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Habitat/Area Relationships, Abundance, and Composition of Bird Communities in 3 Grassland Types

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ABSTRACT

Habitat/area relationships, distribution, abundance, and composition of grassland bird communities were determined for 21 grassland fragments of 3 grassland types: fescue fields, mixed grass fields, and grass/forb fields. Fescue fields had 3-6 grassland bird species, mixed grass fields had 2-5, and grass/forb fields had 3-7. Henslow's sparrows and grasshopper sparrows were found only in fields >16 ha. Bobolinks, eastern meadowlarks, and red-winged blackbirds comprised 65-85% of the bird communities in all 3 habitat types. Numbers of grassland bird species were positively correlated with the size of fescue fields and the fescue-dominated grass/forb field, but negatively correlated for timothy-dominated grass/forb fields.

INTRODUCTION

For maximum biodiversity in grasslands, some of them should be large for area-sensitive species of birds. Unlike shrubland, woodland, or closed-forest ecosystems, where the native consumers are generally less mobile, grassland ecosystems support highly mobile wildlife species, because their food, water, and cover are more variably impacted by weather patterns and climatic extremes (Risser 1988). Essential patch sizes and shapes vary considerably among birds occupying grasslands (Herkert 1994, Vickery et al. 1994). Proximity of patches to each other also is important in determining presence or absence of a species. For example, greater prairie chickens (*Tympanuchus cupido*) need patches of 300 ha within 14 km of each other (Samson 1980). At least 4,000 ha of suitable habitat might be needed to support an isolated population of sharp-tailed grouse (*T. phasianellus*) in Wisconsin (Temple 1992). Of all bird species breeding on tallgrass prairies, nearly 67% are habitat-size-dependent (Samson 1980). Herkert (1994) found 5 (33%) area-sensitive bird species in Illinois grasslands.

Large areas of grassland habitat throughout the United States have become unavailable to wildlife due to intensive agricultural practices and increased urbanization. Federal Breeding Bird Survey (BBS) data and the National Audubon Society Blue List, among others, reported declines of grassland songbirds by 84-98% since 1957-1958 in northern and central Illinois (Anonymous 1983, Robbins et al. 1986, Tate 1986, Bohlen 1989, Herkert 1994).

Over 8.1 million ha of tallgrass prairie once covered 60% of Illinois. By 1970 <1% of that remained in scattered parcels throughout the state (Anderson 1970); <1000 ha of high quality prairie habitat remains (Iverson 1988). Meadows and hayfields that replaced native prairie declined substantially in area due to intensification of row crop farming, mainly corn and soybeans, since the late 1950's, and the loss of federal farm assistance programs such as the Soil Bank (Warner 1981, 1994, Herkert et al. 1996). As a result, habitat management of grassland areas controlled by public and private agencies is becoming increasingly important to preserve grassland birds in Illinois and elsewhere (e.g., Sample and Mossman 1997, Payne 1998, Payne and Bryant 1998). Grassland habitat produced by the federal Conservation Reserve Program has been beneficial, but the benefits will cease for wildlife if the CRP ceases (Patterson and Best 1996).

Opportunities to observe birds in native grasslands are scarce (Johnsgard and Rickard 1957), especially in Illinois where the associations of native tallgrass prairie used by grassland birds were not studied before the prairies were plowed (Birkenholz 1973). As a result, descriptions of habitats used by grassland birds in Illinois (e.g., Graber and Graber 1963, Bohlen 1989) and many other states have been limited mostly to pastures and hayfields, as these usually are the only remaining extensive grassland habitats. Many studies have focused on the behavior and social organization of specific species of grassland birds, but few have examined species' habitat or area requirements (e.g., Frawley and Best 1991, Herkert et al. 1993, Herkert 1994, Herkert et al. 1996, Vickery et al. 1994, Warner 1994, Patterson and Best 1996).

Objectives of this study were to determine (1) differences in vegetative structure among 3 grassland habitat types, (2) bird species diversity relative to 3 grassland habitat types, and (3) the relationship between habitat size and bird species diversity and abundance in 3 grassland habitat types.

STUDY AREA

The study was conducted in the Forest Preserve District of DuPage County, IL. Located in northeastern Illinois about 32 km west of Chicago, and within the Northeastern Morainal Division (Mapes 1979, Neely and Heister 1987), DuPage County is a heavily urbanized county of 847 km^2. Presettlement vegetation in the county was 75% tallgrass prairie and wetland and 25% small savannas and groves timbered by widely scattered oaks (*Quercus* spp.) and hickories (*Carya* spp.) (Lampa 1985).

Within the District, non-native grasslands comprise 3035 ha created by seeding former croplands to perennial grasses,viz., meadow fescue (*Festuca elatior*) and white clover (*Trifolium repens*) before 1979, and a seed mixture of timothy (*Phleum pratense*), peren-

nial rye (*Lolium perenne*), and white clover since 1979, because they are less resistant to successional change than fescue is.

Three habitat types--fescue, mixed grasses, grass/forb--were selected for this study on the basis of plant species composition and percent coverage of the dominant grass and forb species.

Fescue Fields
Fescue fields consisted mainly of 80-95% coverage of meadow fescue interspersed with various forbs. Other grasses such as Kentucky bluegrass (*Poa pratensis*), orchard grass (*Dactylis glomerata*), quackgrass (*Agropyron repens*), smooth brome (*Bromus inermis*), reed canary grass (*Phalaris arundinacea*), and timothy were present in small percentages (≤5%).

Mixed Grass Fields
Mixed grass fields contained varying mixtures of fescue, timothy, Kentucky bluegrass, reed canary grass, smooth brome, orchard grass, quackgrass, and red top (*Agrostis alba*) interspersed with various forbs. Fescue and Kentucky bluegrass were the 2 main grass species in these mixtures. Coverage of grasses was 80-95%. The remaining grass species were present in larger percentages (5-20%) in this habitat type than in the fescue habitat type.

Grass/Forb Fields
Grass/forb fields contained mixtures of fescue, timothy, Kentucky bluegrass, reed canary grass, smooth brome, orchard grass, and quackgrass. Fields dominated by timothy were characterized by a dense coverage of forbs and other vegetation relative to the fields dominated by fescue. Half (4) of these fields contained stands mainly of timothy (24.3-97.1 ha) within mixtures of other grass species. Fescue was the dominant grass in the other 4 fields. Various forbs covered 25-40% of grass/forb fields. A few trees and shrubs such as willow (*Salix* spp.), eastern cottonwood (*Populus deltoides*), and multiflora rose (*Rosa multiflora*) usually were present, mainly in wet depressions and along fencerows. These woody species comprised <10% of the area of each field.

METHODS

A field was considered 1 sampling unit if it consisted of a single habitat type, and was not visually or physically divided by a barrier (e.g., fencerow, road). We assigned 21 fields, 8.9-97.1 ha, to 1 of 3 habitat types on the basis of plant species composition and percent coverage of the dominant grass and forb species. Eight fescue (8.9-87 ha), 5 mixed grasses (8.9-40.5 ha), and 8 grass/forb fields (8.9-97.1 ha) were sampled (Appendix I). Due to the excavation of artificial lakes, a fescue and a mixed grass field, each 40.5 ha, were sampled in 1986 but not in 1987.

Structural Characteristics of Grasslands
Vegetation measurements were taken during the breeding season (19 June-30 July 1986). Vegetation was sampled within 600 1-m^2 quadrats located randomly along bird transect routes (Oosting 1958, Weins 1969, Ohmann and Ream 1971). Transect lengths varied with the length of each field (Appendix I). A random numbers table was used to locate

30 quadrats 3-60 m on alternate sides of the bird transect line. Vegetation also was measured in quadrats surrounding identified bird nests and song posts.

The plant species, sociability, abundance, height, height density, and percent cover of grasses and forbs, standing and fallen litter, and bare ground were recorded within each quadrat. Sociability was determined by using the Braun-Blanquet sociability scale (Mueller-Dombois and Ellenberg 1974). Three representative heights for each plant species were taken within each quadrat. Six Daubenmire cover classes were used to estimate visually the percent of grasses, forbs, and bare ground (Barbour et al. 1980): 1 = 0-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-95%, 6 = 96-100%. All additional plant species observed within habitat types, but not occurring within quadrats, were recorded. Height-density was recorded as a measure of visual obstruction (Robel et al. 1970).

Discriminate function analysis with stepwise inclusion of variables (Klecka 1975) was used to determine the vegetation variables that statistically separated the 3 habitat types. Significance was set at the 0.05 level for all statistical tests. The Statistical Package for the Social Sciences (SPSS) computer program was used in the analyses. Twelve variables were selected for inclusion in the analysis: number of grass species, mean grass height, coverage of live grasses, coverage of dead grasses, total coverage of grasses, mean forb height, coverage of live forbs, coverage of dead forbs, total coverage of forbs, height density, litter depth, and bare ground coverage.

Bird Species Diversity

Bird surveys were conducted 3 times each year, from 28 May-17 June 1986 and 21 May-10 June 1987 to determine the presence of ≥ 90% of the breeding birds within the 3 field types (Kendeigh 1944). The physiognomy of fescue and timothy differs substantially, so the percent species composition of the bird community was calculated separately for fescue-dominated and timothy-dominated grass/forb fields. Fields usually were surveyed on successive days between 0530 and 1200 hours. Surveys were not conducted under conditions of poor visibility, fog, steady drizzle, prolonged rain, or when winds exceeded 19 kph (U.S. Fish and Wildlife Service 1972). The period between the 1st and 3rd bird surveys was always < 7 days.

Fields were surveyed for birds by walking straight line transects at about 20 m/min. Transects were located in the middle of fields to avoid counting birds using edge habitat. Bird species, sex (when distinguishable), and the number of individuals per species observed ≤ 60 m on each side of the transect line were recorded (Emlen 1971, 1977, Mikol 1980). Birds were identified with 10 x 50 binoculars, or by song.

Characteristic grassland breeding species were analyzed because they were widespread and numerous enough to determine if a relationship existed between the abundance (number of individuals) of each species and habitat type size. These species included bobolinks (*Dolichonyx oryzivorus*), eastern meadowlarks (*Sturnella magna*), red-winged blackbirds (*Agelaius phoeniceus*), savanna sparrows (*Passerculus sandwichensis*), and grasshopper sparrows (*Ammodramus savannarum*). Dickcissels (*Spiza americana*), Henslow's sparrows (*A. henslowii*), field sparrows (*Spizella pusilla*), and song sparrows (*Melospiza medodia*), found in only a few areas and in low numbers, were omitted from some analyses. Red-winged blackbirds were included because they were the most

numerous bird species during both years of the study and we wanted to see what affect their presence had on abundance and distribution of true grassland birds.

RESULTS

Structural Characteristics of Grasslands

We observed 61 herbaceous and 9 woody species of plants (Appendix II), with an average of 2.8 grass and 5.2 forb species in fescue fields, 5.2 grass and 9.0 forb species in mixed grass fields, and 5.0 grass and 9.6 forb species in grass/forb fields.

Fescue, Kentucky bluegrass, timothy, and smooth brome were the most common grass species within all habitat types. Commonly occurring forb species were Canada thistle (*Cirsium arvense*) and common milkweed (*Asclepia syrica*) (Table 1). We observed growth patterns (sociability) of 34 plant species occurring in our quadrats. Most (56%) plants observed grew singly. Fescue was the only plant species growing in large, almost pure stands (Table 2).

Discriminant analysis indicated that 9 of the habitat variables separated the 3 habitat types (Table 3). Two discriminant functions were derived by using these 9 habitat variables. The 1st discriminant function explained 74% of the variation in the data. The most important habitat variables separating the habitat types were grass height, height density, and bare ground. The 2nd discriminant function explained the additional 26% of the data variation, describing a separation between habitat types based on number of grass species and total cover of grasses. Number of grass species present, mean grass height, and total coverage of grasses best discriminated between habitat types, on the basis of the Wilks' Lamda values. Wilks' Lamda values ≥0.45 were considered to be significant based on the amount of separation between values.

Analysis of variance (ANOVA) showed that values for grass height, forb height, percent forb cover, percent bare ground, and height density were greater ($P<0.05$) in the grass/forb habitat than in the other 2 habitat types (Table 4). Percent grass cover and litter depth were greater ($P<0.05$) in the fescue habitat than in mixed grass or grass/forb habitat types (Table 4).

Forb cover, height density, and bare ground were greater ($P<0.05$) on the timothy-dominated grass/forb sites than on fescue-dominated sites. Higher ($P<0.05$) percent grass cover occurred in fescue-dominated grass/forb fields than in timothy-dominated fields (Table 4).

Bird Species Abundance and Composition

The 9 most common grassland bird species seen during the breeding season were red-winged blackbirds (1066), bobolinks (246), savanna sparrows (192), eastern meadowlarks (155), song sparrows (64), grasshopper sparrows (37), dickcissels (7), field sparrows (4), and Henslow's sparrows (2). Dickcissels and Henslow's sparrows were found only in the grass/forb fields. Dickcissels occurred in timothy-dominated fields, and Henslow's sparrows in fescue-dominated fields. Field sparrows were found within and next to fescue and mixed grass fields surrounded by trees and shrubs. Two of the 7 species of grassland birds studied most intently varied in their preference for vegetation characteris-

tics in the 3 grassland habitat types (compare Tables 4 and 5). Grass height, forb height, and height density were significantly greater for red-winged blackbirds than for the other 6 bird species, as were percent grass cover and percent bare ground for dickcissels.

We observed 22 other, mostly non-grassland bird species (Appendix III). Fifteen of the species were characteristic inhabitants of woodland edge areas, shrubby areas next to woodlands and fields, and suburban areas. Except for the northern harrier (*Circus cyaneus*), all are common breeding species in Illinois.

Bobolinks, eastern meadowlarks, savanna sparrows, grasshopper sparrows, red-winged blackbirds, and song sparrows occurred in all 3 habitat types (Figure 1). Bobolinks, eastern meadowlarks, and red-winged blackbirds, the 3 most ubiquitous grassland species, occurred in nearly all (90-100%) fields.

Red-winged blackbirds, bobolinks, and eastern meadowlarks comprised 65-85% of the bird communities in all 3 habitat types. Two or 3 species represented ≥75% of the total community structure in each habitat type (Figure 2). Savanna sparrows, red-winged blackbirds, and bobolinks predominated in fescue; bobolinks, eastern meadowlarks, and red-winged blackbirds in mixed grasses; and red-winged blackbirds and bobolinks in grass/forb. Dickcissels, grasshopper sparrows, field sparrows, song sparrows, and Henslow's sparrows each represented <10% of the bird community within any habitat type.

The grass/forb habitat contained a higher mean density ($\underline{t}$-test, $\underline{P}<0.05$) of birds/ha (0.62) than the fescue or mixed grass habitat types (0.40). Mean bird densities for 7 bird species were low (Table 6). Fescue fields contained higher densities of savanna sparrows and grasshopper sparrows than the other 2 habitats did. Mixed grasses fields contained higher densities of eastern meadowlarks. Grass/forb fields contained higher densities of bobolinks and red-winged blackbirds. Dickcissels and Henslow's sparrows were found only in grass/forb fields.

Bird Species and Habitat Area Relationships

Fields contained bird communities of 2-7 grassland species. Fescue fields had 3-6 (mean = 4.86±1.02) grassland bird species, mixed grasses had 2-5 (mean = 4.22±0.92), and grass/forb had 3-7 (mean = 4.93±1.29). Eight bird species (bobolink, eastern meadowlark, savanna sparrow, grasshopper sparrow, dickcissel, red-winged blackbird, Henslow's sparrow, song sparrow) occurred in grass/forb fields of medium size (27.9-52.6 ha).

Numbers of grassland bird species were positively correlated (log-log transformation) with the size of fescue fields ($\underline{r}=0.51$, $\underline{P}<0.05$) and the fescue-dominated grass/forb fields ($\underline{r}=0.73$, $\underline{P}<0.02$). Timothy-dominated grass/forb fields showed a negative correlation; all grass/forb fields combined showed no correlation. Eastern meadowlarks, savanna sparrows, and grasshopper sparrows showed strong positive correlation between the number of individuals and habitat area only in the fescue fields (Table 7). Bobolinks showed a positive correlation only in mixed grasses fields. Red-winged blackbirds exhibited a strong positive correlation in mixed grasses and grass/forb fields. Henslow's sparrows, grasshopper sparrows, and dickcissels were observed only in fields of >16 ha. Other bird species occurred in fields of all sizes (Table 7).

DISCUSSION

Structural Characteristics of Grasslands

Grasslands contain relatively homogeneous vegetation patterns which lack structural diversity, or patchiness, thus limiting the number of bird species that can exploit them (Roth 1976). Weins (1974) noted a general reduction in grass cover and litter depth and an increase in woody vegetation and bare ground cover with increases in plot heterogeneity. In our study, this condition was more pronounced in the grass/forb habitat type, where much heterogeneity was attributed to the presence of timothy. Timothy was prone to invasion by forbs, particularly Canada thistle, which reduced grass cover.

Height and density of vegetation were the factors that separated the 3 habitat types, and which separate grasslands in general. Different grass species and their growth patterns seem to be an important variable in the physiognomy of the habitat types. Growth patterns of the grass species present determined height of the vegetation, height density, amount of bare ground, and kinds of bird species present.

Bird Species Habit Area Relationships, Abundance, and Composition

In general, number of bird species seen in a given habitat increased as amount of habitat increased (Graber and Graber 1976, Nolin and Ritzenthaler 1987, Herkert 1994). Grasslands <10 ha in Illinois had only a few species of prairie birds breeding at low densities (Herkert 1991), and area requirements for 5 area-sensitive birds were 5 ha for eastern meadowlards, 30 ha for grasshopper sparrows, 40 ha for savanna sparrows, 50 ha for bobolinks, and 55 ha for Henslow's sparrows (Herkert 1994). Heckert et al. (1993) recommended that for birds the most sensitive to fragmentation, grasslands should be ≥ 50 ha and preferably >100 ha; area requirements of species might vary geographically (Herkert et al. 1996). Vickery et al. (1994) recommended ≥100 ha and preferably 200 ha. We found that only fescue and fescue-dominated grass/forb fields showed an increase in number of bird species with an increase in habitat size; timothy-dominated grass/forb fields showed a decrease. Samson (1980) found that Henslow's sparrows and grasshopper sparrows nested only in large grasslands. In our study these species were found only in fields >16 ha, suggesting that they might not breed in smaller fields.

Several bird species of grasslands and forests are rare or absent from many small, isolated habitat blocks, or even large blocks if they are too linear (e.g., Hagen and Johnson 1992, Heckert 1991, 1994, Herkert et al. 1993, Vickery et al. 1994, Payne and Bryant 1998), partly due to territorial needs (e.g., Robbins et al. 1989) and edge effects causing increased nest predation (e.g, Rudnicky and Hunter 1993, Burger et al. 1994, Paton 1994) and nest parasitism by brown-headed cowbirds (*Molothrus ater*) (e.g., Johnson and Temple 1990, Robinson et al. 1993, Bielefeldt and Rosenfield 1997, Niemuth and Boyce 1997). Evidently not all edges sustain predation rates higher than the interior (e.g., Burger et al. 1994). Habitat too isolated and small might not be able to sustain a viable population.

Structure and general abundance of the breeding bird community in perennial non-native grasslands in DuPage County, Illinois, were similar to those reported for grasslands by Graber and Graber (1963) in Illinois, Weins (1969) in Wisconsin, Birkenholz (1973) in Illinois, and Nolin and Ritzenthaler (1987) in Ohio. Graber and Graber (1963) found that

red-winged blackbirds represented 57% of the bird community, bobolinks 19%, and eastern meadowlarks 6%, which compares favorably with 54%, 22%, and 7%, respectively, found in similar habitat for these 3 species in our study.

An important characteristic of suitable habitat for red-winged blackbirds, which commonly nest in wetland and upland habitats (Robertson 1972), appears to be the presence of dense and sturdy vegetation for nest support. Several plant species in grass/forb fields, such as dogbane and thistles, provided such support. Zimmermann (1971, 1982) and Frawley and Best (1991) found that dickcissels also prefer habitats with sturdy forbs. Patterson and Best (1996) found that dickcissel abundance was correlated positively with percent forb cover and vertical vegetation cover. But Herkert (1994) found no relationship between numbers of dickcissels and either vegetation or area variables. Henslow's sparrows use grassland vegetation with patches of dense herbaceous vegetation and protruding weed stalks (Robins 1971); territorial males prefer areas with greater coverage by standing dead vegetation, lesser coverage by woody vegetation, and taller live grasses (Zimmerman 1988).

Fescue grasslands are generally classified as low heterogeneity, low diversity habitats that generally supply poor habitat to all but a few species of birds (Urbanek and Klimstra 1986, Nolin and Ritzenthaler 1987). In our study, fescue fields and fescue-dominated grass/forb fields contained higher densities of grasshopper sparrows, eastern meadowlarks, and savanna sparrows.

Nolin and Ritzenthaler (1987) considered timothy to be far superior habitat to fescue in Ohio. But we found that timothy contained few bird species, was prone to invasion by forbs and shrubs, and harbored predominantly red-winged blackbirds.

Grasslands contain relatively homogeneous vegetation patterns which lack structural diversity, or patchiness, and limit the number of bird species that can exploit them (Roth 1976). Grasslands also contain bird species with restricted habitat characteristics (Weins and Dyer 1975). The most common species in our study (bobolinks, eastern meadowlarks, and red-winged blackbirds) were observed in fields of all sizes. Bird diversity and density are low in grasslands compared to most other habitats (Cody 1985). Grassland bird communities tend to be dominated by 1 or 2 abundant widespread species (Graul 1980). In our study each habitat type contained 2 or 3 species that represented >75% of the bird community.

Densities of grassland birds were generally low in our study. Graber and Graber (1963) found greater density of birds in mixed hayfields (grass/forb) than in pastures (fescue and mixed grass). Densities from our study were substantially lower than those found by Graber and Graber (1963) in similar habitat. The lower population densities might be due partly to the loss of grassland habitat in Illinois and resulting decline in grassland bird populations and densities.

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Table 1. Frequency of occurrence (%) of common plant species within 1-m^2 plots in northern Illinois, 1986. (No. of quadrats sampled is in parentheses.)

Plant species	Fescue (240)	Mixed grasses (150)	Grass/forb (240)
Grasses			
Fescue	98.3	83.1	38.7
Kentucky bluegrass	3.0	71.3	9.0
Smooth brome	3.0	6.0	15.4
Timothy	2.1	5.0	46.7
Quackgrass	1.2	5.0	12.9
Reed canary grass	< 1	2.0	4.0
Orchard grass	< 1	2.0	2.9
Forbs			
Canada thistle	11.2	7.3	28.7
Common milkweed	10.8	11.3	8.3
Queen-Anne's lace	2.9	5.0	4.6
Field bindweed	2.9	< 1	2.1
Common sow thistle	2.5	< 1	< 1
Hedge bindweed	2.1	4.0	1.4
Yellow sweet clover	< 1	2.0	5.8
Red clover	1.2	< 1	7.5
Alsike clover	< 1	< 1	7.9
Goldenrods	1.7	< 1	5.8

Table 2. Sociability of plant species based on the Braun-Blanquet Sociability Scale in northern Illinois, June-July 1986.

Plant species	Sociability rating[a]	Plant species	Sociability rating[a]
Meadow fescue	5	Evening primrose	1
Timothy	4	Sow thistle	4
Kentucky bluegrass	4	Dandelion	1
Smooth brome	2	Wild lettuces	1
Reed canary grass	2	Heal-all	1
Quackgrass	3	Peppermint	1
Redtop	1	Yarrow	1
Foxtails	4	Cinquefoils	3
Orchard grass	1	Dogbane	1
Canada thistle	4	Bull thistle	1
Yellow sweet clover	1	Daisy fleabane	1
White sweet clover	1	Lamb's quarters	1
Red clover	1	Pigweed	1
White clover	4	Common ragweed	2
Yellow hop clover	3	Field bindweed	1
Goldenrods	2	Hedge bindweed	1
Curled dock	1	Queen-Anne's lace	3

[a] 1=growing singly; 2=small but dense clumps; 3=small patches or cushions; 4=small colonies or carpets; 5=large, almost pure stands.

Table 3. Discriminant function coefficients for separating the 3 grassland habitat types (fescue, mixed grasses, and grass/forb) in northern Illinois, 1986.

Habitat feature	Discriminant functions[a]	
	1	2
Grass height	0.567	0.225
Number of grass species	-0.059	0.909
Grass cover	-0.358	0.585
Dead grass cover	0.244	0.346
Total grass cover	-0.326	-0.752
Forb height	-0.149	0.004
Dead forb cover	0.044	0.277
Height density	0.406	-0.040
Bare ground	0.365	0.119

[a] The 1st discriminant function explained 74% of the variation, the 2nd explained the other 26%.

Table 4. Mean values and standard deviations (SD) for vegetation characteristics of the fescue, mixed grasses, and grass/forb fields in northern Illinois, summer 1986.

					Grass/forb					
	Fescue		Mixed grasses		Fescue-dominated		Timothy-dominated		Combined	
Vegetable variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Grass height (cm)	74.5	20.2	74.3	14.1	89.7	14.9	88.1	15.2	89.1*	15.1
Grass cover (%)	94.3*	5.4	94.7	5.1	92.6*	9.4	76.3	17.2	81.2	20.6
Forb height (cm)	54.1	19.2	51.3	20.2	59.7	18.2	58.5	20.6	59.7*	19.2
Forb cover (%)	11.2	15.3	12.3	13.6	15.5	14.8	31.3*	20.7	26.7*	24.3
Height density (dm)	2.1	0.7	2.2	0.5	3.2	1.3	3.5*	1.4	3.3*	1.3
Litter depth (cm)	4.7*	1.3	4.4	1.0	4.2	1.8	4.1	1.9	4.1	1.7
Bare ground (%)	5.2	2.3	4.6	1.7	5.9	2.1	19.4*	8.6	17.1*	10.8

* Significant at P=0.05 (ANOVA). For example, grass in the grass/forb fields was significantly higher than in the other 2 types of field.

Table 5. Vegetation characteristics selected[a] by 7 species of birds in 3 grassland habitat types (fescue, mixed grasses, and grass/forb) in northern Illinois, June - July 1987.

		Grass height (cm)		Forb height (cm)		Grass cover (%)		Forb cover (%)		Height density (dm)		Litter depth (cm)		Bare ground (%)	
Bird species	N	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Henslow's sparrow	9	84.0	5.4	65.2	20.2	87.3	8.2	18.4	12.2	3.2	0.5	8.4*	2.0	0.0	0.0
Grasshopper sparrow	16	64.3	19.6	44.2	14.7	74.7	19.4	28.4	17.9	1.8	0.8	3.8	1.5	21.2	4.3
Eastern meadowlark	30	68.4	9.6	36.5	11.0	96.6*	6.4	9.3	7.1	1.8	0.7	5.6	2.1	0.0	0.0
Savannah sparrow	24	74.6	16.6	52.2	19.8	89.5	11.2	15.3	13.7	2.4	1.0	4.6	1.5	16.2	3.4
Dickcissel	11	62.5	34.5	76.9	21.6	32.5	23.3	68.8*	15.3	3.8	1.6	2.2	2.4	25.3	6.2
Red-winged blackbird	37	93.4*	20.5	88.8*	23.6	59.3	23.1	47.2	24.4	4.3*	1.3	3.1	1.8	15.3	3.5
Bobolink	15	83.3	15.7	58.3	20.5	82.3	12.5	23.6	16.5	3.0	0.8	5.2	2.1	0.0	0.0

[a] N = sample size, i.e., number of nests or song posts around which vegetation was sampled. See Payne et al. (1998).

* Significant at P=0.05 (ANOVA pair-wise comparison using Bonferonni test). For example, litter was significantly deeper around nests and song posts in territories of Henslow's sparrows than in territories of other bird species.

Table 6. Calculated mean densities (birds/ha) and standard deviations (SD) for 7 bird species within 3 habitat types in northern Illinois, 1986 and 1987.

Species	Habitat type	N[a]	Mean	SD
Bobolink	Fescue	94	0.10	0.05
	Mixed grasses	48	0.11	0.04
	Grass/forb	79	0.15*	0.08
	Fescue-dominated	33	0.15	0.07
	Timothy-domintated	46	0.13	0.09
Eastern meadowlark	Fescue	66	0.07	0.02
	Mixed grasses	51	0.13*	0.05
	Grass/forb	38	0.06	0.04
	Fescue-dominated	27	0.09	0.03
	Timothy-domintated	11	0.03	0.02
Savannah sparrow	Fescue	131	0.14*	0.11
	Mixed grasses	15	0.08	0.03
	Grass/forb	22	0.05	0.06
Grasshopper sparrow	Fescue	24	0.04*	0.02
	Mixed grasses	2	0.03	0.00
	Grass/forb	10	0.04	0.02
Dickcissel	Grass/forb	7	0.04	0.02
Henslow's sparrow	Grass/forb	2	0.03	0.00
Red-winged blackbird	Fescue	57	0.06	0.04
	Mixed grasses	47	0.11	0.05
	Grass/forb	280	0.31*	0.17
	Fescue-dominated	60	0.19	0.13
	Timothy-domintated	220	0.43	0.11

[a] N = number of birds observed.

* Significant at P=0.05 (t-test). For example, the mean density of boblinks was significantly higher in grass/forb fields than in the other 2 types of field.

Table 7. Correlation coefficients (r) for habitat area (field size) with the number of individuals for each bird species in 3 grassland habitat types in northern Illinois, 1986 and 1987.

Bird species	Grassland habitat type								
	Fescue			Mixed grasses			Grass/forb		
	r	N[a]	P	r	N[a]	P	r	N[a]	P
Bobolink	0.47	15	<0.10	0.77	9	<0.01*	0.47	16	<0.10
Eastern meadowlark	0.65	14	<0.01*	0.61	9	<0.10	-0.19	15	>0.50
Savannah sparrow	0.80	13	<0.001*	-0.13	4	>0.50	-0.40	7	>0.50
Grasshopper sparrow	0.79	8	<0.01*	-	-	-	-0.83	5	>0.50
Red-winged blackbird	0.17	15	>0.50	0.77	8	<0.02	0.88	16	<0.001*

[a] N = number of grassland fields in which the bird species occurred, combined for both years. For example, of the 8 fescue fields, 5 mixed grasses fields, and 8 grass/forb fields studied during 1986 and 1987, bobolinks were present in all 8 grass/forb fields both years, for N = 16 observations.

* Significant at P=0.05 (t-test).

Figure 1. Frequency of occurrence of 9 bird species in 3 grassland habitat types in northern Illinois, 1986-1987. 1=Bobolink, 2=Eastern Meadowlark, 3=Savannah Sparrow, 4=Grasshopper Sparrow, 5=Dickcissel, 6=Red-winged Blackbird, 7=Song Sparrow, 8=Henslow's Sparrow, and 9=Field Sparrow.

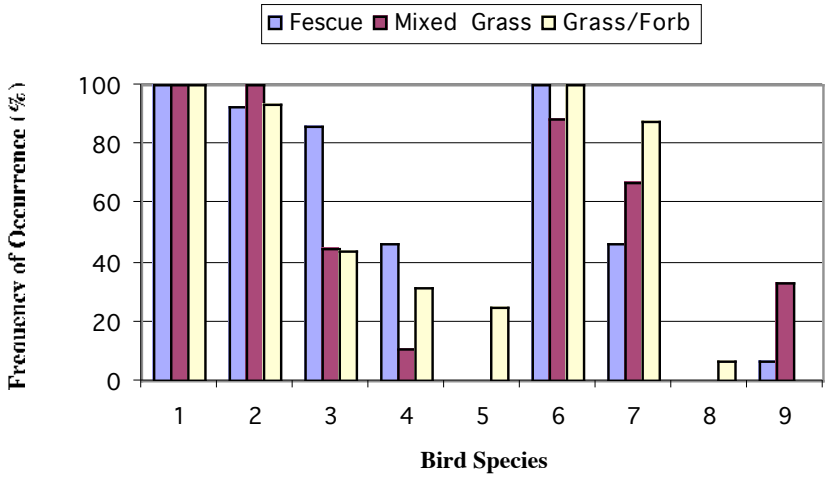
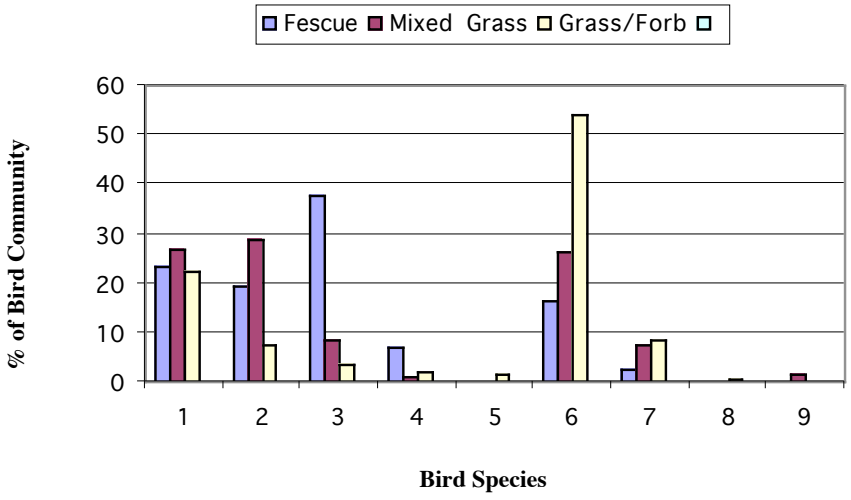


Figure 2. Percentage of the bird community represented by 9 bird species in 3 grassland habitat types in northern Illinois, 1986-1987. 1=Bobolink, 2=Eastern Meadowlark, 3=Savannah Sparrow, 4=Grasshopper Sparrow, 5=Dickcissel, 6=Red-winged Blackbird, 7=Song Sparrow, 8=Henslow's Sparrow, and 9=Field Sparrow.



Appendix I. Field size and length, year of planting, and area of 21 transects within 3 habitat types in northern Illinois, 1986 and 1987.

Field area (ha)	Field length (m)	Year planted	Transect area (ha)
Fescue			
8.9	411	1971/1972	5.1
18.2	594	1979/1983	7.3
20.6	502	1979/1983	6.2
35.2	548	1979	6.7
40.5	937	1978	11.4
52.6	1371	1973	16.7
64.7	807	1979/1982	9.8
87.1	1828	1976	22.3
327.8			85.5
Mixed grasses			
8.9	396	1974	4.8
13.6	457	1974	5.5
18.2	411	1974	5.1
28.3	1005	1974	12.2
40.5	1096	1974	13.4
109.5			41.0
Grass/forb			
8.9	426	1974	5.2
14.5	396	1973	4.8
22.2	579	1971	7.1
27.9	594	1983	7.2
44.5	670	1983	8.2
52.6	777	1971/1972	9.5
64.7	807	1978/1983	9.8
97.1	1035	1978/1982	14.5
332.4			66.3

Appendix II. Plant species occurring within fescue(1), mixed grasses(2), and grass/forb(3) habitat types in northern Illinois, 1986-87.

Common name	Scientific name	Habitat type	Common name	Scientific name	Habitat type
Grasses					
Meadow fescue	*Festuca elatior*	1,2,3	Horse nettle	*Solanum carolinense*	1, 3
Orchard grass	*Dactylis glomerata*	1,2,3	Bittersweet nightshade	*S. dulcamara*	1,2,3
Smooth brome	*Bromus inermis*	1,2,3	Wild parsnip	*Pastinaca sativa*	1
Kentucky bluegrass	*Poa pratensis*	1,2,3	Dogbane	*Apocynum medium*	1, 3
Reed canary grass	*Phalaris arundinacea*	1,2,3	Curled dock	*Rumex crispus*	1,2,3
Redtop	*Agrostis alba*	2,3	Common burdoch	*Arctium minus*	1, 3
Quackgrass	*Agropyron repens*	1,2,3	Wild lettuce	*Lactuca canadensis*	1,2,3
Timothy	*Phleum pratense*	1,2,3	Evening primrose	*Oenothera biennis*	1,2,3
Foxtails	*Setaria* spp.	1, 3	Common plantain	*Plantago major*	2
			Goldenrods	*Solidago* spp.	1,2,3
Forbs			Wild strawberry	*Fragaria virginiana*	2
Yellow sweet clover	*Melilotus officinalis*	1,2,3	Cattail	*Typha latifolia*	1,2
White sweet clover	*M. alba*	1,2,3	Queen-Anne's lace	*Daucus carota*	1,2,3
Red clover	*Trifolium pratense*	1,2,3	Daisy fleabane	*Erigeron annuus*	1,2,3
White clover	*T. repens*	1,2,3	Wild bergamot	*Monarda fistulosa*	1,2
Alsike clover	*T. hybridium*	1,2,3	Gray-headed coneflower	*Ratibida pinnate*	1
Yellow hop clover	*T. agrarium*	1,2,3	Peppermint	*Mentha piperata*	1, 3
Canada thistle	*Cirsium arvense*	1,2,3	Velvetleaf	*Abutilon theophrasti*	1
Bull thistle	*C. vulgare*	1, 3	Yarrow	*Achillia millefolium*	1, 3
Nodding thistle	*Carduus nutens*	3	Cinquefoil	*Potentilla* spp.	1,2,3
Common ragweed	*Ambrosia artemisiifolia*	1,2,3	Heal-all	*Prunella vulgaris*	1
Giant ragweed	*A. trifida*	3	Common mullein	*Verbascum thapsus*	1, 3
Field bindweed	*Convolvulus arvensis*	1,2,3	Moth mullein	*V. blattaria*	3

Appendix II. continued

Common name	Scientific name	Habitat type	Common name	Scientific name	Habitat type
Hedge bindweed	*C. sepium*	1,2,3	Dandelion	*Taraxecum officinale*	1,2,3
Common sow thistle	*Sonchus oleroceus*	1,2,3	Smartweed	*Polygonum* spp.	1,2,3
Spiny-leaved sow thistle	*S. asper*	1			
Yellow wood sorrel	*Oxalis europea*	1,2	Shrubs and trees		
Day lily	*Nemerocallis fulva*	2	Raspberry	*Rubus* spp.	1,2,3
Virginia creeper	*Parthenocissus quinquefolia*	2	Blackberry	*R. allegheniensis*	2
Common milkweed	*Asclepia syrica*	1,2,3	Multiflora rose	*Rosa multiflora*	1,2,3
Whorled milkweed	*A. verticillata*	3	Pasture rose	*R. carolina*	1
Yellow goats beard	*Tragopogan pratensis*	2,3	Wild grape	*Vitus* spp.	1,2,3
Chickory	*Cichorium intybus*	2,3	Boxelder	*Acer negundo*	1,2,3
Ox-eye daisy	*Chrysanthemum leucanthemum*	1,2	Silver maple	*A. saccarinu*m	3
Lamb's quarters	*Chenopodium alba*	1,2,3	Willow	*Salix* spp.	1, 3
White vervain	*Verbena urticifolia*	2,3	Eastern cottonwood	*Populus deltoides*	2,3
Blue vervain	*V. hastata*	2			
Bush clover	*Lezpedeza* spp.	3			

Appendix III. Non-grassland birds seen or heard[a] during bird surveys in 3 grassland habitat types in northern Illinois, 1986 and 1987.

Bird species	Fescue	Mixed grasses	Grass/forb
Eastern kingbird (*Tyrannus tyrannus*)	+(+)	+(+)	+(+)
Barn swallow (*Hirundo rustica*)	+(+)	+(+)	+(+)
Tree swallow (*Irodoprocne bicolor*)	+(+)	+(+)	+(+)
Red-tailed hawk (*Buteo jamaicensis*)	+(+)	+(+)	-(+)
Northern harrier (*Circus cyaneus*)	-(+)	-(-)	-(-)
Common crow (*Corvus brachyrhynchos*)	+(+)	+(+)	+(+)
Common grackle (*Quiscalus quiscula*)	+(+)	+(+)	-(+)
Yellow warbler (*Dendroica petechia*)	-(-)	-(-)	-(+)
Mourning dove (*Zenaidura macroura*)	+(+)	+(+)	-(+)
American kestrel (*Falco sparverius*)	+(+)	+(-)	-(+)
American robin (*Turdus migratorius*)	+(+)	+(+)	+(+)
Brown-headed cowbird (*Molothrus ater*)	+(-)	-(-)	-(+)
American goldfinch (*Spinus tristis*)	+(+)	+(+)	-(+)
Common yellowthroat (*Geothlypis trichas*)	-(+)	-(+)	+(+)
European starling (*Sturnus vulgaris*)	-(+)	+(+)	+(+)
American killdeer (*Charadrius vociferus*)	-(+)	+(+)	-(-)
Northern flicker (*Colaptes auratus*)	-(-)	+(+)	+(+)
Brown thrasher (*Toxostoma rufum*)	-(+)	-(-)	+(+)
Sedge wren (*Cistothorus platensis*)	-(+)	-(-)	+(+)
Chimney swift (*Chaetura pelagica*)	-(+)	-(+)	-(-)
Gray catbird (*Durnetella carolinensis*)	-(+)	-(-)	-(-)
Ring-necked pheasant (*Phasianus colchicus*)	+(+)	+(+)	+(+)

[a] + = presence, - = absence. Data from 1987 in parentheses.