthropogenic changes to grasslands and other ecosystems has created a need for monitoring methods that can detect changes in biotic integrity over large geographic areas. Such systems have been developed for fish (Karr 1981, Karr et al. 1986, Karr 1991), butterflies (Noss 1990, Kremen 1992, Blair and Launer 1997), aquatic invertebrates (Berkman et al. 1986, Lenat 1988, Ohio EPA 1988, Plafkin et al. 1989), and forest birds (Canterbury et al. in review). Grassland birds may be useful indicators of changes in biotic integrity in grassland ecosystems.

Bird taxa are appropriate indicators for monitoring changes on an ecosystem scale for several reasons: (1) Birds are important to a large segment of the public. Approximately 30 million bird watchers reside in the United States, and one in three households feeds backyard birds (Ehrlich et al. 1988). Hence, much of the public may better relate to concerns about changes in bird communities than to those of plants or invertebrates. (2) Birds occur across a broad gradient of anthropogenic disturbance, from pristine wilderness to metropolitan areas. (3) Most birds live only a few years, so changes in species composition and abundance can be detected over a relatively short time period. (4) Bird surveys (e.g., Breeding Bird Survey) are currently conducted across the United States and southern Canada. (5) Bird species are associated with habitat conditions; that is, different habitats support different species (Stewart and Kantrud 1972, Kantrud 1981, Johnson and Schwartz 1993a, Flather and Sauer 1996, Canterbury et al. in review). (6) Groups of bird species can be used to develop associations with cover type that are predictive of the relative level of anthropogenic disturbance (Szaro 1986, Croonquist and Brooks 1991, Canterbury et al. in review).

Purpose

The purpose of this study is to identify the relationships between avian species composition and cover types in the northern Great Plains, specifically the

Prairie Pothole Region of North Dakota. Although trends in grassland bird populations are indicative of negative associations with cropland, quantitative documentation of associations with cover types is currently lacking for many grassland species. By identifying such relationships, I developed a method of monitoring grassland integrity based on grassland birds. This research is part of a larger grassland monitoring program supported by the Environmental Monitoring and Assessment Program (EMAP; U.S. Environmental Protection Agency 1993).

## Objectives

1. To compare the presence of various bird species to habitat and landscape characteristics, specifically the proportion of the area that is cultivated, and quantify these relationships.

2. To use the relationships developed above to classify the tolerance of grassland bird species to anthropogenic disturbance, particularly cultivation.

3. To derive an index, based on presence or relative abundance of disturbance-tolerant and disturbance-intolerant bird species, to the integrity of grassland ecosystems.

## SECTION II

## Methods

### Study Area

Study plots were distributed systematically across the 11.7 million ha portion of North Dakota lying east and north of the Missouri River (Fig. 1). This area comprises four distinct physiographic regions: Southwestern Slope, Prairie Pothole, Turtle Mountain, and the Agassiz Lake Plain. Five biotic subregions of the Southwestern Slope Region and Prairie Pothole Region are contained within the study area: the Couteau Slope, Missouri Couteau, Northwestern Drift Plain, Northeastern Drift Plain, and Southern Drift Plain (Stewart and Kantrud 1972, Stewart 1975). Glaciation during the Wisconsin Age formed gently rolling to nearly flat terrain interspersed with hundreds of thousands of wetland basins. Elevations across the study area range from approximately 240 m at the Minnesota border to about 730 m above mean sea level near the Montana border. The proportion of land under cultivation increases in a rough gradient from west to east, as does average precipitation. Many of the most pristine grasslands in the study area are found in the Missouri Couteau, where rolling topography contains areas of pasture and CRP and many natural wetlands.

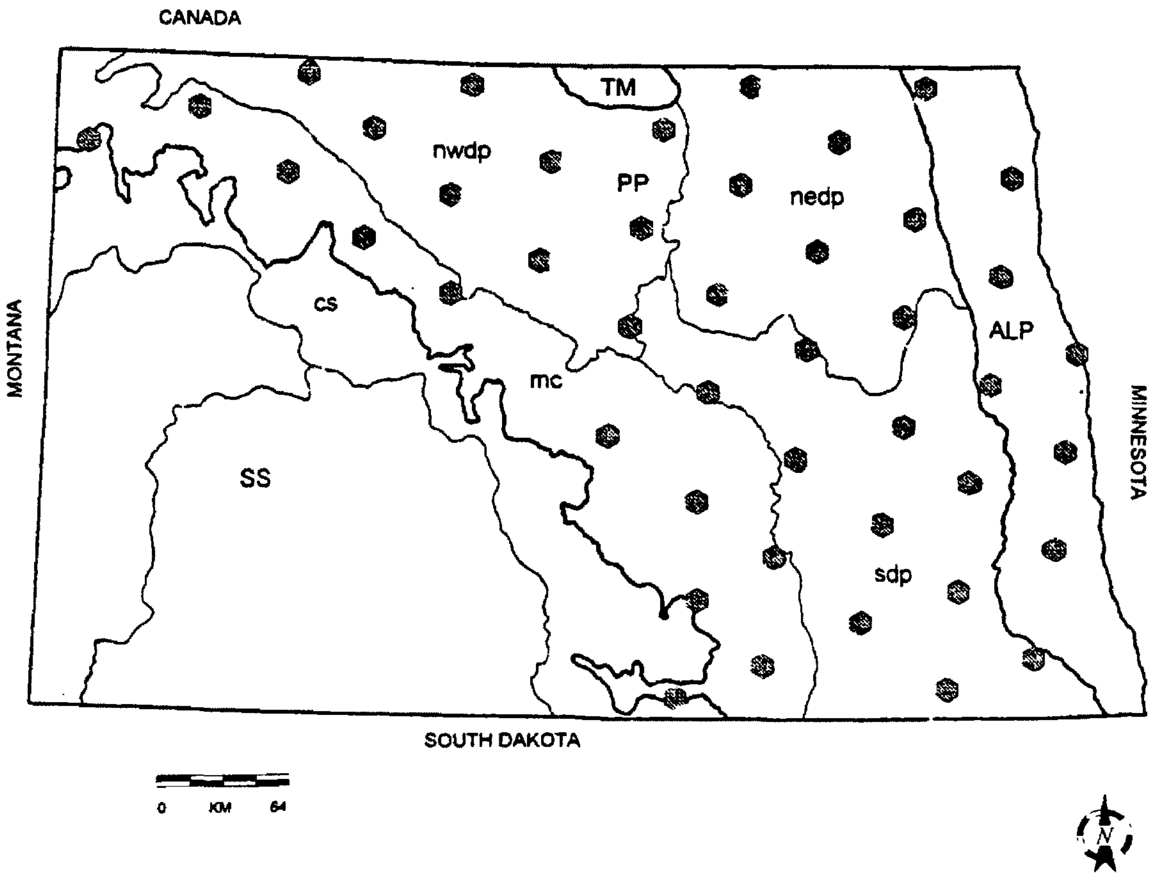


FIG. 1. Study area, locations of hexagons, and biotic regions of North Dakota (Stewart 1975). Physiographic Regions: ALP = Agassiz lake plain, PP = Prairie pothole, SS = Southwestern slope, TM = Turtle mountain. Biotic Subregions: cs = Couteau slope, mc = Missouri couteau, nedp = Northeastern drift plain, nwdp = Northwestern drift plain, sdp = Southern drift plain. = Hexagon location.

Crops in the Missouri Couteau are predominantly small grains. In contrast, the flat Agassiz Lake Plain Region along the Red River in eastern North Dakota contains the most altered landscape in the study area. The region is heavily cultivated, and few natural wetlands or grasslands remain. Many fields have been leveled, ditched, and tile-drained and are often planted to intensively managed crops such as sugar beets or soybeans.

Following the sampling scheme designed for EMAP (U.S. Environmental Protection Agency 1993), I obtained a systematic sample of 44 hexagons distributed across the study area. Of the 44 hexagons, 9 occurred in the Missouri Couteau, 8 in the Northwestern Drift Plain, 7 in the Northeastern Drift Plain, 11 in the Southern Drift Plain, and 7 in the Agassiz Lake Plain. Two hexagons overlapped the Missouri Couteau and Couteau Slope. Mean hexagon size was 4049 ha (range = 3939 to 4135 ha).

Species Composition and Relative Abundance

I recorded the abundance of bird species inside the hexagons using roadside point counts. The method was modified from Breeding Bird Survey protocol (Robbins et al. 1986) in order to adapt it to the size and road configuration of the hexagons and to facilitate analysis of bird associations with cover types. A Breeding Bird Survey route consists of 50 points 0.8 km apart, and data are collected along the route one morning of the year during the peak of the breeding season. Starting 0.5 hr before sunrise, the observer records all birds heard or seen within 400 m during a 3-minute period at each point. My surveys included the following modifications: (1) survey routes were shortened so they could be accommodated inside the hexagons, (2) birds were recorded in quadrants (NE, SE, SW, NW) at each point, and (3) birds flying overhead or observed in the roadway were recorded in separate categories from those observed in quadrants.

Because of the short duration of the point counts, I extended 3-minute counts on 225 points to 5 and 10 minutes in 1996 in order to evaluate the proportion of species and individuals being detected in 3-minute counts (Appendix A).

Bird surveys began in the southwest part of the study area and proceeded to the northeast, following the general sequence of breeding phenology in North Dakota (Stewart 1975). Surveys were conducted from late May through early July in 1995 and 1996. I recorded data in 44 hexagons in 1995 and 43 in 1996 (data were not collected in one hexagon in 1996 due to inclement weather). Hexagons contained an average of 15.3 km of survey route and 20 survey points. High water caused some points to become inaccessible: in 1996, 17 points were deleted and 3 were added. I used a Global Positioning System unit to determine the coordinates of each survey point.

Cover Types

Digital aerial photography recorded cover types at regular intervals on all 44 hexagons between May and August of 1995 and 1996. Northern Prairie Wildlife Research Center (NPWRC) staff used photo-interpretation to create a Geographic Information System using TNTmips software (MicroImages 1996). Because changes in cover type were judged to be minimal between the two study years, data were combined to create a single base map. The predominant cover type and wetland locations in each quadrant were ground truthed. Twenty-two cover types defined through photo-interpretation were collapsed into seven categories (Appendix B): Cropland, Grassland, Wetland, Patch, Wood, Other, and Barren Land.

*Cropland* includes lands that are tilled and planted to grain or row crops, and includes freshly tilled soil, stubble from the previous year, fallow land, or growing crops. *Grassland* includes native grassland tracts >2 ha. Native grasslands were rare, so haylands and CRP lands were added to this category because both provide habitat for grassland birds that is structurally similar. Haylands are composed of grass or legumes that are cut at least annually for livestock forage, and CRP lands are planted to idle cover in the form of grass, legumes, or a mixture of both. *Wetland* includes all wetland types present (Cowardin et al. 1979). *Patch* includes areas <2 ha that contain <50% woody vegetation as well as linear rights-of-way (3-20 m wide) between fields, along fences and section lines, and along roadways and railroad tracks. Rights of way are unplowed, but are sometimes mowed during the growing season. Vegetation often consists of smooth brome (*Bromus inermis*). *Wood* includes areas >2 ha containing woody plants >6 m high with ≥30% aerial cover, areas <2 ha containing >50% woody plants, shelterbelts (rows of trees planted as windbreaks), or scrub land areas >2 ha covered in shrubs 0.9-6 m tall. *Other* includes small (<2 ha) areas, such as farmsteads and rock piles, that do not fit in any other class. *Barren Land* includes highly developed areas such as road surfaces (dirt, gravel, and paved), parking lots, and buildings (except farmsteads, which are categorized as *Other*).

The area of each cover type was obtained using the following procedures. Coordinates collected at each survey point using a Global Positioning System were entered into a point file. Then, all points were buffered at radii of 200 m and 400 m. The 200-m scale was chosen as a reasonable distance within which a stationary observer could identify most passerine birds by sight or sound. The 400-m scale was chosen because it is the standard for Breeding Bird Surveys (Robbins et al. 1996). I then manually digitized additional lines to divide each buffer into quadrants along existing road line features and section lines. Open or "leaky" polygons resulting from original road features were corrected with a series of element snaps, sliver filters, and line-thinning filters. Quadrants then were manually labeled and buffers were merged with the cover type layer. Features inside the buffers were extracted from the merged layer to obtain only those cover type polygons within the buffers. Data base reports produced text files containing the area of each cover type polygon inside the quadrants.

Some 400-m buffers extended beyond hexagon boundaries, and cover type composition could not be determined for these quadrants (n = 468). Hence, 6772 of the original 7240 quadrants were used in the analysis.

I used independent-samples t-tests (Norusis 1995) to compare mean percent of total area for each cover type in the 200-m and 400-m quadrants with those of the hexagons to determine if the quadrants were representative of the hexagons as a whole. To determine if the distribution of cover types differed between the 200-m and 400-m scales, I also examined frequency of occurrence for each cover type in the quadrants analyzed.

Associations Between Species Presence and Cover Type

Species included in the analysis were 11 grassland species (Stewart 1975, Ehrlich et al. 1988, Peterjohn and Sauer 1993) that occurred in at least 15 of the 6772 quadrants and all other species (n = 39) observed in at least 1% of quadrants (Appendix C). Because the ranges of 18 species (Appendix C) did not include all 44 hexagons, I selected hexagons for analysis based on the species' primary ranges (Price et al. 1995), but also included hexagons where I found a species outside its primary range. Many species that occurred in hexagons outside their range were wetland species that likely expanded their ranges in response to extensive flooding of wetlands during 1995 and 1996 (Igl and Johnson 1995).

Associations between the presence of each of the 50 species selected and the percentage of each of the seven cover types in the quadrants were obtained using logistic regression (Norusis 1995). Species presence was regressed against the percentages of each of seven cover types at both the 200-m and 400-m scales to obtain 700 logistic regression coefficients (Appendix D).

Association between bird species and cover type was measured using the -2LL (-2 x log likelihood) value of each regression model (Appendix D). A logistic regression model with perfect fit would have a -2LL value of 0 (Norusis 1995), so I considered those species with a significant ($\alpha \leq 0.05$) regression coefficient and smallest -2LL to have the strongest relationships.

In order to examine the relationships between groups of species and cover types, I grouped the 50 species into seven breeding habitat groups (Stewart 1975, Ehrlich et al. 1988, Peterjohn and Sauer 1993, Appendix E). Habitat categories were Grassland, Wetland, Bare-ground, Savanna, Edge, Woodland,

and Generalist. I then examined the proportions of each group associated with the cover types.

For purposes of discussion in the text, significant results, relationships, or differences are those where $\alpha \leq 0.05$.

## SECTION III

## Results

### Species Composition and Relative Abundance

I recorded 130 species (Appendix E), six of which were recorded in 1995 but not in 1996 and 10 of which were recorded in 1996 but not in 1995. I recorded 14,399 individuals of 117 species at 894 points in 1995 and 14,330 individuals of 123 species at 868 points in 1996. Averages per hexagon were 40 species and 324 individuals in 1995 and 40 species and 333 individuals in 1996.

### Cover Types

Percent composition for most cover types was similar among hexagons, 400-m quadrants, and 200-m quadrants. However, mean percent of total area differed significantly for three cover types (Table 1). Both 200-m and 400-m quadrants contained higher proportions of Patch, Other, and Barren Land than did hexagons. Distribution was similar between the 200-m and 400-m scales for every cover type except Other. Other occurred nearly twice as often in the 400-m quadrants as in the 200-m quadrants (Appendix B).

Table 1. Percent of total area for each cover type at three scales on hexagons in the Prairie Pothole Region of North Dakota.

| | Hexagon[†] (n = 44) | | 400-m Quadrant (n = 3620) | | | 200-m Quadrant (n = 3620) | | |
|---|---|---|---|---|---|---|---|---|
| Cover Type* | $\bar{x}$ | (95% CI) | $\bar{x}$ | (95% CI) | P[‡] | $\bar{x}$ | (95% CI) | P[‡] |
| Cropland | 62.10 | (56.24, 67.97) | 61.46 | (60.33, 62.60) | 0.830 | 57.34 | (56.15, 58.51) | 0.115 |
| Grassland | 19.39 | (14.56, 24.23) | 16.10 | (15.14, 17.06) | 0.185 | 15.44 | (14.46, 16.43) | 0.114 |
| Wetland | 8.81 | (7.26, 0.35) | 8.81 | (8.39, 9.23) | 0.999 | 8.18 | (7.72, 8.65) | 0.442 |
| Patch | 4.47 | (3.91, 5.03) | 7.30 | (7.03, 7.57) | 0.005 | 10.58 | (10.23, 10.92) | 0.005 |
| Wood | 3.26 | (0.74, 5.79) | 2.63 | (2.23, 2.94) | 0.615 | 2.72 | (2.37, 3.07) | 0.667 |
| Other | 1.23 | (1.08, 1.37) | 2.00 | (1.76, 2.24) | 0.005 | 2.70 | (2.30, 3.11) | 0.005 |
| Barren Land | 0.75 | (0.67, 0.83) | 1.72 | (1.66, 1.79) | 0.005 | 3.07 | (2.94, 3.20) | 0.005 |

*Cover types defined in Appendix B.

[†]Mean hexagon size = 4050 ha

[‡]Significance levels ($\alpha = 0.05$) from independent-samples t-tests (Norusis 1995) used to compare the mean percent of total area for each cover type in 200-m and 400-m quadrants with those of the hexagons.

Associations Between Species Presence and Cover Type

Of the 700 relationships between species presence and cover type analyzed, 386 were significant (Appendix D). Only two species [Upland Sandpiper (*Bartramia longicauda*) and Ferruginous Hawk (*Buteo regalis*)] of 50 showed no significant relationship with any cover type, and all but two species with significant associations had relationships with two or more cover types.

Cropland was negatively correlated with the presence of more species (80%) than any other cover type. Only 6-8% of species were positively correlated with Cropland, two of which [Killdeer (*Charadrius vociferus*) and Horned Lark (*Eremophila alpestris*)] were Bare-ground species. Most (73%) Grassland species were negatively correlated with Cropland. At least 73% of every group except Bare-ground species was negatively correlated with Cropland, and 100% of Savanna, Woodland, and Generalist species were negatively correlated with Cropland. All Bare-ground species were positively correlated with Cropland.

Grassland was positively correlated with the presence of 40-42% of all species, and was correlated with a higher percentage (73%) of Grassland species than any other cover type. Only 14-16% of all species analyzed and 9% of Grassland species were negatively correlated with Grassland. Woodland species had no correlations with Grassland, and the Generalist and Bare-ground species had no positive correlations with Grassland.

Wetland was positively correlated with the presence of 42-46% of all species, including 89% of Wetland species. No Woodland or Generalist species were positively correlated with Wetland, and no Savanna species were correlated with Wetland.

Patch was correlated with the most species of any single cover type: 40-56% of all species were positively correlated, and only 8% were negatively correlated. Patch attracted the second highest percentage of Grassland birds (27%) after Grassland, and the second highest percentage of Wetland birds (61%) after Wetland. Patch was correlated to high proportions of Edge (46-69%) and Savanna (50-100%) species, although the proportions varied greatly between scales.

Wood was positively correlated with the presence of 24-28% of all species, and negatively correlated to 32-34% of all species. No Grassland, Wetland, or Bare-ground species were positively correlated with Wood. Most Edge (69-77%) and Woodland (100%) species were positively correlated. Positive correlations with Savanna species were highly variable between scales. Twenty-seven percent of Grassland species and 56-67% of Wetland species were negatively correlated with Wood.

Other was positively correlated with the presence of 34-36% of all species. No Grassland, Wetland, or Bare-ground species were positively correlated with

Other. However, most Edge and all Savanna, Woodland, and Generalist species were positively correlated with Other.

Few species were positively correlated with Barren Land, and results were often inconsistent between scales. Only Wetland species showed a pattern-one of consistently low percentages of both positively and negatively correlated species at both scales. No Savanna, Woodland, Generalist, or Bare-ground species were correlated at either scale.

The 200-m and 400-m scales were similar in terms of associations between habitat groups and cover types (Appendix F, Figs. 2 - 5), although individual species correlations varied somewhat. In general, cover types that composed the largest proportion of the quadrant area tended to have the most similar species and cover-type correlations between scales. Cover types that composed the smallest proportions of the quadrants and varied more in percentage of the total area between scales exhibited more differences in species and cover type correlations between scales. Patch, which exhibited the greatest proportionate difference in area between scales, showed more variability between scales in terms of species relationships than any other cover type.

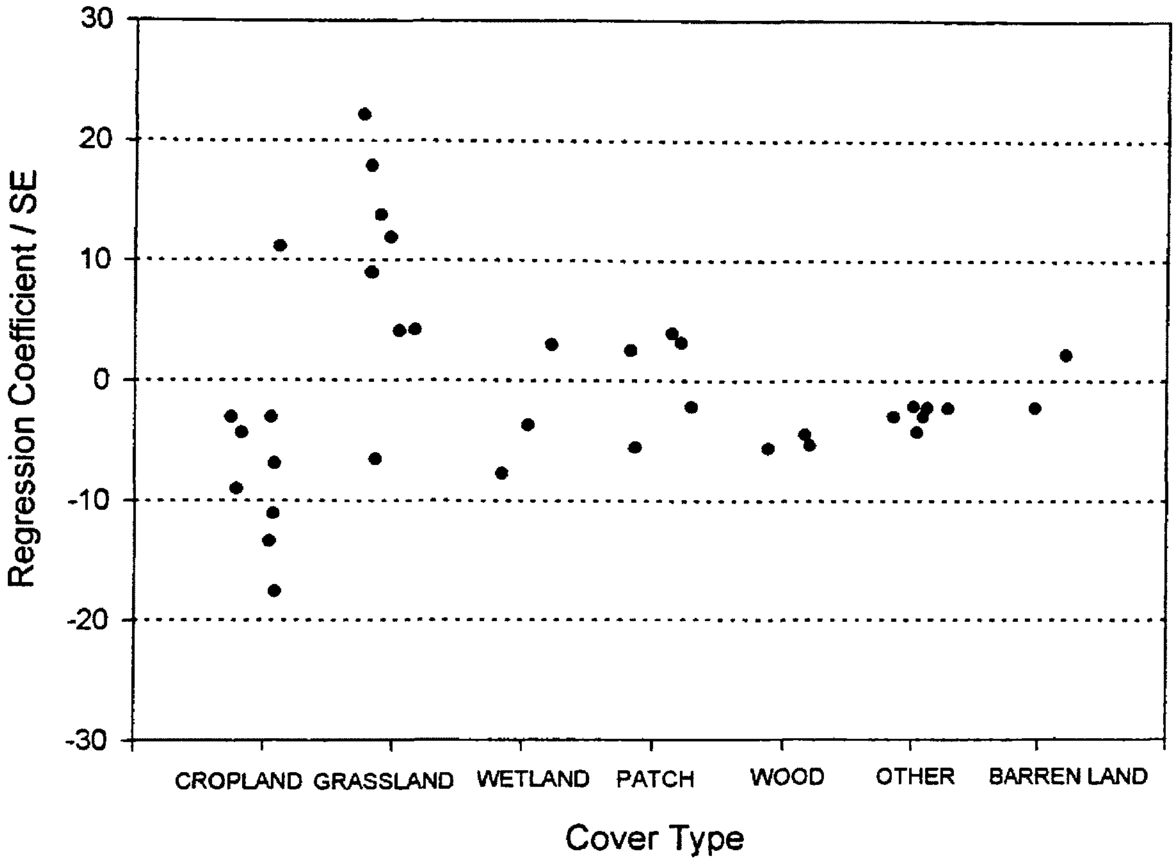


FIG. 2. Significant relationships ($\alpha \leq 0.05$) of grassland species to cover type (200 m), measured by the model regression coefficient divided by the standard error.

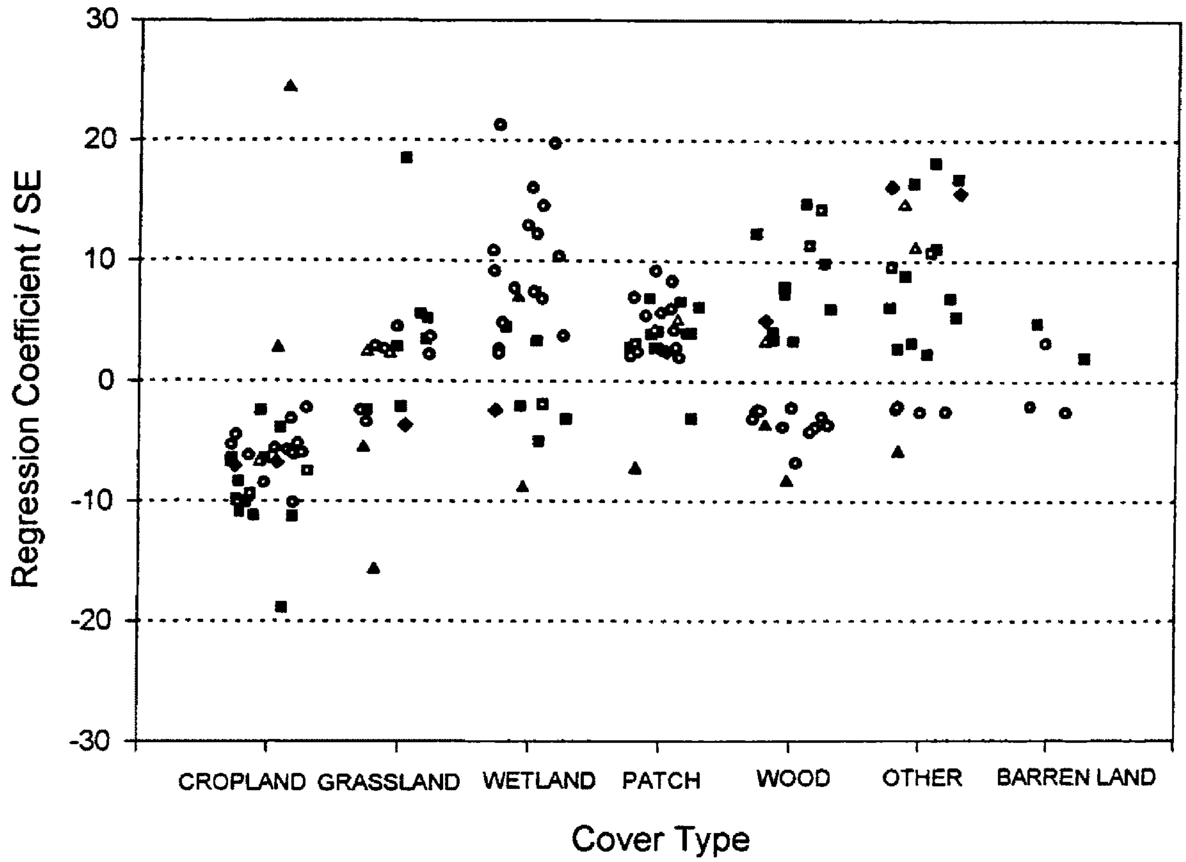


FIG. 3. Significant relationships ($\alpha \leq 0.05$) of species to cover type (200 m) for habitat groups other than grassland, measured by the model regression coefficient divided by the standard error.
● Wetland, ▲ Bare Ground, △ Savanna, ■ Edge, ◻ Woodland, ◆ Generalist.

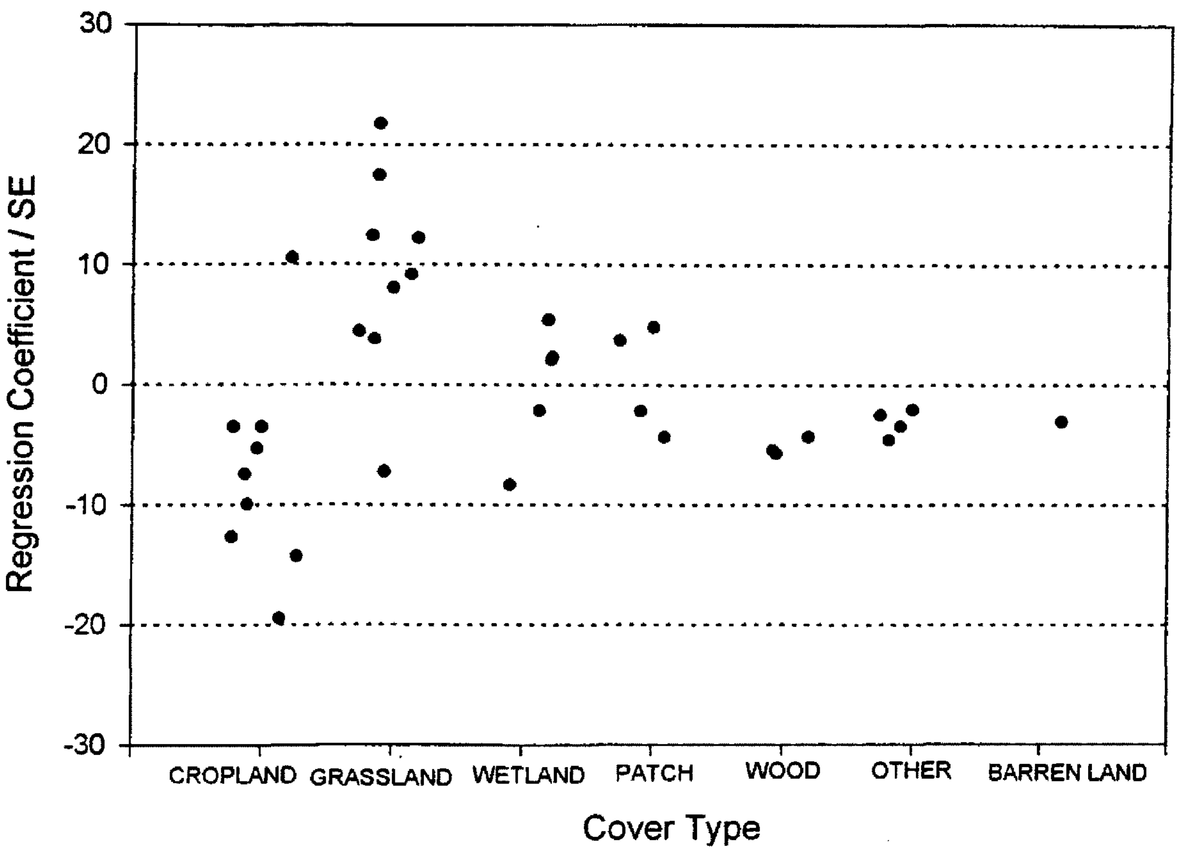


FIG. 4. Significant relationships ($\alpha \leq 0.05$) of grassland species to cover type (400 m), measured by the model regression coefficient divided by the standard error.

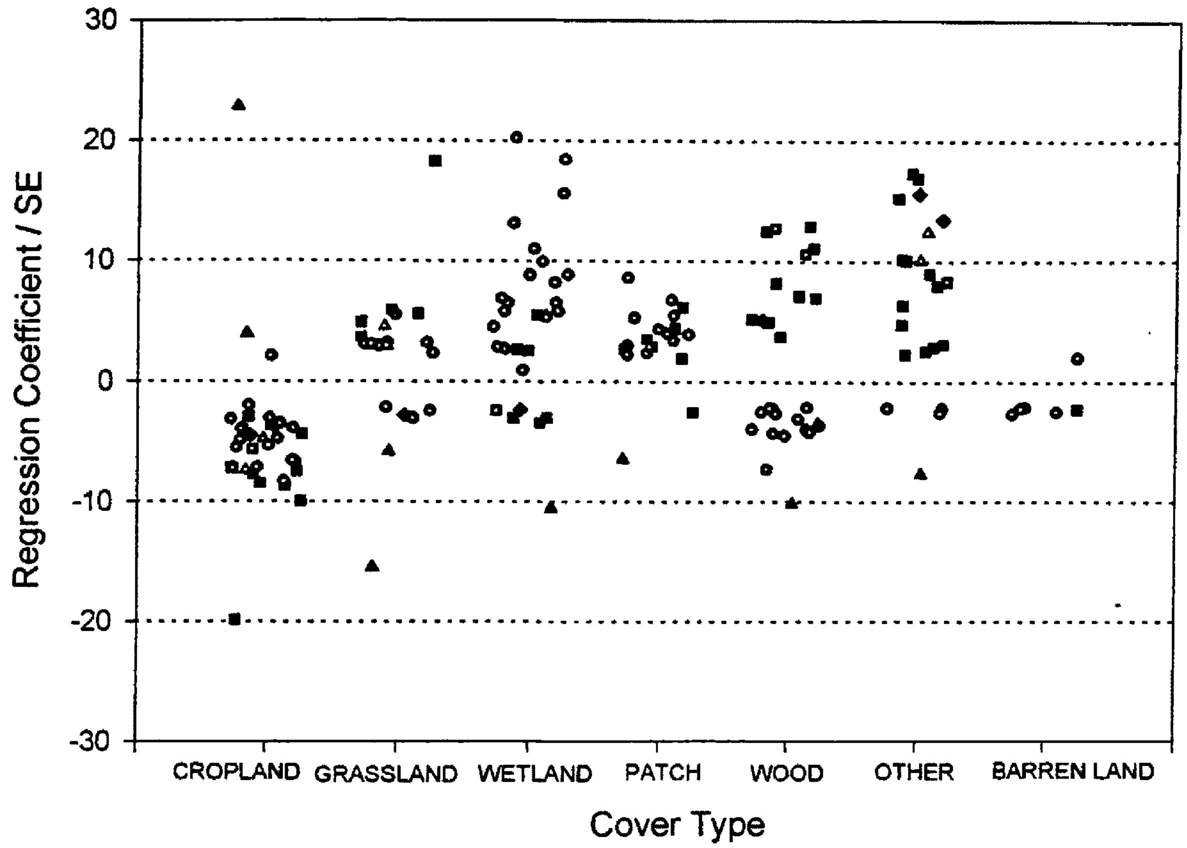


FIG. 5. Significant relationships ($\alpha \leq 0.05$) of species to cover type (400 m) for habitat groups other than grassland, measured by the model regression coefficient divided by the standard error.

● Wetland, ▲ Bare Ground, △ Savanna, ■ Edge, ▪ Woodland, ◆ Generalist.

Grassland Integrity Models and Indices

I developed an index of grassland integrity that included those cover types that appeared to exert the most influence, either positive or negative, on grassland bird species:

Grassland Integrity = %Grassland - (%Cropland + %Wood + %Other).

Grassland provided habitat structurally similar to an intact grassland ecosystem, and was attractive to the highest proportion (73%) of grassland species. Cropland, Wood, and Other were considered detractors to grassland integrity. These cover types represent effects of anthropogenic changes to the historic structure of a grassland ecosystem and showed the fewest positive correlations and the most negative correlations with grassland species. Three cover types, Wetland, Patch, and Barren Land, were not included in the index. Wetland density varied greatly among regions of the study area, so an area of degraded uplands with high wetland density might receive a higher grassland integrity rating than a drier area in more pristine condition if Wetland was included in the index. Patch appeared to be neither a positive or negative indicator of grassland integrity. Although some grassland species are positively associated with Patch (18-27%), it is unused by many and nest success along fencerows or in small grassland patches may be very low (Johnson and Temple 1990, Herkert 1991, Bollinger and Gavin 1992). Barren Land was not indicative of grassland integrity because it had few significant or strong associations with grassland species.

Using forward linear regression and a random sample of two thirds of the data, I used presence and abundance of the 50 species analyzed to build four models predicting grassland integrity: 200-m presence, 400-m presence, 200-m abundance, and 400-m abundance. Data from 2 heavily-wooded hexagons were not used in the models. The final models contained only those 12 species that were significant in all four models (Table 2).

I tested the predictive capacity of each of the models by cross validation using the remaining third of the data. Predicted index values were calculated for each quadrant by first multiplying the presence (1 if present, 0 if absent) or abundance of each species in the model by its regression coefficient and then adding the model intercept. The coefficients of determination ($R^2$) of each cross-validation test were then compared to those from the original fitting. Coefficients of determination ($R^2$) for these models were similar for the initial fitting and for the cross-validation testing (Table 2).

Table 2. Linear regression models predicting grassland integrity from species presence or abundance at 200-m and 400-m scales, and coefficients of determination ($R^2$) for initial model fitting and cross-validation.

| | Species Presence | | Species Abundance | |
|---|---|---|---|---|
| Term | 200 m | 400 m | 200 m | 400 m |
| Intercept | -57.615 | -60.528 | -54.602 | -56.189 |
| CCLO | 91.285 | 82.453 | 53.691 | 80.868 |
| BAIS | 62.646 | 66.949 | 49.007 | 48.532 |
| GRSP | 61.003 | 49.683 | 44.948 | 46.346 |
| CCSP | 40.251 | 40.137 | 36.822 | 37.219 |
| AMBI | 31.891 | 38.982 | 29.880 | 29.038 |
| WEME | 32.627 | 37.243 | 27.346 | 23.335 |
| SEWR | 26.695 | 33.664 | 24.194 | 23.217 |
| SAVS | 21.359 | 17.926 | 18.702 | 14.717 |
| AMCO | 21.029 | 16.907 | 16.499 | 14.179 |
| PBGR | 12.756 | 13.136 | 5.231 | 3.782 |
| VESP | -18.662 | -18.053 | -18.811 | -18.501 |
| HOLA | -23.765 | -23.073 | -20.700 | -19.523 |
| $R^2$ Initial Fitting | 0.287 | 0.288 | 0.304 | 0.285 |
| $R^2$ Cross-validation | 0.273 | 0.287 | 0.270 | 0.240 |

## SECTION IV

## Discussion

### Species Composition and Relative Abundance

Species richness and abundance were remarkably similar between years. Even though some point locations changed between years and an entire hexagon was not sampled in 1996, the average number of species per hexagon and individuals per point were identical between years. Differences in species composition between years were slight: a maximum of 10 species, most of which were uncommon, were observed in one year but not the other. Such consistency between years can likely be attributed to similar wet conditions in both years and data collection by only one observer (Robbins et al. 1986).

### Cover Types

Proportions of most cover types in the 200-m and 400-m quadrants were reasonably representative of the hexagons as a whole. However, the mean percent of total area differed significantly for Patch, Other, and Barren Land (Table 1). This is likely a result of roadside sampling and sampling along section lines and half-section lines. Patch is largely composed of road rights-of-way, Barren Land includes mostly road surfaces, and Other is largely composed of farmsteads, which tend to be near roads.

Associations Between Species Presence and Cover Type

Associations developed between species presence and cover type were used as a meta-analysis to obtain an overview of species and group associations with cover type. These associations were used as a tool to develop the index of grassland integrity, not as a final analysis. Caution must be used when interpreting the results of this procedure, because a large number of statistical tests conducted on a large dataset creates inferential difficulties. The large sample size increases the chance of Type I errors (falsely rejecting the null hypothesis of no relationship between a given species and cover type). Testing a large number of relationships between species and cover types (350 at each scale) further increases the likelihood of Type I errors because as the number of tests increases, the proportion of associations expected to be significant by chance alone also increases. Using a Bonferroni correction to the significance level can reduce the possibility of Type I errors when multiple tests are used (Rice 1989). In this case, a Bonferroni adjusted significance level of $\alpha = 0.00015$ would be required for each test in order to maintain an overall significance level of $\alpha = 0.05$. The tradeoff of using such an adjustment is that the possibility of Type II errors (failing to reject the null hypothesis of no relationships between a given species and cover type, when such a relationship exists) is increased. I used $\alpha = 0.05$ when deciding which cover types should be included in the grassland integrity index rather than $\alpha = 0.00015$, so an overall significance level of $\alpha = 0.05$ is not implied. However, I carefully considered whether or not each relationship made biological sense; that is, whether the species being tested was likely to be attracted or repelled by a given cover type based on life history requirements. As a second measure, the -2LL was also considered when evaluating the relationships. Lower -2LL values indicated a better model fit. Because of the inferential difficulties, the results of the meta-analysis were not meant to stand alone, but to act only as a guide for developing the grassland integrity formula. P-values and -2LL values for each test were included in Appendix D so that readers may draw their own conclusions based on the significance and strength of each relationship. The selection of the 12 species included in the final models did not rely on this meta-analysis, but rather on four separate regression models where multiple testing was not an issue. Nevertheless, P-values generated in meta-analysis regressions of the presence of these species on Cropland and Grassland were nearly all below the Bonferroni adjusted significance level. Only two species [Baird's Sparrow and Pied-billed Grebe (*Podilymbus podiceps*)] showed $P > 0.00015$ for either Cropland or Grassland, the most influential cover types in the index.

Almost all of the species analyzed exhibited significant relationships with at least one cover type, with Ferruginous Hawk and Upland Sandpiper the only exceptions. For Ferruginous Hawks, the lack of significant association may be related to their large home range and relatively small number of observations. In Upland Sandpipers the lack of significant association may have occurred because determining the distance and direction from which they are calling is exceedingly difficult. Thus, assigning observations to a given quadrant was at times arbitrary.

The scale at which the cover types were sampled changed the number and type of species relationships detected in several cover types, particularly those for which cover-type composition differed between scales. Variability in associations of species and proportions of habitat groups between scales was small for cover types that composed the largest percentages of the land area and larger for those that composed a smaller proportion. Cropland, with the largest percentage of land area, had nearly all of the same relationships at 200 m and 400 m. Species relationships with Grassland also varied little between the two scales. Patch, which varied the most of the three cover types that were significantly different between scales, also varied the most in terms of species relationships between the scales. Caution should be exercised when interpreting associations of species with cover type at scales other than the one at which they were developed, particularly for cover types that compose small proportions of the total area or that are highly variable between scales.

Species associations with cover type are dependent on the detectability of the species during the count period. Species are differentially detected depending on the frequency and loudness of their call, and their relative visibility due both to behavioral traits and to the habitat in which they occur. Yellow Rails, for example, are seldom detected in wet meadows during the day. In contrast, Bobolinks are frequently detected in the same habitat due to the conspicuous song and flight display of the male. This sort of bias could cause a species' relationship to be overlooked or under represented. Models that rely on this method cannot be expected to detect all possible associations of species with cover type, and might overlook significant ones. However, as data from this study and the Breeding Bird Survey indicate, repeated point count data collected by the same observer can provide consistent results over time (Robbins et al. 1986). Although cryptic species that are strongly tied to a given cover type may be overlooked, easily counted species that are very strongly related to a single cover type, such as Baird's Sparrow (n = 16) and Chestnut-collared Longspur (*Calcarius ornatus*) (n = 70), will likely be represented in the models even when the species occur in low numbers.

Relatively large tracts of land seem important for Grassland species in particular, as evidenced by the greater proportion of Grassland species positively correlated to Grassland rather than to Patch. Still, Patch was attractive to some Grassland birds, and was attractive to a greater proportion of Wetland species than was Grassland. The relationship between Patch and Wetland species may be due to the proximity of well-sampled roadside wetlands and borrow ditches to areas of Patch and to the tendency of many wetlands to be associated with areas of Patch. Cropland appears to be unattractive to most birds in general and to Grassland birds in particular: only one Grassland species, the Vesper Sparrow (*Pooecetes gramineus*), was positively correlated with Cropland. The association of Vesper Sparrows with Cropland has been documented previously (Herkert 1991, Johnson and Schwartz 1993a, Camp and Best 1994). Wood and Other, composed largely of farmsteads, appear to be powerful influences on species composition in the region. Tree-dependent species now occur in much larger numbers than many of the Grassland species that predominated historically.

Grassland Integrity Models and Indices

The selection of cover types for the index was based on a reasonable interpretation of the influence, structure, and function of each cover type in a grassland ecosystem and on the relative proportions of Grassland species either positively or negatively correlated with each cover type. However, no absolute values for the proportions of Grassland species correlated with cover type were established as criteria for the inclusion of a cover type in the index. The rigor of future models may be increased by establishing more objective rules governing the inclusion of cover types in an integrity index.

Although species were selected for the models based on their statistical associations to grassland integrity, the breeding habitat requirements of these species further justifies their inclusion. Most species that were positively correlated to grassland integrity breed exclusively in grassland habitats or in wetland habitats associated with grassland. The upland species represented in the model require grassland habitats ranging from short- and mixed-grass with low litter accumulation and very few shrubs for Chestnut-collared Longspurs (Renken 1983, Arnold and Higgins 1986, Berkey et al. 1993) to relatively dense mixed grass with a high litter accumulation and a component of small shrubs for Clay-colored Sparrows (Renken 1983, Arnold and Higgins 1986, Knapton 1994, Madden 1996 ). Baird's Sparrows, Grasshopper Sparrows, Savannah Sparrows (*Passerculus sandwichensis*), and Western Meadowlarks (*Sturnella neglecta*) prefer an intermediate grass height with moderate levels of litter (Wiens 1969, Wiens 1973, Kantrud and Kologiski 1983, Sample 1989, Johnson and Schwartz 1993b, Anstey et al. 1995). With the exception of Clay-colored Sparrows and Western Meadowlarks, most of these species have a low tolerance for woody vegetation (Faanes 1983). Though area sensitivity has not been studied in all of these species, Grasshopper Sparrows, Baird's Sparrows, and Savannah Sparrows are known to occur more frequently in relatively large grassland tracts than in small ones (Herkert 1991, Vickery et al. 1994, Helzer 1996). Sedge Wrens (*Cistothorus platensis*) prefer dense vegetation on moist sites, and are often found in CRP fields (Sample 1989, Herkert 1991, Johnson and Schwartz 1993a). Sedge Wrens do not appear to require particularly large grassland tracts (Herkert 1994). American Bitterns (*Botaurus lentiginosus*) require mid- or tallgrass uplands near emergent marshes $\geq$1 ha (Kantrud and Higgins 1992, Daub 1993). Pied-billed Grebes and American Coots (*Fulica americana*) breed in grassland marshes of all sizes (Stewart 1975, Daub 1993).

Species that were negatively correlated to grassland integrity in the index included Horned Larks and the Vesper Sparrows. Horned Larks regularly breed in sparsely vegetated habitat and cropland (DuBois 1935, Wershler et al. 1991, Patterson 1994). Vesper Sparrows are flexible in their habitat selection, but are often found in sparse vegetation and cropland (Herkert 1991, Johnson and Schwartz 1993a, Camp and Best 1994). Both species were positively associated with Cropland and negatively associated with Grassland at the 200-m and 400-m scales. Two other species [Killdeer and American Robin (*Turdus migratorius*)] were found to be negatively correlated to grassland integrity in preliminary species abundance models, but were not included in the final models because they were not significant in the species presence models.

Cross validation produced coefficients of determination ($R^2$) similar to those of the original four grassland integrity models, indicating that the models predict reliably when tested with fresh data. The greater similarity of coefficients of determination ($R^2$) between species-presence models and their cross-validation tests indicates that presence may be a slightly more reliable predictor of grassland integrity than abundance. This may be a result of less variation in presence data than in abundance data. The binary nature of presence data treats a species that occurred, for example, 11 times in a quadrant the same as if it only occurred once.

Like all models, the grassland integrity models are limited in their predictive abilities. Presence and abundance measurements recorded on the breeding grounds do not differentiate between population changes that occurred there rather than on the wintering grounds or elsewhere. Thus, low grassland integrity could be falsely attributed to conditions on the breeding grounds if species that are positive covariates in the model are absent or occur in low frequencies as a result of off-site population declines. Another limitation of the model is that the index values are indicative only of the relative percentages of four cover types, not habitat quality. While higher grassland integrity values likely represent the best habitat available for grassland birds, the presence and abundance measurements used in the model cannot detect nest success rates or indicate changes in population on a local scale, nor can they measure the relative patchiness of the habitat. Therefore, relatively high grassland integrity values could still represent a population sink.

Data selected for cross validation were randomly selected from all portions of the study area in an effort to approximate an unbiased sample of independently-collected data. They are a reasonable approximation of Breeding Bird Survey data generated during the same time period for the region because the study methods followed the same basic protocol. Nevertheless, data from the study itself likely fit the model slightly better than would independent data because of the lack of observer bias. Pooling data from several observers would likely produce coefficients of determination ($R^2$) less similar to those from the initial model fitting than those from the current cross-validation. While it would be highly desirable to cross-validate the model using actual Breeding Bird Survey data, such data are only available with observations grouped in 10-point clusters rather than single points. I have obtained these data for 1995 and 1996 and plan to test the models with them in the future. According to Patuxent Wildlife Research Center personnel, data are being entered separately for each point beginning in 1998. This will greatly facilitate future efforts to cross-validate similar models using independently collected data.

The presence of those species associated with woody vegetation or Cropland, combined with the absence of many Grassland species, can provide a measure of grassland integrity. Although identifying regional associations of species with cover types is labor-intensive, the indices presented here can be applied relatively inexpensively to monitor grassland integrity over a large geographic area because survey data are already available. I constructed the grassland integrity index to be predicted using presence and abundance of birds, so that data already available through the Breeding Bird Survey could be used in future applications of the model. The use of existing bird data to predict grassland integrity is currently more cost-effective than repeated measuring of cover type composition using remote sensing. Also, the use of birds as an indicator of grassland integrity incorporates an important biological component not available from remote sensing alone. The Breeding Bird Survey has been collecting annual abundance data on hundreds of routes in North America since 1965. Although the density of routes varies, at least one route occurs within each one degree block of latitude and longitude across the U.S. and southern Canada. Hence, indices could be applied to a specified region without the added cost of annual data collection.

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# APPENDIX A

Differences in detection rates among point count periods.

## Introduction

Bird presence and abundance data were collected using 3-minute point counts. Because of the short duration of the counts, it was conceivable that only a small proportion of the birds present might be sampled at each point, biasing the analyses in favor of those species most easily detected in a short period. In order to investigate this possibility, I collected data for extended time periods at selected points during 1996. I then examined differences between the numbers of species and individuals counted during 3-, 5-, and 10-minute intervals as a proportion of the total observed in a 10-minute period.

## Methods

I selected hexagons that contained the most Grassland (as defined in the thesis) for the extended counts. I then conducted sequential 3-, 5- and 10-minute point counts at 225 points on 14 hexagons and one off-frame route (n =15) between 28 May and 28 June, 1996. The off-frame route was located at Lostwood National Wildlife Refuge in Burke County, North Dakota. Although I conducted separate analyses both with and without the additional off-frame route, the results were nearly identical. Results shown here include the off-frame route. The hexagons contained a mean of 15 points each, and a range of 8 to 24 points. Wherever possible, points were located on secondary or tertiary unpaved roads. However, 14 of the 225 points occurred on a paved road or at the intersection of paved and unpaved roads.

Two groups of species were analyzed: (1) all species combined, and (2) 11 grassland species used to develop species relationships with cover types in the thesis. I used paired-difference t-tests ($\alpha = 0.05$) to compare differences in mean number of species and individuals among periods for the 15 routes. Whole routes, rather than individual points, were analyzed in order to meet the assumption of independence for the statistical tests. I plotted proportions of species and individuals observed during each period in accumulation curves to visually compare the periods.

**APPENDIX A.** Continued.

## Results

### Differences in Numbers of Species

Most species were observed in the first 3 minutes. However, the proportions of species observed in the 3- and 5-minute periods were higher for grassland birds than for all species combined (Table 1). Over 95% of grassland birds were observed in the first 3 minutes, whereas only about 84% of all species combined were observed during the same period (Fig. 1).

Table 1. Mean numbers and proportions of species and individuals observed.

| Group | Period (minutes) | $\bar{x}$ No. Species Observed | SE | $\bar{x}$ % Species Observed | SE |
|---|---|---|---|---|---|
| All Species | 3 | 39.87 | 2.27 | 84.10 | 1.68 |
| | 5 | 42.67 | 2.37 | 90.02 | 1.37 |
| | 10 | 47.27 | 2.33 | 100.00 | 0.00 |
| Grassland Species | 3 | 7.07 | 0.30 | 95.83 | 1.99 |
| | 5 | 7.20 | 0.31 | 97.50 | 1.81 |
| | 10 | 7.40 | 0.31 | 100.00 | 0.00 |

| Group | Period (minutes) | $\bar{x}$ No. Individuals Observed | SE | $\bar{x}$ % Individuals Observed | SE |
|---|---|---|---|---|---|
| All Species | 3 | 238.27 | 29.46 | 55.94 | 1.28 |
| | 5 | 305.73 | 38.26 | 71.39 | 1.05 |
| | 10 | 426.67 | 51.53 | 100.00 | 0.00 |
| Grassland Species | 3 | 46.53 | 4.57 | 69.93 | 2.60 |
| | 5 | 56.27 | 6.30 | 82.31 | 1.79 |
| | 10 | 70.60 | 9.59 | 100.00 | 0.00 |

Differences among mean numbers of all species observed during the three periods were statistically significant ($P < 0.0005$), even though the number of species gained by increased observation time was fairly small (Table 2). On average, 2.8 species were added to the total number observed by increasing the observation period from 3 to 5 minutes; 4.6 additional species were added when the observation period was increased from 5 to 10 minutes. The greatest benefit occurred when the observation period was increased from 3 to 10 minutes, adding 7.4 species to the total number observed. Differences among mean numbers of grassland species observed during the three periods, less than one species for each added period, were not statistically significant (Table 2).

### Differences in Numbers of Individuals

More than half of all individuals were detected in the first 3 minutes. However, proportions of individuals observed in the 3- and 5-minute periods were higher for grassland species than for all species combined (Table 1). Nearly 70% of all grassland individuals were detected in the first 3 minutes, whereas only about 55% of all individuals combined were observed during the same period (Fig. 1). Differences among mean numbers of individuals observed during the three periods were statistically significant for all species combined and for grassland species alone (Table 2).

## Discussion

Assuming that 100% of species present are sampled in 10 minutes, species accumulation curves show that a large proportion of species, particularly grassland obligates, are observed during the first 3 minutes. The large proportion of grassland species sampled early on may be due to their occurrence in relatively low densities and to the conspicuous displays of breeding males. Analyses of all species combined show that differences in the number of species observed among periods is statistically significant, but these differences seem of little practical importance, particularly since differences in the number of grassland species observed were not significant. Proportions of the total number of individuals are apparently observed at a slower rate, although it is not clear whether this is a result of an increased observations of new individuals or repeat counts of the same individuals that have moved to new locations. Extended observation near wetlands and shelterbelts likely results in the largest overall increases in both species and individuals recorded. Because such high proportions of species are sampled in 3-minutes, particularly grassland species that are of primary interest, time spent in extended observation seems unwarranted.

**APPENDIX A.** Continued.

Table 2. Mean differences in the numbers of species and individuals observed.

| Group | Period (minutes) | $\bar{x}$ Difference in No. Species | SE | 95% Confidence Interval | P* |
|---|---|---|---|---|---|
| All Species | 5 - 3 | 2.80 | 0.37 | 2.01, 3.59 | * |
| | 10 - 5 | 4.60 | 0.60 | 3.31, 5.89 | * |
| | 10 - 3 | 7.40 | 0.75 | 5.78, 9.02 | * |
| Grassland Species | 5 - 3 | 0.13 | 0.09 | -0.06, 0.32 | 0.164 |
| | 10 - 5 | 0.20 | 0.14 | -0.12, 0.51 | 0.189 |
| | 10 - 3 | 0.33 | 0.16 | -0.01, 0.68 | 0.055 |

| Group | Period (minutes) | $\bar{x}$ Difference in No. Individuals | SE | 95% Confidence Interval | P* |
|---|---|---|---|---|---|
| All Species | 5 - 3 | 67.47 | 9.24 | 47.66, 87.28 | * |
| | 10 - 5 | 120.93 | 14.13 | 90.62, 151.25 | * |
| | 10 - 3 | 188.40 | 22.76 | 139.58, 237.22 | * |
| Grassland Species | 5 - 3 | 9.73 | 1.85 | 5.78, 13.69 | * |
| | 10 - 5 | 14.33 | 3.75 | 6.30, 22.37 | 0.002 |
| | 10 - 3 | 24.07 | 5.30 | 12.70, 35.43 | * |

*P < 0.0005.

**APPENDIX A.** Continued.

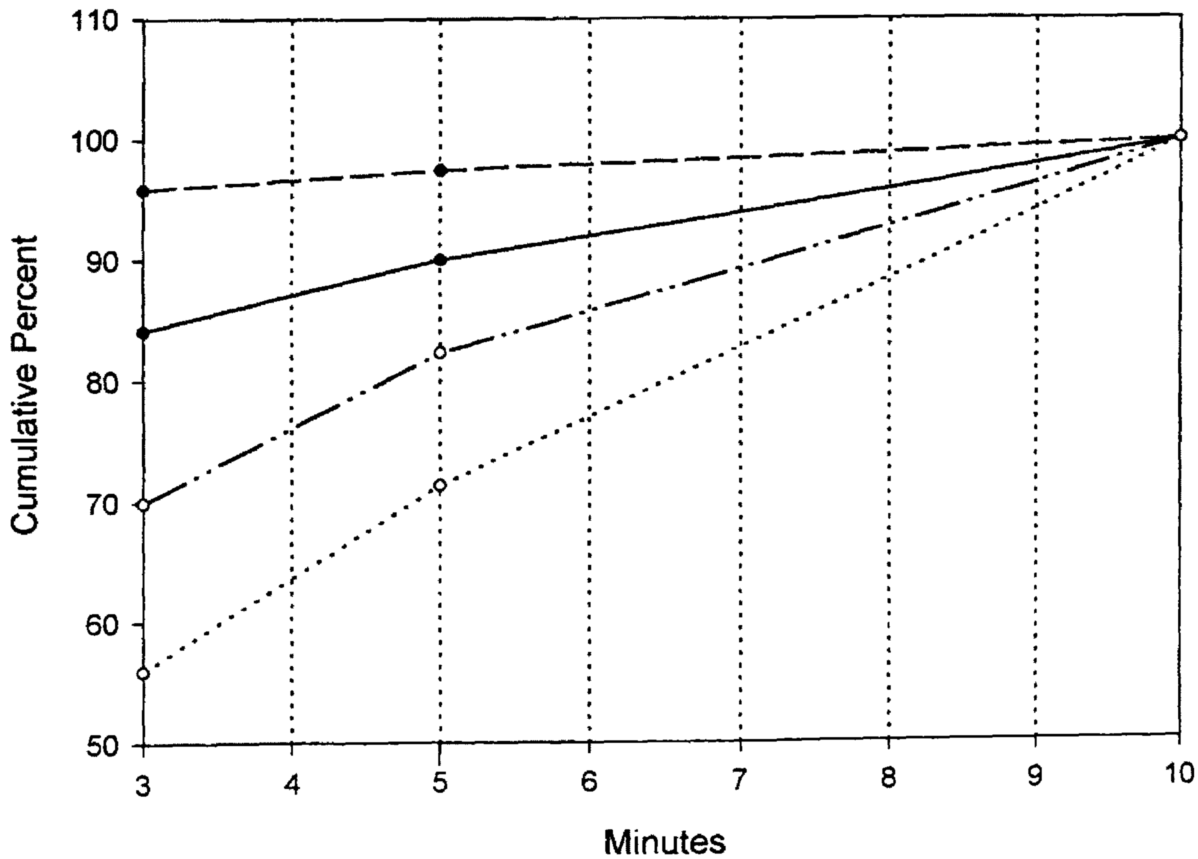


FIG 1. Accumulation curves for species and individuals observed on selected routes (n = 15).

--●— Grassland Species
—●— All Species
—○·· Grassland Individuals
··○·· All Individuals

## APPENDIX B

Cover type definitions and frequencies.

Table 1. Cover types defined in the Northern Prairie Wildlife Research Center (NPWRC) GIS and this study.

| NPWSC Land Use | NPWRC Code | Cover Type | NPWRC Codes |
|---|---|---|---|
| Grassland | 1 | Cover | 1,2,3,11 |
| Hayland | 2 | | |
| Planted Cover | 3 | | |
| Cropland | 4 | Cropland | 4 |
| Woodland | 5 | Wood | 5,6,7-5,7-5S |
| Scrubland | 6 | | |
| Odd Area | 7 | Other | 7 |
| Odd w/ Herb | 7-1 | | |
| Odd w/ Woody | 7-5 | | |
| Shelterbelt | 7-5S | | |
| Right of Way | 8A | Patch | 7-1,8A, 8B, 8C, 8D |
| Right of Way | 8B | | |
| Right of Way | 8C | | |
| Right of Way | 8D | | |
| Right of Way | 8E | | |
| Barren Land | 9 | Barren Land | 9, 8E |
| CRP | 11 | | |
| Wetland | TEMP (10A) | Wetland | 10A, 10B, 10C, |
| Wetland | SEASONAL (10B) | | 10D, 10E |
| Wetland | SEMIPERM (10C) | | |
| Wetland | PERM (10D) | | |
| Wetland | RIVERINE (10E) | | |

**APPENDIX B.** Continued.

Table 2. Frequency and percentage of cover type occurrence at two scales in 6772 quadrants analyzed.

| | Frequency | | Percentage | |
|---|---|---|---|---|
| Cover Type | 200 m | 400 m | 200 m | 400 m |
| Cropland | 5536 | 5913 | 82 | 87 |
| Grassland | 1902 | 2408 | 28 | 36 |
| Wetland | 4057 | 5342 | 60 | 79 |
| Patch | 6170 | 6314 | 91 | 93 |
| Wood | 1108 | 1726 | 16 | 25 |
| Other | 762 | 1495 | 11 | 22 |
| Barren Land | 6449 | 6469 | 95 | 96 |

## APPENDIX C

Species range and occurrence in quadrants.

| Species | No. Quadrants in Species Range* | No. Quadrants Where Species Occurred |
|---|---|---|
| Black Tern† | 6068 | 151 |
| Mallard | 6772 | 325 |
| Gadwall | 6356 | 226 |
| Blue-winged Teal | 6772 | 352 |
| Northern Shoveler† | 5668 | 174 |
| Northern Pintail† | 5860 | 127 |
| Redhead† | 5680 | 75 |
| American Bittern | 6332 | 70 |
| Sora | 6772 | 291 |
| American Coot† | 6492 | 430 |
| Common Snipe† | 5412 | 109 |
| Marbled Godwit | 5120 | 44 |
| Upland Sandpiper | 6772 | 94 |
| Killdeer | 6772 | 410 |
| Mourning Dove | 6772 | 766 |
| Ring-necked Pheasant | 5372 | 129 |
| Northern Harrier† | 5324 | 15 |
| Ferruginous Hawk† | 4388 | 16 |
| Eastern Kingbird | 6772 | 345 |
| Western Kingbird | 6772 | 209 |
| Least Flycatcher† | 6772 | 128 |
| Horned Lark | 6772 | 1535 |
| American Crow | 6772 | 197 |
| Bobolink | 6772 | 511 |
| Brown-headed Cowbird | 6772 | 797 |
| Yellow-headed Blackbird | 6772 | 506 |
| Red-winged Blackbird | 6772 | 1883 |
| Western Meadowlark | 6772 | 1113 |
| Common Grackle | 6772 | 275 |
| American Goldfinch | 6772 | 79 |
| Chestnut-colrd.Longspur | 4960 | 57 |
| Vesper Sparrow | 6772 | 737 |
| Savannah Sparrow | 6772 | 803 |
| Baird's Sparrow | 3640 | 16 |
| Grasshopper Sparrow† | 6772 | 210 |
| LeConte's Sparrow† | 4636 | 70 |
| Sharp-tailed Sparrow† | 4820 | 33 |
| Clay-colored Sparrow | 6772 | 505 |

**APPENDIX C.** Continued.

| Species | No. Quadrants in Species Range* | No. Quadrants Where Species Occurred |
|---|---|---|
| Song Sparrow | 6772 | 378 |
| Barn Swallow | 6772 | 67 |
| Warbling Vireo | 6772 | 94 |
| Yellow Warbler | 6772 | 171 |
| Common Yellowthroat | 6772 | 476 |
| House Sparrow | 6772 | 78 |
| Brown Thrasher | 6772 | 81 |
| House Wren | 6772 | 325 |
| Sedge Wren† | 6468 | 217 |
| Marsh Wren | 6772 | 186 |
| American Robin | 6772 | 191 |

*Values below 6772 indicate that the species range (Price et al. 1995) included only a portion of the study area.

†Species occurred in one or more study plots outside primary range (Price et al. 1995).

## APPENDIX D

Species relationships to cover types at 200 m and 400 m.

Table 1. Species relationships to cover types at 200 m.

| Species[†] | Cover Types | B[‡] | B/SE[§] | -2LL[ǀ] | P |
|---|---|---|---|---|---|
| HOLA | Cropland | 0.0317 | 24.38 | 6365 | * |
| VESP | Cropland | 0.0156 | 11.14 | 4502 | * |
| KILL | Cropland | 0.0041 | 2.73 | 3086 | 0.0060 |
| NOPI | Cropland | 0.0050 | 1.92 | 1221 | 0.0551 |
| RWBL | Cropland | -0.0039 | -5.57 | 7979 | * |
| WEME | Cropland | -0.0158 | -17.56 | 5727 | * |
| BHCO | Cropland | -0.0066 | -6.60 | 4864 | * |
| SAVS | Cropland | -0.0090 | -9.00 | 4850 | * |
| MODO | Cropland | -0.0100 | -10.00 | 4685 | * |
| BOBO | Cropland | -0.0052 | -4.33 | 3606 | * |
| YHBL | Cropland | -0.0101 | -8.42 | 3531 | * |
| COYE | Cropland | -0.0141 | -10.85 | 3320 | * |
| CCSP | Cropland | -0.0264 | -18.86 | 3163 | * |
| AMCO | Cropland | -0.0131 | -10.08 | 3067 | * |
| SOSP | Cropland | -0.0089 | -6.36 | 2876 | * |
| BWTE | Cropland | -0.0083 | -5.93 | 2735 | * |
| MALL | Cropland | -0.0011 | -0.69 | 2608 | 0.4915 |
| EAKI | Cropland | -0.0167 | -11.13 | 2596 | * |
| HOWR | Cropland | -0.0168 | -11.20 | 2483 | * |
| SORA | Cropland | -0.0084 | -5.25 | 2373 | * |
| COGR | Cropland | -0.0133 | -8.31 | 2233 | * |
| GADW | Cropland | -0.0103 | -5.72 | 1919 | * |
| AMCR | Cropland | -0.0015 | -0.75 | 1781 | 0.4541 |
| WEKI | Cropland | -0.0191 | -10.05 | 1761 | * |
| SEWR | Cropland | -0.0221 | -11.05 | 1759 | * |
| AMRO | Cropland | -0.0128 | -6.74 | 1696 | * |
| MAWR | Cropland | -0.0115 | -6.05 | 1669 | * |
| GRSP | Cropland | -0.0307 | -13.35 | 1636 | * |
| PBGR | Cropland | -0.0120 | -6.00 | 1604 | * |

APPENDIX D. Continued.

| Species[†] | Cover Types | B[‡] | B/SE[§] | -2LL[|] | P |
|---|---|---|---|---|---|
| NSHO | Cropland | -0.0062 | -3.10 | 1546 | 0.0023 |
| YWAR | Cropland | -0.0216 | -9.82 | 1488 | * |
| BLTE | Cropland | -0.0113 | -5.14 | 1386 | * |
| RPHE | Cropland | -0.0055 | -2.39 | 1212 | 0.0186 |
| LEFL | Cropland | -0.0243 | -9.35 | 1170 | * |
| COSN | Cropland | -0.0145 | -5.58 | 1035 | * |
| UPSA | Cropland | -0.0015 | -0.54 | 991 | 0.5883 |
| WAVI | Cropland | -0.0215 | -7.41 | 932 | * |
| BRTH | Cropland | -0.0112 | -3.86 | 864 | 0.0001 |
| AMGO | Cropland | -0.0197 | -6.35 | 818 | * |
| HOSP | Cropland | -0.0231 | -7.00 | 796 | * |
| REDH | Cropland | -0.0137 | -4.42 | 778 | * |
| AMBI | Cropland | -0.0209 | -6.15 | 728 | * |
| LCSP | Cropland | -0.0067 | -2.16 | 726 | 0.0331 |
| BARS | Cropland | -0.0249 | -6.73 | 697 | * |
| CCLO | Cropland | -0.0440 | -6.88 | 523 | * |
| MAGO | Cropland | -0.0025 | -0.63 | 506 | 0.5335 |
| STSP | Cropland | -0.0069 | -1.50 | 392 | 0.1314 |
| FEHA | Cropland | -0.0009 | -0.13 | 212 | 0.8896 |
| NOHA | Cropland | -0.0231 | -3.04 | 195 | 0.0024 |
| BAIS | Cropland | -0.0248 | -3.02 | 194 | 0.0025 |
| WEME | Grassland | 0.0200 | 22.22 | 5601 | * |
| BHCO | Grassland | 0.0062 | 5.64 | 4878 | * |
| SAVS | Grassland | 0.0138 | 13.80 | 4768 | * |
| BOBO | Grassland | 0.0117 | 9.00 | 3545 | * |
| COYE | Grassland | 0.0074 | 5.29 | 3419 | * |
| CCSP | Grassland | 0.0222 | 18.50 | 3277 | * |
| AMCO | Grassland | 0.0009 | 0.56 | 3165 | 0.5777 |
| BWTE | Grassland | 0.0038 | 2.24 | 2762 | 0.0221 |
| EAKI | Grassland | 0.0056 | 3.50 | 2715 | 0.0006 |
| GADW | Grassland | 0.0054 | 2.70 | 1945 | 0.0065 |
| WEKI | Grassland | 0.0051 | 2.43 | 1860 | 0.0135 |
| SEWR | Grassland | 0.0215 | 11.94 | 1762 | * |
| PBGR | Grassland | 0.0079 | 3.76 | 1627 | 0.0002 |

**APPENDIX D.** Continued.

| Species[†] | Cover Types | B[‡] | B/SE[§] | -2LL[ǁ] | P |
|---|---|---|---|---|---|
| YWAR | Grassland | 0.0002 | 0.08 | 1596 | 0.9454 |
| NSHO | Grassland | 0.0013 | 0.54 | 1546 | 0.5764 |
| GRSP | Grassland | 0.0358 | 17.90 | 1503 | * |
| RPHE | Grassland | 0.0070 | 2.92 | 1209 | 0.0043 |
| COSN | Grassland | 0.0114 | 4.56 | 1049 | * |
| UPSA | Grassland | 0.0029 | 0.91 | 990 | 0.3648 |
| AMGO | Grassland | 0.0046 | 1.35 | 859 | 0.1740 |
| REDH | Grassland | 0.0008 | 0.22 | 798 | 0.8225 |
| BARS | Grassland | 0.0078 | 2.29 | 747 | 0.0227 |
| AMBI | Grassland | 0.0156 | 5.03 | 747 | 0.1758 |
| LCSP | Grassland | 0.0097 | 2.94 | 723 | 0.0029 |
| MAGO | Grassland | 0.0028 | 0.62 | 506 | 0.5282 |
| CCLO | Grassland | 0.0450 | 9.00 | 483 | * |
| STSP | Grassland | 0.0083 | 1.69 | 392 | 0.0893 |
| FEHA | Grassland | 0.0066 | 0.97 | 211 | 0.3277 |
| NOHA | Grassland | 0.0284 | 4.18 | 188 | * |
| BAIS | Grassland | 0.0338 | 4.28 | 181 | * |
| RWBL | Grassland | -0.0007 | -0.78 | 8005 | 0.4683 |
| HOLA | Grassland | -0.0282 | -15.67 | 6836 | * |
| MODO | Grassland | -0.0001 | -0.08 | 4781 | 0.9325 |
| VESP | Grassland | -0.0111 | -6.53 | 4606 | * |
| YHBL | Grassland | -0.0057 | -3.35 | 3587 | 0.0011 |
| KILL | Grassland | -0.0127 | -5.52 | 3056 | * |
| SOSP | Grassland | -0.0040 | -2.11 | 2911 | 0.0361 |
| MALL | Grassland | -0.0016 | -0.84 | 2607 | 0.4105 |
| HOWR | Grassland | -0.0049 | -2.33 | 2602 | 0.0209 |
| SORA | Grassland | -0.0019 | -0.90 | 2400 | 0.3511 |
| COGR | Grassland | -0.0023 | -1.10 | 2300 | 0.2927 |
| AMCR | Grassland | -0.0017 | -0.68 | 1781 | 0.5032 |
| AMRO | Grassland | -0.0123 | -3.62 | 1723 | 0.0003 |
| MAWR | Grassland | -0.0054 | -1.93 | 1700 | 0.0537 |
| BLTE | Grassland | -0.0041 | -1.37 | 1412 | 0.1646 |
| LEFL | Grassland | -0.0033 | -1.03 | 1268 | 0.2959 |
| NOPI | Grassland | -0.0083 | -2.37 | 1218 | 0.0187 |

APPENDIX D. Continued.

| Species[†] | Cover Types | B[‡] | B/SE[§] | -2LL[\|] | P |
|---|---|---|---|---|---|
| WAVI | Grassland | -0.0023 | -0.64 | 990 | 0.5222 |
| BRTH | Grassland | -0.0009 | -0.24 | 878 | 0.8191 |
| HOSP | Grassland | -0.0043 | -1.02 | 850 | 0.3078 |
| RWBL | Wetland | 0.0277 | 14.58 | 7772 | * |
| WEME | Wetland | 0.0004 | 0.17 | 6052 | 0.8537 |
| SAVS | Wetland | 0.0037 | 1.48 | 4929 | 0.1355 |
| BOBO | Wetland | 0.0007 | 0.22 | 3623 | 0.8308 |
| COYE | Wetland | 0.0187 | 7.48 | 3398 | * |
| YHBL | Wetland | 0.0490 | 21.30 | 3136 | * |
| KILL | Wetland | 0.0182 | 7.00 | 3055 | * |
| SOSP | Wetland | 0.0134 | 4.62 | 2898 | * |
| AMCO | Wetland | 0.0455 | 19.78 | 2796 | * |
| EAKI | Wetland | 0.0109 | 3.41 | 2716 | 0.0006 |
| BWTE | Wetland | 0.0272 | 10.88 | 2673 | * |
| MALL | Wetland | 0.0209 | 7.46 | 2562 | * |
| COGR | Wetland | 0.0040 | 1.00 | 2300 | 0.3125 |
| SORA | Wetland | 0.0318 | 12.23 | 2280 | * |
| SEWR | Wetland | 0.0117 | 3.08 | 1892 | 0.0023 |
| GADW | Wetland | 0.0266 | 9.17 | 1888 | * |
| AMRO | Wetland | 0.0010 | 0.20 | 1740 | 0.8425 |
| YWAR | Wetland | 0.0061 | 1.27 | 1594 | 0.2061 |
| PBGR | Wetland | 0.0249 | 7.78 | 1594 | * |
| NSHO | Wetland | 0.0242 | 6.91 | 1518 | * |
| MAWR | Wetland | 0.0450 | 16.07 | 1495 | * |
| BLTE | Wetland | 0.0388 | 12.93 | 1289 | * |
| NOPI | Wetland | 0.0113 | 2.35 | 1220 | 0.0177 |
| COSN | Wetland | 0.0184 | 3.83 | 1055 | 0.0001 |
| UPSA | Wetland | 0.0055 | 0.85 | 990 | 0.3963 |
| AMGO | Wetland | 0.0042 | 0.58 | 860 | 0.5623 |
| AMBI | Wetland | 0.0245 | 4.90 | 752 | * |
| LCSP | Wetland | 0.0002 | 0.03 | 731 | 0.9833 |
| REDH | Wetland | 0.0406 | 10.41 | 721 | * |
| MAGO | Wetland | 0.0103 | 1.27 | 505 | 0.2066 |
| STSP | Wetland | 0.0212 | 2.72 | 389 | 0.0068 |

APPENDIX D. Continued.

| Species[†] | Cover Types | B[‡] | B/SE[§] | -2LL[ǁ] | P |
|---|---|---|---|---|---|
| HOLA | Wetland | -0.0257 | -8.86 | 7149 | * |
| BHCO | Wetland | -0.0016 | -0.59 | 4907 | 0.5537 |
| MODO | Wetland | -0.0024 | -0.86 | 4780 | 0.3860 |
| VESP | Wetland | -0.0385 | -7.70 | 4570 | * |
| CCSP | Wetland | -0.0246 | -4.92 | 3560 | * |
| HOWR | Wetland | -0.0167 | -3.09 | 2596 | 0.0020 |
| WEKI | Wetland | -0.0087 | -1.50 | 1863 | 0.1382 |
| GRSP | Wetland | -0.0303 | -3.65 | 1853 | 0.0003 |
| AMCR | Wetland | -0.0134 | -2.03 | 1777 | 0.0408 |
| LEFL | Wetland | -0.0095 | -1.25 | 1268 | 0.2077 |
| RPHE | Wetland | -0.0095 | -1.32 | 1215 | 0.1880 |
| WAVI | Wetland | -0.0197 | -1.86 | 986 | 0.0618 |
| BRTH | Wetland | -0.0040 | -0.47 | 878 | 0.6415 |
| HOSP | Wetland | -0.0336 | -2.35 | 843 | 0.0188 |
| BARS | Wetland | -0.0094 | -0.90 | 751 | 0.3645 |
| CCLO | Wetland | -0.0248 | -1.66 | 619 | 0.0952 |
| FEHA | Wetland | -0.0724 | -1.51 | 207 | 0.1328 |
| NOHA | Wetland | -0.0053 | -0.26 | 206 | 0.7941 |
| BAIS | Wetland | -0.0730 | -1.56 | 201 | 0.1182 |
| RWBL | Patch | 0.0201 | 8.38 | 7938 | * |
| WEME | Patch | 0.0113 | 4.04 | 6036 | 0.0001 |
| SAVS | Patch | 0.0083 | 2.59 | 4925 | 0.0107 |
| BHCO | Patch | 0.0127 | 4.10 | 4892 | * |
| MODO | Patch | 0.0094 | 2.85 | 4773 | 0.0041 |
| CCSP | Patch | 0.0152 | 4.22 | 3578 | * |
| YHBL | Patch | 0.0296 | 9.25 | 3525 | * |
| COYE | Patch | 0.0227 | 6.68 | 3408 | * |
| AMCO | Patch | 0.0247 | 7.06 | 3124 | * |
| KILL | Patch | 0.0082 | 1.91 | 3091 | 0.0582 |
| SOSP | Patch | 0.0163 | 4.08 | 2902 | 0.0001 |
| BWTE | Patch | 0.0176 | 4.29 | 2751 | * |
| EAKI | Patch | 0.0258 | 6.97 | 2687 | * |
| MALL | Patch | 0.0013 | 0.25 | 2608 | 0.8049 |
| HOWR | Patch | 0.0077 | 1.60 | 2606 | 0.1103 |

APPENDIX D. Continued.

| Species† | Cover Types | B‡ | B/SE§ | -2LL‖ | P |
|---|---|---|---|---|---|
| SORA | Patch | 0.0244 | 6.10 | 2371 | * |
| COGR | Patch | 0.0179 | 3.98 | 2287 | 0.0001 |
| GADW | Patch | 0.0133 | 2.51 | 1946 | 0.0121 |
| SEWR | Patch | 0.0165 | 3.24 | 1891 | 0.0012 |
| WEKI | Patch | 0.0239 | 5.09 | 1844 | * |
| AMRO | Patch | 0.0142 | 2.54 | 1734 | 0.0113 |
| MAWR | Patch | 0.0261 | 5.55 | 1680 | * |
| PBGR | Patch | 0.0155 | 2.87 | 1633 | 0.0044 |
| YWAR | Patch | 0.0294 | 6.26 | 1566 | * |
| NSHO | Patch | 0.0128 | 2.17 | 1551 | 0.0311 |
| BLTE | Patch | 0.0300 | 5.77 | 1388 | * |
| LEFL | Patch | 0.0197 | 3.18 | 1261 | 0.0014 |
| RPHE | Patch | 0.0054 | 0.68 | 1217 | 0.4957 |
| COSN | Patch | 0.0009 | 0.10 | 1067 | 0.9226 |
| WAVI | Patch | 0.0138 | 1.75 | 988 | 0.0811 |
| BRTH | Patch | 0.0214 | 2.89 | 871 | 0.0039 |
| AMGO | Patch | 0.0157 | 1.89 | 857 | 0.0596 |
| HOSP | Patch | 0.0209 | 2.75 | 845 | 0.0063 |
| REDH | Patch | 0.0164 | 1.91 | 795 | 0.0560 |
| AMBI | Patch | 0.0173 | 2.04 | 766 | 0.0419 |
| BARS | Patch | 0.0302 | 4.31 | 738 | * |
| LCSP | Patch | 0.0142 | 1.61 | 729 | 0.1086 |
| HOLA | Patch | -0.0254 | -7.26 | 7186 | * |
| VESP | Patch | -0.0276 | -5.52 | 4622 | * |
| BOBO | Patch | -0.0103 | -2.10 | 3619 | 0.0370 |
| GRSP | Patch | -0.0083 | -1.12 | 1871 | 0.2647 |
| AMCR | Patch | -0.0290 | -3.05 | 1771 | 0.0024 |
| NOPI | Patch | -0.0023 | -0.26 | 1224 | 0.7885 |
| UPSA | Patch | -0.0030 | -0.29 | 991 | 0.7698 |
| CCLO | Patch | -0.0208 | -1.26 | 621 | 0.2066 |
| MAGO | Patch | -0.0001 | -0.01 | 506 | 0.9925 |
| STSP | Patch | -0.0096 | -0.55 | 394 | 0.5835 |
| FEHA | Patch | -0.0163 | -0.55 | 211 | 0.5799 |
| NOHA | Patch | -0.0580 | -1.39 | 204 | 0.1644 |

APPENDIX D. Continued.

| Species[†] | Cover Types | B[‡] | B/SE[§] | -2LL[¶] | P |
|---|---|---|---|---|---|
| BAIS | Patch | -0.0644 | -1.62 | 202 | 0.1056 |
| BHCO | Wood | 0.0010 | 0.29 | 4907 | 0.7554 |
| MODO | Wood | 0.0184 | 7.36 | 4735 | * |
| CCSP | Wood | 0.0257 | 9.88 | 3514 | * |
| COYE | Wood | 0.0117 | 3.55 | 3434 | 0.0003 |
| SOSP | Wood | 0.0230 | 7.93 | 2867 | * |
| EAKI | Wood | 0.0124 | 3.44 | 2717 | 0.0007 |
| HOWR | Wood | 0.0400 | 14.81 | 2420 | * |
| COGR | Wood | 0.0082 | 1.82 | 2298 | 0.0667 |
| WEKI | Wood | 0.0144 | 3.35 | 1857 | 0.0008 |
| AMCR | Wood | 0.0263 | 7.97 | 1739 | * |
| AMRO | Wood | 0.0200 | 5.13 | 1720 | * |
| YWAR | Wood | 0.0371 | 12.37 | 1490 | * |
| RPHE | Wood | 0.0078 | 0.90 | 1216 | 0.3721 |
| LEFL | Wood | 0.0444 | 14.32 | 1125 | * |
| COSN | Wood | 0.0008 | 0.09 | 1067 | 0.9276 |
| WAVI | Wood | 0.0398 | 11.37 | 908 | * |
| BRTH | Wood | 0.0222 | 4.19 | 866 | * |
| HOSP | Wood | 0.0046 | 0.51 | 851 | 0.6154 |
| AMGO | Wood | 0.0281 | 6.11 | 836 | * |
| RWBL | Wood | -0.0289 | -6.72 | 7937 | * |
| HOLA | Wood | -0.1965 | -8.29 | 6970 | * |
| WEME | Wood | -0.0334 | -5.30 | 6003 | * |
| SAVS | Wood | -0.0831 | -5.58 | 4848 | * |
| VESP | Wood | -0.0031 | -0.82 | 4659 | 0.4207 |
| BOBO | Wood | -0.0839 | -4.39 | 3571 | * |
| YHBL | Wood | -0.0577 | -4.12 | 3560 | * |
| AMCO | Wood | -0.0549 | -3.73 | 3134 | 0.0002 |
| KILL | Wood | -0.0528 | -3.62 | 3066 | 0.0003 |
| BWTE | Wood | -0.1260 | -3.76 | 2720 | 0.0002 |
| MALL | Wood | -0.1026 | -3.56 | 2570 | 0.0004 |
| SORA | Wood | -0.0422 | -2.87 | 2385 | 0.0040 |
| GADW | Wood | -0.1489 | -3.02 | 1919 | 0.0025 |
| SEWR | Wood | -0.0054 | -0.75 | 1899 | 0.4563 |

**APPENDIX D. Continued.**

| Species[†] | Cover Types | B[‡] | B/SE[§] | -2LL[¶] | P |
|---|---|---|---|---|---|
| GRSP | Wood | -0.0196 | -1.81 | 1867 | 0.0711 |
| MAWR | Wood | -0.0469 | -2.36 | 1692 | 0.0184 |
| PBGR | Wood | -0.0402 | -2.26 | 1630 | 0.0236 |
| NSHO | Wood | -0.3520 | -2.42 | 1526 | 0.0157 |
| BLTE | Wood | -0.0500 | -2.16 | 1403 | 0.0309 |
| NOPI | Wood | -0.0410 | -1.62 | 1220 | 0.1044 |
| UPSA | Wood | -0.0230 | -1.31 | 988 | 0.1915 |
| REDH | Wood | -0.6030 | -1.58 | 781 | 0.1131 |
| AMBI | Wood | -0.0172 | -0.81 | 769 | 0.4172 |
| BARS | Wood | -0.0425 | -1.38 | 748 | 0.1689 |
| LCSP | Wood | -0.0162 | -1.04 | 729 | 0.2980 |
| CCLO | Wood | -86.6199 | -0.27 | 603 | 0.7861 |
| MAGO | Wood | -0.1151 | -1.20 | 502 | 0.2292 |
| STSP | Wood | -0.2434 | -1.05 | 389 | 0.2953 |
| FEHA | Wood | -0.0050 | -0.14 | 212 | 0.8866 |
| NOHA | Wood | -44.6333 | -0.16 | 202 | 0.8757 |
| BAIS | Wood | -59.6152 | -0.16 | 201 | 0.8695 |
| BHCO | Other | 0.0073 | 2.81 | 4900 | 0.0045 |
| MODO | Other | 0.0354 | 16.86 | 4511 | * |
| CCSP | Other | 0.0095 | 3.28 | 3584 | 0.0011 |
| COYE | Other | 0.0073 | 2.35 | 3441 | 0.0201 |
| SOSP | Other | 0.0188 | 6.96 | 2878 | * |
| EAKI | Other | 0.0266 | 11.08 | 2637 | * |
| HOWR | Other | 0.0400 | 18.18 | 2357 | * |
| COGR | Other | 0.0380 | 16.52 | 2101 | * |
| AMCR | Other | 0.0057 | 1.16 | 1781 | 0.2440 |
| WEKI | Other | 0.0366 | 14.64 | 1715 | * |
| AMRO | Other | 0.0405 | 16.20 | 1553 | * |
| YWAR | Other | 0.0274 | 8.84 | 1540 | * |
| RPHE | Other | 0.0006 | 0.08 | 1217 | 0.9280 |
| LEFL | Other | 0.0333 | 10.74 | 1192 | * |
| COSN | Other | 0.0060 | 0.91 | 1066 | 0.3618 |
| WAVI | Other | 0.0336 | 9.60 | 930 | * |
| BRTH | Other | 0.0243 | 5.40 | 858 | * |

APPENDIX D. Continued.

| Species[†] | Cover Types | B[‡] | B/SE[§] | -2LL[‖] | P |
|---|---|---|---|---|---|
| AMGO | Other | 0.0269 | 6.26 | 834 | * |
| BARS | Other | 0.0410 | 11.08 | 669 | * |
| HOSP | Other | 0.0517 | 15.67 | 667 | * |
| FEHA | Other | 0.0064 | 0.37 | 211 | 0.7132 |
| RWBL | Other | -0.0060 | -2.50 | 7999 | 0.0129 |
| HOLA | Other | -0.0688 | -5.83 | 7114 | * |
| WEME | Other | -0.0062 | -2.07 | 6047 | 0.0405 |
| SAVS | Other | -0.0261 | -4.21 | 4900 | * |
| VESP | Other | -0.0128 | -2.91 | 4649 | 0.0039 |
| YHBL | Other | -0.0135 | -2.45 | 3590 | 0.0136 |
| BOBO | Other | -0.0980 | -2.93 | 3575 | 0.0034 |
| AMCO | Other | -0.0133 | -2.25 | 3159 | 0.0250 |
| KILL | Other | -0.0046 | -0.98 | 3093 | 0.3251 |
| BWTE | Other | -0.0110 | -1.80 | 2763 | 0.0705 |
| MALL | Other | -0.0093 | -1.55 | 2605 | 0.1217 |
| SORA | Other | -0.0004 | -0.08 | 2401 | 0.9351 |
| GADW | Other | -0.0010 | -0.17 | 1952 | 0.8679 |
| SEWR | Other | -0.0421 | -2.24 | 1887 | 0.0249 |
| GRSP | Other | -0.0388 | -2.19 | 1860 | 0.0279 |
| MAWR | Other | -0.0521 | -2.00 | 1691 | 0.0450 |
| PBGR | Other | -0.0081 | -1.03 | 1639 | 0.3031 |
| NSHO | Other | -0.0249 | -1.84 | 1549 | 0.0661 |
| BLTE | Other | -0.0078 | -0.93 | 1413 | 0.3478 |
| NOPI | Other | -0.0116 | -1.08 | 1223 | 0.2787 |
| UPSA | Other | -0.0038 | -0.40 | 991 | 0.6827 |
| REDH | Other | -0.0206 | -1.17 | 796 | 0.2424 |
| AMBI | Other | -0.0050 | -0.44 | 770 | 0.6617 |
| LCSP | Other | -0.0384 | -1.25 | 727 | 0.2122 |
| CCLO | Other | -0.0182 | -0.92 | 621 | 0.3592 |
| MAGO | Other | -0.0124 | -0.67 | 506 | 0.5043 |
| STSP | Other | -0.0404 | -0.83 | 393 | 0.4078 |
| BAIS | Other | -0.0744 | -0.53 | 204 | 0.5944 |
| NOHA | Other | -0.5033 | -0.52 | 204 | 0.6059 |
| RWBL | Barren Land | 0.0057 | 0.89 | 8005 | 0.3747 |

APPENDIX D. Continued.

| Species[†] | Cover Types | B[‡] | B/SE[§] | -2LL[¹] | P |
|---|---|---|---|---|---|
| WEME | Barren Land | 0.0151 | 2.25 | 6047 | 0.0238 |
| MODO | Barren Land | 0.0007 | 0.07 | 4781 | 0.9386 |
| CCSP | Barren Land | 0.0349 | 4.92 | 3572 | * |
| COYE | Barren Land | 0.0031 | 0.28 | 3445 | 0.7818 |
| KILL | Barren Land | 0.0131 | 1.41 | 3093 | 0.1555 |
| EAKI | Barren Land | 0.0110 | 1.06 | 2725 | 0.2908 |
| MALL | Barren Land | 0.0014 | 0.10 | 2608 | 0.9214 |
| HOWR | Barren Land | 0.0062 | 0.51 | 2608 | 0.6066 |
| GADW | Barren Land | 0.0100 | 0.79 | 1951 | 0.4274 |
| SEWR | Barren Land | 0.0033 | 0.21 | 1900 | 0.8333 |
| WEKI | Barren Land | 0.0145 | 1.23 | 1864 | 0.2203 |
| AMRO | Barren Land | 0.0109 | 0.81 | 1739 | 0.4195 |
| NSHO | Barren Land | 0.0473 | 3.26 | 1544 | 0.0011 |
| LEFL | Barren Land | 0.0021 | 0.10 | 1269 | 0.9221 |
| WAVI | Barren Land | 0.0100 | 0.52 | 991 | 0.6069 |
| UPSA | Barren Land | 0.0133 | 0.76 | 990 | 0.4495 |
| AMGO | Barren Land | 0.0260 | 2.05 | 858 | 0.0412 |
| MAGO | Barren Land | 0.0257 | 1.12 | 505 | 0.2618 |
| NOHA | Barren Land | 0.0459 | 0.47 | 206 | 0.6351 |
| HOLA | Barren Land | -0.0055 | -0.70 | 7248 | 0.4828 |
| SAVS | Barren Land | -0.0165 | -1.29 | 4929 | 0.1969 |
| BHCO | Barren Land | -0.0069 | -0.64 | 4907 | 0.5242 |
| VESP | Barren Land | -0.0063 | -0.57 | 4660 | 0.5676 |
| BOBO | Barren Land | -0.0098 | -0.70 | 3623 | 0.4897 |
| YHBL | Barren Land | -0.0553 | -2.50 | 3590 | 0.0122 |
| AMCO | Barren Land | -0.0221 | -1.19 | 3164 | 0.2350 |
| SOSP | Barren Land | -0.0010 | -0.07 | 2916 | 0.9395 |
| BWTE | Barren Land | -0.0001 | -0.01 | 2767 | 0.9920 |
| SORA | Barren Land | -0.0148 | -0.73 | 2400 | 0.4668 |
| COGR | Barren Land | -0.0038 | -0.23 | 2301 | 0.8197 |
| GRSP | Barren Land | -0.0544 | -1.61 | 1869 | 0.1068 |
| AMCR | Barren Land | -0.0242 | -0.86 | 1781 | 0.3913 |
| MAWR | Barren Land | -0.0741 | -1.94 | 1699 | 0.0524 |
| PBGR | Barren Land | -0.0776 | -1.98 | 1635 | 0.0475 |

**APPENDIX D.** Continued.

| Species† | Cover Types | B‡ | B/SE§ | -2LL¹ | P |
|---|---|---|---|---|---|
| YWAR | Barren Land | -0.0146 | -0.55 | 1595 | 0.5801 |
| BLTE | Barren Land | -0.0441 | -1.14 | 1412 | 0.2557 |
| NOPI | Barren Land | -0.0090 | -0.26 | 1224 | 0.7956 |
| RPHE | Barren Land | -0.0476 | -1.06 | 1216 | 0.2921 |
| COSN | Barren Land | -0.0349 | -0.82 | 1066 | 0.4136 |
| BRTH | Barren Land | -0.0183 | -0.45 | 878 | 0.6530 |
| HOSP | Barren Land | -0.0335 | -0.68 | 851 | 0.4941 |
| REDH | Barren Land | -0.1000 | -1.52 | 795 | 0.1275 |
| AMBI | Barren Land | -0.0944 | -1.40 | 767 | 0.1610 |
| BARS | Barren Land | -0.0245 | -0.51 | 752 | 0.6128 |
| LCSP | Barren Land | -0.0125 | -0.34 | 731 | 0.7370 |
| CCLO | Barren Land | -0.1973 | -2.19 | 616 | 0.0288 |
| STSP | Barren Land | -0.0486 | -0.64 | 394 | 0.5217 |
| FEHA | Barren Land | -0.1821 | -1.12 | 210 | 0.2609 |
| BAIS | Barren Land | -0.0309 | -0.28 | 206 | 0.7828 |

*$P \leq 0.00005$

†Species abbreviations defined in Appendix E.

‡B = regression coefficient from logistic regression of species against cover type.

§B/SE = regression coefficient / standard error.

¹-2LL = -2(log likelihood) (Norusis 1995).

**APPENDIX D.** Continued.

Table 2. Species relationships to cover types at 400 m.

| Species[†] | Cover Types | B[‡] | B/SE[§] | -2LL[ǀ] | P |
|---|---|---|---|---|---|
| HOLA | Cropland | 0.0320 | 22.86 | 6432 | * |
| VESP | Cropland | 0.0148 | 10.57 | 4528 | * |
| KILL | Cropland | 0.0063 | 3.94 | 3077 | 0.0001 |
| NOPI | Cropland | 0.0060 | 2.14 | 1219 | 0.0303 |
| RWBL | Cropland | -0.0024 | -3.00 | 7997 | 0.0021 |
| WEME | Cropland | -0.0175 | -19.44 | 5672 | * |
| BHCO | Cropland | -0.0071 | -7.10 | 4860 | * |
| SAVS | Cropland | -0.0099 | -9.90 | 4839 | * |
| MODO | Cropland | -0.0077 | -7.70 | 4727 | * |
| BOBO | Cropland | -0.0063 | -5.25 | 3599 | * |
| YHBL | Cropland | -0.0085 | -7.08 | 3553 | * |
| COYE | Cropland | -0.0129 | -9.92 | 3344 | * |
| CCSP | Cropland | -0.0258 | -19.85 | 3176 | * |
| AMCO | Cropland | -0.0107 | -8.23 | 3103 | * |
| SOSP | Cropland | -0.0050 | -3.57 | 2904 | 0.0005 |
| BWTE | Cropland | -0.0070 | -4.67 | 2745 | * |
| EAKI | Cropland | -0.0129 | -8.60 | 2650 | * |
| MALL | Cropland | -0.0005 | -0.31 | 2608 | 0.7807 |
| HOWR | Cropland | -0.0111 | -7.40 | 2555 | * |
| SORA | Cropland | -0.0055 | -3.44 | 2390 | 0.0008 |
| COGR | Cropland | -0.0074 | -4.35 | 2281 | * |
| GADW | Cropland | -0.0087 | -4.83 | 1929 | * |
| WEKI | Cropland | -0.0140 | -7.37 | 1810 | * |
| AMCR | Cropland | -0.0023 | -1.15 | 1781 | 0.2529 |
| AMRO | Cropland | -0.0074 | -3.70 | 1726 | 0.0002 |
| SEWR | Cropland | -0.0252 | -12.60 | 1722 | * |
| MAWR | Cropland | -0.0106 | -5.30 | 1676 | * |
| GRSP | Cropland | -0.0327 | -14.22 | 1603 | * |
| PBGR | Cropland | -0.0130 | -6.50 | 1598 | * |
| NSHO | Cropland | -0.0041 | -1.95 | 1551 | 0.0489 |
| YWAR | Cropland | -0.0177 | -8.43 | 1522 | * |
| BLTE | Cropland | -0.0086 | -3.91 | 1399 | 0.0001 |
| LEFL | Cropland | -0.0173 | -7.21 | 1216 | * |

APPENDIX D. Continued.

| Species[†] | Cover Types | B[‡] | B/SE[§] | -2LL[ǁ] | P |
|---|---|---|---|---|---|
| RPHE | Cropland | -0.0070 | -2.92 | 1208 | 0.0030 |
| COSN | Cropland | -0.0142 | -5.46 | 1036 | * |
| UPSA | Cropland | -0.0006 | -0.20 | 991 | 0.8308 |
| WAVI | Cropland | -0.0151 | -5.59 | 961 | * |
| BRTH | Cropland | -0.0086 | -2.87 | 870 | 0.0036 |
| AMGO | Cropland | -0.0118 | -3.93 | 845 | 0.0001 |
| HOSP | Cropland | -0.0133 | -4.43 | 832 | * |
| REDH | Cropland | -0.0119 | -3.84 | 784 | 0.0001 |
| BARS | Cropland | -0.0156 | -4.73 | 729 | * |
| AMBI | Cropland | -0.0218 | -6.61 | 724 | * |
| LCSP | Cropland | -0.0099 | -3.09 | 721 | 0.0019 |
| CCLO | Cropland | -0.0464 | -7.37 | 510 | * |
| MAGO | Cropland | -0.0023 | -0.55 | 506 | 0.5829 |
| STSP | Cropland | -0.0077 | -1.67 | 392 | 0.0947 |
| FEHA | Cropland | -0.0001 | -0.01 | 212 | 0.9936 |
| NOHA | Cropland | -0.0263 | -3.42 | 192 | 0.0006 |
| BAIS | Cropland | -0.0305 | -3.43 | 189 | 0.0006 |
| WEME | Grassland | 0.0218 | 21.80 | 5551 | * |
| BHCO | Grassland | 0.0068 | 5.67 | 4874 | * |
| SAVS | Grassland | 0.0137 | 12.45 | 4781 | * |
| MODO | Grassland | 0.0016 | 1.23 | 4779 | 0.2120 |
| BOBO | Grassland | 0.0105 | 8.08 | 3566 | * |
| COYE | Grassland | 0.0083 | 5.93 | 3413 | * |
| CCSP | Grassland | 0.0238 | 18.31 | 3252 | * |
| AMCO | Grassland | 0.0005 | 0.29 | 3165 | 0.7682 |
| BWTE | Grassland | 0.0041 | 2.41 | 2762 | 0.0175 |
| EAKI | Grassland | 0.0079 | 4.94 | 2704 | * |
| COGR | Grassland | 0.0007 | 0.33 | 2301 | 0.1181 |
| GADW | Grassland | 0.0063 | 3.15 | 1943 | 0.0017 |
| WEKI | Grassland | 0.0091 | 4.55 | 1847 | * |
| SEWR | Grassland | 0.0220 | 12.22 | 1765 | * |
| PBGR | Grassland | 0.0069 | 3.14 | 1631 | 0.0021 |
| YWAR | Grassland | 0.0030 | 1.20 | 1594 | 0.2265 |
| NSHO | Grassland | 0.0011 | 0.46 | 1555 | 0.6617 |

APPENDIX D. Continued.

| Species[†] | Cover Types | B[‡] | B/SE[§] | -2LL[I] | P |
|---|---|---|---|---|---|
| GRSP | Grassland | 0.0350 | 17.50 | 1535 | * |
| LEFL | Grassland | 0.0026 | 0.90 | 1269 | 0.3681 |
| RPHE | Grassland | 0.0093 | 3.72 | 1204 | 0.0002 |
| COSN | Grassland | 0.0088 | 3.26 | 1057 | 0.0011 |
| UPSA | Grassland | 0.0030 | 0.91 | 990 | 0.3697 |
| BRTH | Grassland | 0.0031 | 0.89 | 877 | 0.3760 |
| AMGO | Grassland | 0.0059 | 1.74 | 857 | 0.0797 |
| HOSP | Grassland | 0.0039 | 1.11 | 850 | 0.2659 |
| REDH | Grassland | 0.0043 | 1.23 | 797 | 0.2169 |
| BARS | Grassland | 0.0101 | 2.97 | 744 | 0.0033 |
| AMBI | Grassland | 0.0177 | 5.53 | 742 | * |
| LCSP | Grassland | 0.0100 | 2.94 | 723 | 0.0032 |
| MAGO | Grassland | 0.0005 | -0.01 | 506 | 0.9941 |
| CCLO | Grassland | 0.0479 | 9.21 | 476 | * |
| STSP | Grassland | 0.0067 | 1.31 | 393 | 0.1883 |
| FEHA | Grassland | 0.0065 | 0.93 | 211 | 0.3550 |
| NOHA | Grassland | 0.0261 | 3.84 | 192 | 0.0001 |
| BAIS | Grassland | 0.0439 | 4.48 | 172 | * |
| RWBL | Grassland | -0.0011 | -1.22 | 8004 | 0.2176 |
| HOLA | Grassland | -0.0294 | -15.47 | 6815 | * |
| VESP | Grassland | -0.0129 | -7.17 | 4593 | * |
| YHBL | Grassland | -0.0051 | -3.00 | 3589 | 0.0032 |
| KILL | Grassland | -0.0139 | -5.79 | 3052 | * |
| SOSP | Grassland | -0.0038 | -2.00 | 2912 | 0.0516 |
| HOWR | Grassland | -0.0011 | -0.55 | 2608 | 0.5804 |
| MALL | Grassland | -0.0014 | -0.70 | 2608 | 0.4942 |
| SORA | Grassland | -0.0028 | -1.27 | 2399 | 0.2015 |
| AMCR | Grassland | -0.0010 | -0.40 | 1782 | 0.6920 |
| AMRO | Grassland | -0.0086 | -2.77 | 1731 | 0.0052 |
| MAWR | Grassland | -0.0048 | -1.71 | 1701 | 0.0878 |
| BLTE | Grassland | -0.0068 | -2.13 | 1409 | 0.0373 |
| NOPI | Grassland | -0.0086 | -2.39 | 1218 | 0.0174 |
| WAVI | Grassland | -0.0005 | -0.14 | 991 | 0.8881 |
| RWBL | Wetland | 0.0243 | 1.00 | 7859 | * |

APPENDIX D. Continued.

| Species[†] | Cover Types | B[‡] | B/SE[§] | -2LL[‖] | P |
|---|---|---|---|---|---|
| WEME | Wetland | 0.0027 | 1.08 | 6051 | 0.2842 |
| SAVS | Wetland | 0.0063 | 2.33 | 4926 | 0.0188 |
| BHCO | Wetland | 0.0039 | 1.39 | 4905 | 0.1586 |
| BOBO | Wetland | 0.0068 | 2.13 | 3619 | 0.0363 |
| COYE | Wetland | 0.0161 | 5.55 | 3419 | * |
| YHBL | Wetland | 0.0527 | 20.27 | 3181 | * |
| KILL | Wetland | 0.0169 | 5.45 | 3069 | * |
| SOSP | Wetland | 0.0064 | 1.73 | 2913 | 0.0844 |
| AMCO | Wetland | 0.0480 | 18.46 | 2848 | * |
| EAKI | Wetland | 0.0100 | 2.70 | 2720 | 0.0065 |
| BWTE | Wetland | 0.0257 | 8.86 | 2705 | * |
| MALL | Wetland | 0.0194 | 5.88 | 2579 | * |
| SORA | Wetland | 0.0299 | 9.97 | 2322 | * |
| GADW | Wetland | 0.0243 | 6.94 | 1914 | * |
| SEWR | Wetland | 0.0206 | 5.42 | 1876 | * |
| YWAR | Wetland | 0.0124 | 2.58 | 1590 | 0.0104 |
| PBGR | Wetland | 0.0364 | 11.03 | 1549 | * |
| NSHO | Wetland | 0.0197 | 4.58 | 1538 | * |
| MAWR | Wetland | 0.0485 | 15.65 | 1511 | * |
| BLTE | Wetland | 0.0435 | 13.18 | 1284 | * |
| NOPI | Wetland | 0.0085 | 1.47 | 1223 | 0.1413 |
| COSN | Wetland | 0.0302 | 6.57 | 1035 | * |
| UPSA | Wetland | 0.0056 | 0.77 | 990 | 0.4453 |
| REDH | Wetland | 0.0378 | 8.22 | 750 | * |
| AMBI | Wetland | 0.0291 | 5.39 | 749 | * |
| LCSP | Wetland | 0.0039 | 0.48 | 731 | 0.6361 |
| MAGO | Wetland | 0.0209 | 2.75 | 500 | 0.0057 |
| STSP | Wetland | 0.0246 | 2.89 | 388 | 0.0038 |
| NOHA | Wetland | 0.0156 | 1.02 | 205 | 0.3058 |
| HOLA | Wetland | -0.0357 | -10.50 | 7104 | * |
| MODO | Wetland | -0.0041 | -1.28 | 4779 | 0.1951 |
| VESP | Wetland | -0.0448 | -8.30 | 4560 | * |
| CCSP | Wetland | -0.0155 | -3.37 | 3580 | 0.0007 |
| HOWR | Wetland | -0.0172 | -2.97 | 2598 | 0.0031 |

APPENDIX D. Continued.

| Species† | Cover Types | B‡ | B/SE§ | -2LL¹ | P |
|---|---|---|---|---|---|
| COGR | Wetland | -0.0014 | -0.29 | 2301 | 0.7775 |
| GRSP | Wetland | -0.0123 | -1.84 | 1868 | 0.0664 |
| WEKI | Wetland | -0.0041 | -0.69 | 1865 | 0.4785 |
| AMCR | Wetland | -0.0242 | -2.95 | 1771 | 0.0032 |
| AMRO | Wetland | -0.0029 | -0.48 | 1739 | 0.6334 |
| LEFL | Wetland | -0.0064 | -0.82 | 1269 | 0.4102 |
| RPHE | Wetland | -0.0141 | -1.68 | 1214 | 0.0940 |
| WAVI | Wetland | -0.0304 | -2.38 | 983 | 0.0176 |
| BRTH | Wetland | -0.0037 | -0.40 | 878 | 0.6954 |
| AMGO | Wetland | -0.0208 | -1.69 | 857 | 0.0917 |
| HOSP | Wetland | -0.0329 | -2.27 | 844 | 0.0231 |
| BARS | Wetland | -0.0044 | -0.42 | 752 | 0.6691 |
| CCLO | Wetland | -0.0274 | -1.70 | 619 | 0.0887 |
| FEHA | Wetland | -0.0871 | -1.72 | 206 | 0.0848 |
| BAIS | Wetland | -0.1200 | -2.09 | 197 | 0.0366 |
| RWBL | Patch | 0.0260 | 8.67 | 7934 | * |
| WEME | Patch | 0.0132 | 3.77 | 6039 | 0.0002 |
| SAVS | Patch | 0.0072 | 1.00 | 4928 | 0.0877 |
| BHCO | Patch | 0.0143 | 3.58 | 4895 | 0.0003 |
| MODO | Patch | 0.0057 | 1.33 | 4779 | 0.1871 |
| CCSP | Patch | 0.0142 | 2.96 | 3585 | 0.0028 |
| YHBL | Patch | 0.0287 | 6.83 | 3558 | * |
| COYE | Patch | 0.0267 | 6.21 | 3413 | * |
| AMCO | Patch | 0.0254 | 5.52 | 3140 | * |
| KILL | Patch | 0.0018 | 0.30 | 3094 | 0.7627 |
| SOSP | Patch | 0.0113 | 2.02 | 2912 | 0.0426 |
| BWTE | Patch | 0.0210 | 4.04 | 2753 | * |
| EAKI | Patch | 0.0228 | 4.47 | 2709 | * |
| MALL | Patch | 0.0084 | 1.35 | 2606 | 0.1735 |
| SORA | Patch | 0.0279 | 5.37 | 2377 | * |
| COGR | Patch | 0.0088 | 1.33 | 2299 | 0.1815 |
| GADW | Patch | 0.0164 | 2.45 | 1947 | 0.0135 |
| SEWR | Patch | 0.0281 | 4.84 | 1881 | * |
| GRSP | Patch | 0.0072 | 0.94 | 1871 | 0.3505 |

APPENDIX D. Continued.

| Species[†] | Cover Types | B[‡] | B/SE[§] | -2LL[I] | P |
|---|---|---|---|---|---|
| WEKI | Patch | 0.0195 | 2.95 | 1858 | 0.0032 |
| AMRO | Patch | 0.0099 | 1.27 | 1738 | 0.2017 |
| MAWR | Patch | 0.0259 | 3.98 | 1691 | 0.0001 |
| PBGR | Patch | 0.0166 | 2.31 | 1635 | 0.0200 |
| YWAR | Patch | 0.0198 | 2.75 | 1589 | 0.0061 |
| NSHO | Patch | 0.0217 | 3.06 | 1547 | 0.0023 |
| BLTE | Patch | 0.0304 | 4.41 | 1398 | * |
| LEFL | Patch | 0.0073 | 0.75 | 1269 | 0.4515 |
| RPHE | Patch | 0.0088 | 0.93 | 1216 | 0.3536 |
| COSN | Patch | 0.0052 | 0.49 | 1067 | 0.6295 |
| WAVI | Patch | 0.0078 | 0.70 | 990 | 0.4887 |
| BRTH | Patch | 0.0089 | 0.75 | 878 | 0.4542 |
| AMGO | Patch | 0.0032 | 0.25 | 860 | 0.8041 |
| HOSP | Patch | 0.0151 | 1.35 | 850 | 0.1770 |
| REDH | Patch | 0.0100 | 0.83 | 797 | 0.4021 |
| AMBI | Patch | 0.0092 | 0.73 | 769 | 0.4640 |
| BARS | Patch | 0.0120 | 0.95 | 751 | 0.3381 |
| LCSP | Patch | 0.0314 | 3.45 | 722 | 0.0006 |
| CCLO | Patch | 0.0014 | 0.09 | 622 | 0.9289 |
| STSP | Patch | 0.0096 | 0.55 | 394 | 0.5844 |
| HOLA | Patch | -0.0277 | -6.44 | 7200 | * |
| VESP | Patch | -0.0254 | -4.31 | 4638 | * |
| BOBO | Patch | -0.0020 | -0.36 | 3623 | 0.7237 |
| HOWR | Patch | -0.0069 | -0.95 | 2607 | 0.3482 |
| AMCR | Patch | -0.0294 | -2.51 | 1774 | 0.0122 |
| NOPI | Patch | -0.0003 | -0.03 | 1224 | 0.9750 |
| UPSA | Patch | -0.0185 | -1.22 | 989 | 0.2257 |
| MAGO | Patch | -0.0028 | -0.15 | 506 | 0.8793 |
| FEHA | Patch | -0.0740 | -1.29 | 209 | 0.1982 |
| NOHA | Patch | -0.0001 | 0.00 | 206 | 0.9961 |
| BAIS | Patch | -0.1580 | -2.12 | 198 | 0.0338 |
| MODO | Wood | 0.0208 | 7.17 | 4735 | * |
| VESP | Wood | 0.0029 | 0.76 | 4659 | 0.4489 |
| CCSP | Wood | 0.0323 | 11.14 | 3490 | * |

APPENDIX D. Continued.

| Species[†] | Cover Types | B[‡] | B/SE[§] | -2LL[l] | P |
|---|---|---|---|---|---|
| COYE | Wood | 0.0171 | 5.03 | 3425 | * |
| SOSP | Wood | 0.0231 | 7.00 | 2879 | * |
| EAKI | Wood | 0.0065 | 1.33 | 2725 | 0.1804 |
| HOWR | Wood | 0.0402 | 12.97 | 2468 | * |
| SEWR | Wood | 0.0044 | 0.71 | 1899 | 0.4781 |
| WEKI | Wood | 0.0065 | 1.07 | 1864 | 0.2915 |
| AMCR | Wood | 0.0304 | 8.22 | 1735 | * |
| AMRO | Wood | 0.0222 | 5.16 | 1721 | * |
| YWAR | Wood | 0.0427 | 12.56 | 1483 | * |
| RPHE | Wood | 0.0009 | 0.07 | 1217 | 0.9409 |
| LEFL | Wood | 0.0462 | 12.83 | 1153 | * |
| COSN | Wood | 0.0024 | 0.26 | 1067 | 0.7935 |
| WAVI | Wood | 0.0427 | 10.68 | 917 | * |
| BRTH | Wood | 0.0231 | 3.79 | 868 | 0.0002 |
| AMGO | Wood | 0.0284 | 5.26 | 843 | * |
| FEHA | Wood | 0.0144 | 0.51 | 211 | 0.6079 |
| RWBL | Wood | -0.0392 | -7.26 | 7919 | * |
| HOLA | Wood | -0.2204 | -10.11 | 6926 | * |
| WEME | Wood | -0.0360 | -5.37 | 6005 | * |
| BHCO | Wood | -0.0020 | -0.49 | 4907 | 0.6143 |
| SAVS | Wood | -0.0745 | -5.69 | 4858 | * |
| BOBO | Wood | -0.0591 | -4.25 | 3586 | * |
| YHBL | Wood | -0.0700 | -4.43 | 3555 | * |
| AMCO | Wood | -0.0836 | -4.24 | 3123 | * |
| KILL | Wood | -0.0409 | -3.38 | 3074 | 0.0008 |
| BWTE | Wood | -0.1128 | -4.12 | 2723 | * |
| MALL | Wood | -0.1078 | -3.92 | 2569 | 0.0001 |
| SORA | Wood | -0.0287 | -2.45 | 2392 | 0.0142 |
| COGR | Wood | -0.0022 | -0.33 | 2301 | 0.7481 |
| GADW | Wood | -0.1821 | -3.59 | 1912 | 0.0003 |
| GRSP | Wood | -0.0136 | -1.35 | 1870 | 0.1777 |
| MAWR | Wood | -0.0250 | -1.82 | 1699 | 0.0673 |
| PBGR | Wood | -0.0352 | -2.15 | 1632 | 0.0317 |
| NSHO | Wood | -0.2395 | -3.03 | 1527 | 0.0025 |

APPENDIX D. Continued.

| Species[†] | Cover Types | B[‡] | B/SE[§] | -2LL[‖] | P |
|---|---|---|---|---|---|
| BLTE | Wood | -0.0979 | -2.60 | 1396 | 0.0094 |
| NOPI | Wood | -0.1011 | -2.19 | 1214 | 0.0287 |
| UPSA | Wood | -0.0631 | -1.84 | 984 | 0.0662 |
| HOSP | Wood | -0.0011 | -0.09 | 851 | 0.9275 |
| REDH | Wood | -0.2347 | -2.07 | 785 | 0.0387 |
| AMBI | Wood | -0.0208 | -0.83 | 769 | 0.4049 |
| BARS | Wood | -0.0156 | -0.83 | 751 | 0.4022 |
| LCSP | Wood | -0.0011 | -0.10 | 731 | 0.9244 |
| CCLO | Wood | -1.1465 | -1.78 | 601 | 0.0752 |
| MAGO | Wood | -0.4241 | -1.59 | 496 | 0.1112 |
| STSP | Wood | -0.0848 | -1.13 | 391 | 0.2594 |
| NOHA | Wood | -188.111 | -0.15 | 199 | 0.8822 |
| BAIS | Wood | -248.212 | -0.14 | 198 | 0.8847 |
| BHCO | Other | 0.0141 | 3.20 | 4898 | 0.0015 |
| MODO | Other | 0.0677 | 17.36 | 4478 | * |
| CCSP | Other | 0.0154 | 2.96 | 3586 | 0.0031 |
| COYE | Other | 0.0130 | 2.36 | 3440 | 0.0181 |
| KILL | Other | 0.0001 | 0.01 | 3094 | 0.9904 |
| SOSP | Other | 0.0406 | 9.02 | 2852 | * |
| EAKI | Other | 0.0462 | 10.27 | 2643 | * |
| HOWR | Other | 0.0728 | 16.93 | 2359 | * |
| COGR | Other | 0.0673 | 15.30 | 2113 | * |
| GADW | Other | 0.0023 | 0.25 | 1952 | 0.8009 |
| AMCR | Other | 0.0196 | 2.65 | 1776 | 0.0077 |
| WEKI | Other | 0.0598 | 12.46 | 1749 | * |
| YWAR | Other | 0.0450 | 8.04 | 1550 | * |
| AMRO | Other | 0.0753 | 15.69 | 1540 | * |
| LEFL | Other | 0.0502 | 8.37 | 1221 | * |
| RPHE | Other | 0.0013 | 0.11 | 1217 | 0.9129 |
| COSN | Other | 0.0122 | 1.09 | 1066 | 0.2754 |
| WAVI | Other | 0.0618 | 10.13 | 921 | * |
| BRTH | Other | 0.0395 | 4.82 | 862 | * |
| AMGO | Other | 0.0475 | 6.42 | 833 | * |
| AMBI | Other | 0.0027 | 0.17 | 770 | 0.8633 |

**APPENDIX D.** Continued.

| Species[†] | Cover Types | B[‡] | B/SE[§] | -2LL[I] | P |
|---|---|---|---|---|---|
| HOSP | Other | 0.0825 | 13.52 | 713 | * |
| BARS | Other | 0.0669 | 10.14 | 685 | * |
| FEHA | Other | 0.0084 | 0.27 | 212 | 0.7857 |
| RWBL | Other | -0.0104 | -2.54 | 7999 | 0.0113 |
| HOLA | Other | -0.0641 | -7.63 | 7146 | * |
| WEME | Other | -0.0054 | -1.13 | 6050 | 0.2616 |
| SAVS | Other | -0.0244 | -3.39 | 4917 | 0.0007 |
| VESP | Other | -0.0165 | -2.43 | 4653 | 0.0147 |
| YHBL | Other | -0.0091 | -1.25 | 3597 | 0.2138 |
| BOBO | Other | -0.0864 | -4.50 | 3578 | * |
| AMCO | Other | -0.0148 | -1.72 | 3162 | 0.0866 |
| BWTE | Other | -0.0180 | -1.82 | 2763 | 0.0701 |
| MALL | Other | -0.0244 | -2.16 | 2602 | 0.0311 |
| SORA | Other | -0.0007 | -0.08 | 2401 | 0.9299 |
| SEWR | Other | -0.0291 | -1.98 | 1895 | 0.0476 |
| GRSP | Other | -0.0185 | -1.43 | 1870 | 0.1522 |
| MAWR | Other | -0.0375 | -2.08 | 1698 | 0.0370 |
| PBGR | Other | -0.0204 | -1.44 | 1637 | 0.1504 |
| NSHO | Other | -0.0231 | -1.49 | 1552 | 0.1370 |
| BLTE | Other | -0.0124 | -0.88 | 1413 | 0.3784 |
| NOPI | Other | -0.0151 | -0.93 | 1223 | 0.3509 |
| UPSA | Other | -0.0033 | -0.22 | 991 | 0.8271 |
| REDH | Other | -0.0319 | -1.23 | 796 | 0.2181 |
| LCSP | Other | -0.1111 | -1.68 | 723 | 0.0929 |
| CCLO | Other | -0.0504 | -1.27 | 620 | 0.2062 |
| MAGO | Other | -0.0432 | -1.05 | 504 | 0.2955 |
| STSP | Other | -0.2376 | -1.00 | 390 | 0.3184 |
| NOHA | Other | -0.1753 | -0.74 | 204 | 0.4587 |
| BAIS | Other | -0.2378 | -0.72 | 203 | 0.4690 |
| RWBL | Barren Land | 0.0272 | 2.06 | 8002 | 0.0399 |
| HOLA | Barren Land | 0.0221 | 1.58 | 7247 | 0.1149 |
| WEME | Barren Land | 0.0191 | 1.22 | 6050 | 0.2222 |
| BHCO | Barren Land | 0.0192 | 1.08 | 4906 | 0.2779 |
| VESP | Barren Land | 0.0125 | 1.00 | 4660 | 0.5093 |

**APPENDIX D.** Continued.

| Species† | Cover Types | B‡ | B/SE§ | -2LL' | P |
|---|---|---|---|---|---|
| BWTE | Barren Land | 0.0010 | 0.04 | 2767 | 0.9702 |
| COGR | Barren Land | 0.0137 | 0.47 | 2301 | 0.6381 |
| AMRO | Barren Land | 0.0132 | 0.38 | 1740 | 0.7054 |
| NSHO | Barren Land | 0.0351 | 1.16 | 1554 | 0.2442 |
| LEFL | Barren Land | 0.0043 | 0.10 | 1269 | 0.9229 |
| UPSA | Barren Land | 0.0395 | 0.98 | 990 | 0.3288 |
| AMGO | Barren Land | 0.0267 | 0.55 | 860 | 0.5837 |
| LCSP | Barren Land | 0.0022 | 0.04 | 731 | 0.9708 |
| MAGO | Barren Land | 0.0648 | 1.45 | 505 | 0.1466 |
| STSP | Barren Land | 0.0192 | 0.26 | 395 | 0.7966 |
| NOHA | Barren Land | 0.0929 | 1.71 | 204 | 0.0879 |
| SAVS | Barren Land | -0.0428 | -1.86 | 4927 | 0.0622 |
| MODO | Barren Land | -0.0276 | -1.24 | 4779 | 0.2136 |
| BOBO | Barren Land | -0.0518 | -1.77 | 3620 | 0.0774 |
| CCSP | Barren Land | -0.0108 | -0.43 | 3593 | 0.6669 |
| YHBL | Barren Land | -0.0764 | -2.40 | 3591 | 0.0164 |
| COYE | Barren Land | -0.0524 | -1.72 | 3442 | 0.0852 |
| AMCO | Barren Land | -0.0672 | -2.01 | 3161 | 0.0443 |
| KILL | Barren Land | -0.0452 | -1.42 | 3092 | 0.1567 |
| SOSP | Barren Land | -0.0847 | -2.25 | 2910 | 0.0241 |
| EAKI | Barren Land | -0.0052 | -0.18 | 2726 | 0.8575 |
| HOWR | Barren Land | -0.0394 | -1.13 | 2607 | 0.2589 |
| MALL | Barren Land | -0.0563 | -1.52 | 2605 | 0.1294 |
| SORA | Barren Land | -0.0353 | -0.97 | 2400 | 0.3300 |
| GADW | Barren Land | -0.0387 | -0.94 | 1951 | 0.3481 |
| SEWR | Barren Land | -0.1873 | -2.99 | 1888 | 0.0027 |
| GRSP | Barren Land | -0.0389 | -0.90 | 1871 | 0.3673 |
| WEKI | Barren Land | -0.0143 | -0.37 | 1865 | 0.7135 |
| AMCR | Barren Land | -0.0061 | -0.16 | 1782 | 0.8744 |
| MAWR | Barren Land | -0.0644 | -1.29 | 1702 | 0.1989 |
| PBGR | Barren Land | -0.1689 | -2.59 | 1631 | 0.0095 |
| YWAR | Barren Land | -0.0873 | -1.56 | 1593 | 0.1183 |
| BLTE | Barren Land | -0.1510 | -2.15 | 1408 | 0.0311 |
| NOPI | Barren Land | -0.0067 | -0.14 | 1224 | 0.8863 |

**APPENDIX D.** Continued.

| Species[†] | Cover Types | B[‡] | B/SE[§] | -2LL[l] | P |
|---|---|---|---|---|---|
| RPHE | Barren Land | -0.0012 | -0.03 | 1217 | 0.9799 |
| COSN | Barren Land | -0.0129 | -0.25 | 1067 | 0.7995 |
| WAVI | Barren Land | -0.0077 | -0.14 | 991 | 0.8901 |
| BRTH | Barren Land | -0.0535 | -0.73 | 877 | 0.4632 |
| HOSP | Barren Land | -0.0486 | -0.66 | 851 | 0.5057 |
| REDH | Barren Land | -0.1245 | -1.36 | 796 | 0.1752 |
| AMBI | Barren Land | -0.1974 | -1.75 | 766 | 0.0795 |
| BARS | Barren Land | -0.1376 | -1.37 | 749 | 0.1716 |
| CCLO | Barren Land | -0.0175 | -0.23 | 622 | 0.8173 |
| FEHA | Barren Land | -0.3860 | -1.27 | 209 | 0.2028 |
| BAIS | Barren Land | -0.1929 | -0.86 | 205 | 0.3882 |

*$P \leq 0.00005$

[†]Species abbreviations defined in Appendix E.

[‡]B = regression coefficient from logistic regression of species against cover type.

§B/SE = regression coefficient / standard error.

[l]-2LL = -2(log likelihood) (Norusis 1995).

## APPENDIX E

Common, scientific, and abbreviated names of bird species observed and their habitat groups*.

| Common Name | Scientific Name | Abbrev. | Habitat Group |
|---|---|---|---|
| Western Grebe | *Aechmophorus occidentalis* | WEGR | Wetland |
| Horned Grebe | *Podiceps auritus* | HOGR | Wetland |
| Eared Grebe | *Podiceps nigricollis* | EAGR | Wetland |
| Pied-billed Grebe | *Podilymbus podiceps* | PBGR | Wetland |
| Ring-billed Gull | *Larus delawarensis* | RBGU | Wetland |
| Franklin's Gull | *Larus pipixcan* | FRGU | Wetland |
| Black Tern | *Chlidonias niger* | BLTE | Wetland |
| Double-crested Cormorant | *Phalacrocorax auritus* | DCCO | Wetland |
| American White Pelican | *Pelecanus erythrorhynchos* | WHPE | Wetland |
| Mallard | *Anas platyrhynchos* | MALL | Wetland |
| Gadwall | *Anas strepera* | GADW | Wetland |
| American Wigeon | *Anas americana* | AMWI | Wetland |
| Green-winged Teal | *Anas creccia* | AGWT | Wetland |
| Blue-winged Teal | *Anas discors* | BWTE | Wetland |
| Northern Shoveler | *Anas clypeata* | NSHO | Wetland |
| Northern Pintail | *Anas acuta* | NOPI | Wetland |
| Wood Duck | *Aix sponsa* | WODU | Wetland |
| Redhead | *Aythya americana* | REDH | Wetland |
| Canvasback | *Aythya valisineria* | CANV | Wetland |
| Lesser Scaup | *Aythya affinis* | LESC | Wetland |
| Ring-necked Duck | *Aythya collaris* | RNDU | Wetland |
| Ruddy Duck | *Oxyura jamaicensis* | RUDU | Wetland |
| Lesser Snow Goose | *Chen caerulescens* | LSGO | Tundra |
| Canada Goose | *Branta canadensis* | CAGO | Wetland |
| American Bittern | *Botaurus lentiginosus* | AMBI | Wetland |
| Great Blue Heron | *Ardea herodias* | GBHE | Wetland |
| Great Egret | *Casmerodius albus* | GREG | Wetland |
| Black-crowned Night-heron | *Nycticorax nycticorax* | BCNH | Wetland |
| Sandhill Crane | *Grus canadensis* | SACR | Wetland |
| Virginia Rail | *Rallus limicola* | VIRA | Wetland |

**APPENDIX E.** Continued.

| Common Name | Scientific Name | Abbrev. | Habitat Group |
|---|---|---|---|
| Sora | *Porzana carolina* | SORA | Wetland |
| Yellow Rail | *Coturnicops noveboracensis* | YERA | Wetland |
| American Coot | *Fulica americana* | AMCO | Wetland |
| Wilson's Phalarope | *Phalaropus tricolor* | WIPH | Wetland |
| American Avocet | *Recurvirostra americana* | AMAV | Wetland |
| Common Snipe | *Gallinago gallinago* | COSN | Wetland |
| White-rumped Sandpiper | *Calidris fuscicollis* | WRSA | Tundra |
| Marbled Godwit | *Limosa fedoa* | MAGO | Wetland |
| Greater Yellowlegs | *Tringa melanoleuca* | GRYE | Tundra |
| Lesser Yellowlegs | *Tringa flavipes* | LEYE | Tundra |
| Willet | *Catoptrophorus semipalmatus* | WILL | Wetland |
| Upland Sandpiper | *Bartramia longicauda* | UPSA | Grassland |
| Killdeer | *Charadrius vociferus* | KILL | Bare Ground |
| Mourning Dove | *Zenaida macroura* | MODO | Edge |
| Rock Dove | *Columba livia* | RODO | Generalist |
| Sharp-tailed Grouse | *Tympanuchus phasianellus* | STGR | Grassland |
| Ring-necked Pheasant | *Phasianus colchicus* | RPHE | Grassland |
| Northern Harrier | *Circus cyaneus* | NOHA | Grassland |
| Sharp-shinned Hawk | *Accipiter striatus* | SSHA | Woodland |
| Red-tailed Hawk | *Buteo jamaicensis* | RTHA | Savanna |
| Swainson's Hawk | *Buteo swainsoni* | SWHA | Savanna |
| Ferruginous Hawk | *Buteo regalis* | FEHA | Grassland |
| Great Horned Owl | *Bubo virginianus* | GHOW | Woodland |
| Black-billed Cuckoo | *Coccyzus erythropthalmus* | BBCU | Woodland |
| Hairy Woodpecker | *Picoides villosus* | HAWO | Woodland |
| Downy Woodpecker | *Picoides pubescens* | DOWO | Woodland |
| Yellow-bellied Sapsucker | *Sphyrapicus varius* | YBSA | Woodland |
| Pileated Woodpecker | *Dryocopus pileatus* | PIWO | Woodland |
| Red-headed Woodpecker | *Melanerpes erythrocephalus* | RHWO | Woodland |
| Northern Flicker | *Colaptes auratus* | NOFL | Generalist |
| Common Nighthawk | *Chordeiles minor* | CONI | Savanna |

**APPENDIX E.** Continued.

| Common Name | Scientific Name | Abbrev. | Habitat Group |
|---|---|---|---|
| Ruby-throated Hummingbird | *Archilochus colubris* | RTHU | Woodland |
| Eastern Kingbird | *Tyrannus tyrannus* | EAKI | Edge |
| Western Kingbird | *Tyrannus verticalis* | WEKI | Savanna |
| Eastern Phoebe | *Sayornis phoebe* | EAPH | Edge |
| Eastern Wood-pewee | *Contopus sordidulus* | EAWP | Edge |
| Willow Flycatcher | *Empidonax traillii* | WIFL | Wetland |
| Least Flycatcher | *Empidonax minimus* | LEFL | Woodland |
| Horned Lark | *Eremophila alpestris* | HOLA | Bare Ground |
| Black-billed Magpie | *Pica pica* | BBMA | Generalist |
| Blue Jay | *Cyanocitta cristata* | BLJA | Woodland |
| American Crow | *Corvus brachyrhynchos* | AMCR | Edge |
| European Starling | *Sturnus vulgaris* | EUST | Generalist |
| Bobolink | *Dolichonyx oryzivorus* | BOBO | Grassland |
| Brown-headed Cowbird | *Molothrus ater* | BHCO | Edge |
| Yellow-headed Blackbird | *Xanthocephalus xanthocephalus* | YHBL | Wetland |
| Red-winged Blackbird | *Agelaius phoeniceus* | RWBL | Wetland |
| Western Meadowlark | *Sturnella neglecta* | WEME | Grassland |
| Orchard Oriole | *Icterus spurius* | OROR | Edge |
| Northern Oriole | *Icterus galbula* | BAOR | Edge |
| Brewer's Blackbird | *Euphagus cyanocephalus* | BRBL | Generalist |
| Common Grackle | *Quiscalus quiscula* | COGR | Edge |
| House Finch | *Carpodacus mexicanus* | HOFI | Generalist |
| American Goldfinch | *Cardeulis tristis* | AMGO | Edge |
| Pine Siskin | *Cardeulis pinus* | PISI | Woodland |
| Chestnut-collared Longspur | *Calcarius ornatus* | CCLO | Grassland |
| Vesper Sparrow | *Pooecetes gramineus* | VESP | Grassland |
| Savannah Sparrow | *Passerculus sandwichensis* | SAVS | Grassland |
| Baird's Sparrow | *Ammodramus bairdii* | BAIS | Grassland |
| Grasshopper Sparrow | *Ammodramus savannarum* | GRSP | Grassland |
| LeConte's Sparrow | *Ammodramus leconteii* | LCSP | Grassland |
| Sharp-tailed Sparrow | *Ammodramus caudacutus* | STSP | Wetland |

**APPENDIX E.** Continued.

| Common Name | Scientific Name | Abbrev. | Habitat Group |
|---|---|---|---|
| Lark Sparrow | *Chondestes grammacus* | LASP | Savanna |
| Chipping Sparrow | *Spizella passerina* | CHSP | Edge |
| Clay-colored Sparrow | *Spizella pallida* | CCSP | Edge |
| Field Sparrow | *Spizella pusilla* | FISP | Edge |
| Song Sparrow | *Melospiza melodia* | SOSP | Edge |
| Rose-breasted Grosbeak | *Pheucticus ludovicianus* | RBGR | Woodland |
| Indigo Bunting | *Passerina cyanea* | INBU | Edge |
| Dickcissel | *Spiza americana* | DICK | Grassland |
| Lark Bunting | *Calamospiza melanocorys* | LARB | Grassland |
| Purple Martin | *Progne subis* | PUMA | Savanna |
| Cliff Swallow | *Hirundo pyrrhonota* | CLSW | Savanna |
| Barn Swallow | *Hirundo rustica* | BARS | Savanna |
| Tree Swallow | *Tachycineta bicolor* | TRES | Edge |
| Bank Swallow | *Riparia riparia* | BANS | Savanna |
| NorthernRough-winged Swallow | *Stelgidopteryx serripennis* | NRWS | Savanna |
| Cedar Waxwing | *Bombycillla cedrorum* | CEDW | Edge |
| Loggerhead Shrike | *Lanius ludovicianus* | LOSH | Savanna |
| Red-eyed Vireo | *Vireo olivaceus* | REVI | Woodland |
| Warbling Vireo | *Vireo gilvus* | WAVI | Woodland |
| Yellow-throated Vireo | *Vireo flavifrons* | YTVI | Woodland |
| Solitary Vireo | *Vireo solitarius* | SOVI | Woodland |
| Black-and-white Warbler | *Mniotilta varia* | BAWW | Woodland |
| Tennessee Warbler | *Vermivora peregrina* | TEWA | Woodland |
| Yellow Warbler | *Dendroica petechia* | YWAR | Edge |
| Ovenbird | *Seiurus aurocapillus* | OVEN | Woodland |
| Common Yellowthroat | *Geothlypis trichas* | COYE | Edge |
| American Redstart | *Setophaga ruticilla* | AMRE | Woodland |
| House Sparrow | *Passer domesticus* | HOSP | Generalist |
| Sprague's Pipit | *Anthus spragueii* | SPPI | Grassland |
| Gray Catbird | *Dumetella carolinensis* | GRCA | Edge |
| Brown Thrasher | *Toxostoma rufum* | BRTH | Edge |

**APPENDIX E.** Continued.

| Common Name | Scientific Name | Abbrev. | Habitat Group |
| --- | --- | --- | --- |
| House Wren | *Troglodytes aedon* | HOWR | Edge |
| Sedge Wren | *Cistothorus platensis* | SEWR | Grassland |
| Marsh Wren | *Cistothorus palustris* | MAWR | Wetland |
| Black-capped Chickadee | *Parus atricapillus* | BCCH | Woodland |
| Veery | *Catharus fuscescens* | VEER | Woodland |
| American Robin | *Turdus migratorius* | AMRO | Generalist |
| Eastern Bluebird | *Sialia sialis* | EABL | Edge |

*(Stewart 1975, Ehrlich et al. 1988, Peterjohn and Sauer 1993).

## APPENDIX F

Percentages* of species correlated† (P≤ 0.05) with cover types at 200-m and 400-m scales for each habitat group.

| Group and Correlation | Cover Type: Cropland | | Grassland | | Wetland | | Patch | | Wood | | Other | | Barren Land | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| All Groups Combined | | | | | | | | | | | | | | |
| 200 m (+) | | 6 | | 40 | | 42 | | 56 | | 28 | | 34 | | 8 |
| 200 m (-) | | 80 | | 16 | | 16 | | 8 | | 32 | | 22 | | 6 |
| 400 m (+) | | 8 | | 42 | | 46 | | 40 | | 24 | | 36 | | 2 |
| 400 m (-) | | 80 | | 14 | | 16 | | 8 | | 34 | | 16 | | 12 |
| Habitat Group | | | | | | | | | | | | | | |
| Grassland | | | | | | | | | | | | | | |
| 200 m (+) | 2 | (9) | 16 | (73) | 2 | (9) | 6 | (27) | 0 | (0) | 0 | (0) | 2 | (9) |
| 200 m (-) | 16 | (73) | 2 | (9) | 4 | (18) | 4 | (18) | 6 | (27) | 12 | (55) | 2 | (9) |
| 400 m (+) | 2 | (9) | 16 | (73) | 6 | (27) | 4 | (18) | 0 | (0) | 0 | (0) | 0 | (0) |
| 400 m (-) | 16 | (73) | 2 | (9) | 4 | (18) | 4 | (18) | 6 | (27) | 8 | (36) | 2 | (9) |

**APPENDIX F.** Continued.

| Group and Correlation | Cover Type | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cropland | Grassland | Wetland | Patch | Wood | Other | Barren Land |
| Habitat Group | | | | | | | |
| Wetland | | | | | | | |
| 200 m (+) | 0 (0) | 10 (28) | 32 (89) | 22 (61) | 0 (0) | 0 (0) | 2 (6) |
| 200 m (-) | 28 (78) | 4 (11) | 0 (0) | 0 (0) | 20 (56) | 8 (23) | 4 (11) |
| 400 m (+) | 2 (6) | 12 (33) | 32 (89) | 22 (61) | 0 (0) | 0 (0) | 2 (6) |
| 400 m (-) | 28 (78) | 6 (17) | 0 (0) | 0 (0) | 24 (67) | 6 (17) | 8 (23) |
| Edge | | | | | | | |
| 200 m (+) | 0 (0) | 10 (38) | 6 (46) | 18 (69) | 20 (77) | 22 (85) | 4 (15) |
| 200 m (-) | 24 (92) | 4 (15) | 6 (46) | 2 (8) | 0 (0) | 0 (0) | 0 (0) |
| 400 m (+) | 0 (0) | 10 (38) | 6 (46) | 12 (46) | 18 (69) | 24 (92) | 0 (0) |
| 400 m (-) | 24 (92) | 0 (0) | 6 (46) | 2 (8) | 0 (0) | 0 (0) | 2 (8) |
| Savanna | | | | | | | |
| 200 m (+) | 0 (0) | 4 (100) | 0 (0) | 4 (100) | 2 (50) | 4 (100) | 0 (0) |
| 200 m (-) | 4 (100) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| 400 m (+) | 0 (0) | 4 (100) | 0 (0) | 2 (50) | 0 (0) | 4 (100) | 0 (0) |
| 400 m (-) | 4 (100) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |

**APPENDIX F.** Continued.

| Group and Correlation | Cover Type | | | | | | |
|---|---|---|---|---|---|---|---|
| | Cropland | Grassland | Wetland | Patch | Wood | Other | Barren Land |
| Habitat Group | | | | | | | |
| Woodland | | | | | | | |
| 200 m (+) | 0 (0) | 0 (0) | 0 (0) | 2 (50) | 4 (100) | 4 (100) | 0 (0) |
| 200 m (-) | 4 (100) | 0 (0) | 2 (50) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| 400 m (+) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 4 (100) | 4 (100) | 0 (0) |
| 400 m (-) | 4 (100) | 0 (0) | 2 (50) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Generalist | | | | | | | |
| 200 m (+) | 0 (0) | 0 (0) | 0 (0) | 4 (100) | 2 (50) | 4 (100) | 0 (0) |
| 200 m (-) | 4 (100) | 2 (50) | 2 (50) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| 400 m (+) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 2 (50) | 4 (100) | 0 (0) |
| 400 m (-) | 4 (100) | 2 (50) | 2 (50) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |

| Group and Correlation | Cover Type | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cropland | | Grassland | | Wetland | | Patch | | Wood | | Other | | Barren Land | |
| Habitat Group | | | | | | | | | | | | | | |
| Bare Ground | | | | | | | | | | | | | | |
| 200 m (+) | 4 | (100) | 0 | (0) | 2 | (50) | 0 | (0) | 0 | (0) | 0 | (0) | 0 | (0) |
| 200 m (-) | 0 | (0) | 4 | (100) | 2 | (50) | 2 | (50) | 4 | (100) | 2 | (50) | 0 | (0) |
| 400 m (+) | 4 | (100) | 0 | (0) | 2 | (50) | 0 | (0) | 0 | (0) | 0 | (0) | 0 | (0) |
| 400 m (-) | 0 | (0) | 4 | (100) | 2 | (50) | 2 | (50) | 4 | (100) | 2 | (50) | 0 | (0) |

*First value is the percentage of the total number of species analyzed (50). Value in parentheses is the percentage of the total number of species within the habitat group.

†(+) indicates a positive correlation, (-) indicates a negative correlation.