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PETER D. VICKERY AND JAMES R. HERKERT, EDITORS

Studies in Avian Biology No. 19
A Publication of the Cooper Ornithological Society

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Proceedings of a Conference
Tulsa, Oklahoma
October 1995

Sponsor:

Association of Field Ornithologists

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Cover photograph of Greater Rheas (*Rhea americana*) in the Pampas of Argentina by Juan Carlos Reboreda.

Studies in Avian Biology No. 19:112–121, 1999.

HABITAT RELATIONS AND BREEDING BIOLOGY OF GRASSLAND BIRDS IN NEW YORK

CHRISTOPHER J. NORMENT, CHARLES D. ARDIZZONE, AND KATHLEEN HARTMAN

Abstract. In 1994 we began a study of the habitat relations and breeding biology of grassland birds in western New York. Most fields contained fewer than four grassland species, with Bobolink (*Dolichonyx oryzivorous*) and Savannah Sparrow (*Passerculus sandwichensis*) being the two most common species. Species of management concern in the Northeast, such as Henslow's Sparrow (*Ammodramus henslowii*) and Upland Sandpiper (*Bartramia longicauda*), were absent from the study area. Bird-habitat models generated through Principal Components Analysis and stepwise multiple regression indicated that field area, or variables correlated with area, explained most of the variation in overall grassland bird species richness (partial $r^2 = 0.43$) and abundance (partial $r^2 = 0.60$) and in the abundance of Bobolinks and Savannah Sparrows. Grassland birds were generally absent from fields smaller than 5 hectares. Areas with few shrubs and low horizontal heterogeneity supported more grassland bird species than did fields with more shrubs and high horizontal heterogeneity, and fields with shorter, less dense vegetation had more individuals than did fields with taller, dense vegetation. Few grassland birds occurred in fields planted in switchgrass (*Panicum virgatum*) monocultures. More than 90 percent of all known nesting pairs fledged young by the end of the first week in July. Nest success was generally high; the proportion of nests fledging one or more young was 0.76 for Savannah Sparrows, 0.54 for Bobolinks, and 0.67 for Eastern Meadowlarks (*Sturnella magna*).

Grassland bird populations in this study may benefit from management practices that increase field area, control shrub invasion, and encourage the growth of grasses other than switchgrass. The current low levels of grazing at Iroquois National Wildlife Refuge, with cattle allowed in pastures only after 15 July, do not appear to be harmful to grassland bird populations.

LAS RELACIONES ENTRE LOS HÁBITATS Y LA BIOLOGÍA REPRODUCTIVA DE AVES DE PASTIZAL EN NUEVA YORK

Sinopsis. En 1994 iniciamos un estudio de las relaciones entre los hábitats y la biología reproductiva de aves de pastizal en el oeste de Nueva York. La mayoría de los campos tenían menos de cuatro especies de pastizal, con el Tordo Arrocero (*Dolichonyx oryzivorous*) y el Gorrión Sabanero (*Passerculus sandwichensis*) como las dos especies más comunes. Las especies de importancia para manejo en el noreste, como el Gorrión de Henslow (*Ammodramus henslowii*) y el Zarapito Ganga (*Bartramia longicauda*) estaban ausentes del área de estudio. Los modelos de hábitat para aves producidos por el Análisis de Componentes Principales y las regresiones múltiples de escala indicaron que el área del campo (o las variables correlacionadas con el área) daban cuenta de la mayor parte de la variación de la riqueza total de especies de aves de pastizal (parcial $r^2 = 0{,}43$), de la abundancia total de ellas (parcial $r^2 = 0{,}60$) y de la abundancia de los Tordos Arroceros y los Gorriones de Henslow. Las aves de pastizal generalmente estaban ausentes en los campos de menos de 5 hectáreas. Las áreas con pocos arbustos y una escasa heterogeneidad horizontal mantenían más especies de aves de pastizal que los campos con más arbustos y una abundante heterogeneidad horizontal; los campos con vegetación más baja y menos densa tenían más individuos que los campos con vegetación más alta y densa. Había pocas aves de pastizal en campos sembrados con monoculturas de *Panicum virgatum.* Más de un 90 por ciento de todas las parejas conocidas con nidos produjeron pollos para el fin de la primera semana de julio. El éxito de los nidos fue generalmente alto; la proporción de los nidos que produjeron un pollo o más fue 0,76 para los Gorriones Sabaneros, 0,54 para los Tordos Arroceros y 0,67 para los Praderos Orientales (*Sturnella magna*).

Las poblaciones de aves de pastizal pueden beneficiarse con las prácticas de manejo que aumenten el área de los campos, controlen la invasión de arbustos y estimulen el crecimiento de hierbas que no sean *Panicum virgatum.* Los bajos niveles actuales de apacentamiento en el Refugio Nacional de Fauna Iroquois, con ganado permitido en las praderas solamente después del 15 de julio, no parecen ser dañinos para las poblaciones de aves de pastizal.

Key Words: Bobolink; breeding biology; *Dolichonyx oryzivorous*; Eastern Meadowlark; grassland birds; habitat selection; New York; *Passerculus sandwichensis*; Savannah Sparrow; *Sturnella magna.*

Populations of many grassland bird species in the United States have declined significantly since the mid-1960s (Robbins et al. 1986, Knopf 1994). Although declines of North American breeding birds may vary across geographic regions (James et al. 1992; Peterjohn and Sauer 1994, 1999; Herkert 1995a), the trend evident for grassland birds is consistent across North America (Robbins et al. 1986, Bollinger and Gavin 1992, Smith and Smith 1992, Askins 1993, Peterjohn and Sauer 1999). Reasons for declines of grassland birds in the northeastern United

TABLE 1. TYPES AND SIZES OF FIELDS CENSUSED FOR GRASSLAND BIRDS IN WESTERN NEW YORK, 1995

	Sample sizes				
Habitat type	Iroquois NWR[a]	Montezuma NWR[b]	Braddock Bay WMA	Total	Size (ha)
Cool-season grassland[c]	8	1		9	5.1–20.1
Warm-season grassland	6		1	7	1.3–44
Pasture	3			3	19.0–98.4
Fallow farm field	4	1		5	5.0–14.0
Forb-dominated field	5	2		7	3.0–32.9
Old field with shrubs	8	4		12	2.0–14.6
Total	34	8	1	43	1.3–98.4

[a] Includes Oak Orchard and Tonawanda WMAs.
[b] Includes NYSDEC lands in the Northern Montezuma Wetlands Complex.
[c] Habitat descriptions given in Appendix.

States include farmland abandonment, decline of hayfield area, and earlier and more frequent haycropping rotations (Andrle and Carroll 1988, Bollinger and Gavin 1992). Many species of grassland birds are area sensitive and are particularly vulnerable to loss of grassland habitat (Smith and Smith 1990, Vickery et al. 1994). In the Northeast, grassland habitat has declined by about 60% since the 1930s (Vickery et al. 1994).

In 1994 we began a study of grassland birds on lands in western New York administered by the U.S. Fish and Wildlife Service (USFWS) and New York State Department of Environmental Conservation (NYSDEC). Our objectives were to determine grassland bird species richness and abundance, breeding biology, and habitat relations on these lands. Studies on breeding biology focused on determining nest success and chronology, whereas bird-habitat relations were examined at both the local (vegetation) and landscape levels. Results of this study will be used to evaluate the status of grassland bird populations on public lands in the Great Lakes Plain of western New York and to suggest management alternatives to increase grassland bird populations in the region.

STUDY AREA

We began our study in May 1994 at Iroquois National Wildlife Refuge (NWR) and the contiguous NYSDEC Tonawanda and Oak Orchard Wildlife Management Areas (WMAs), located about 65 km west of Rochester, New York, in the Great Lakes Plain ecozone of New York (Andrle and Carroll 1988). The area comprises approximately 8,000 ha of wetlands and uplands that historically has been managed to provide habitat for breeding and migratory waterfowl (Iroquois NWR 1993). More than 1,000 ha of potential upland habitat for grassland birds also exist in the area. This potential habitat includes fields managed as cool-season grasslands, warm-season grasslands dominated by switchgrass (*Panicum virgatum*), old fields with a grass/forb/shrub mix, fallow farm fields, forb-dominated fields, and pastures (Iroquois NWR 1990; Table 1; see Appendix for a description of habitat types). The various fields range in size from 0.5 to 98 ha, interspersed in a landscape matrix of wetlands, croplands, and hardwood forests.

In 1995 we expanded the study to include two additional sites: a 44-ha warm-season grassland at Beattie Point in the NYSDEC Braddock Bay WMA, 11 km west of Rochester, New York, and approximately 55 ha of upland habitat in the Northern Montezuma Wetlands Complex, about 50 km west of Syracuse, New York, and administered by the USFWS and NYSDEC. The grassland at Braddock Bay is on the southern shore of Lake Ontario and is bordered on three sides by extensive wetlands. The upland habitat in the Northern Montezuma Wetlands Complex is surrounded by a mixture of wetlands, agricultural fields, and deciduous forest.

METHODS

We determined grassland bird species abundance and richness using fixed 50-m-radius point counts. We established 59 census points in 34 fields in 1994 and 82 points (the same 59 points plus an additional 23) in 43 fields in 1995. These fields represented the range of shrub/grassland habitats found in the study area (Table 1). To control for area-related differences in sampling intensity, we placed no more than one census point in fields smaller than 10 ha and maintained a density of approximately one census point per 7 ha in larger fields. In fields with more than one census point, we separated point centers by at least 200 m to minimize recounts. Each point was censused five times a year for 10 min per census. We conducted censuses between 0600 and 1000 eastern standard time from 15 May to 1 July. For each point, we recorded the number of species, individuals per species, and total number of individuals seen and/or heard during the 10 min. For fields with more than one census point, we averaged bird abundance across points and censuses to obtain the mean number of individuals per census per point for the field. We also searched the study area for species of management concern at either the state or federal level (e.g., Henslow's Sparrow [*Ammodramus henslowii*] and Upland Sandpiper [*Bartramia longicauda*]) by walking transects and broadcasting songs in likely habitat.

We monitored nests of grassland and old-field species at Iroquois NWR in 1994, 1995, and 1996 to determine nest success and chronology for grassland birds; we restricted intensive nest searches and monitoring to this site because of time constraints. We located nests either by dragging ropes or by following birds to their nests. All nests located were marked with a small piece of flagging 5 m north of the nest and were checked at approximately 3-d intervals until fledging. We recorded the number of eggs and/or nestlings and checked for the presence of brood parasitism by Brown-headed Cowbirds (*Molothrus ater*). For species with a sample size larger than 10 per year, we used Mayfield's (1975) method to calculate nest success based on exposure.

We evaluated data from the 1995 field season on grassland bird-habitat relations at both the local, or in-field, and landscape levels using methods similar to those of Wiens and Rotenberry (1981) and Pearson (1993). Between 18 and 25 May 1995, we measured vegetation at 10-m intervals along 50-m transects extending out from each census point in the four cardinal directions ($N = 20$ samples/point). At each sampling point we passed a 3-mm-diam, 1-m-long rod vertically through the vegetation perpendicular to the ground and counted the number of contacts made by four classes of vegetation (grass, forb, shrub, and dead). These measurements were used to derive 12 in-field variables: (1) mean vegetation height; (2) maximum vegetation height; (3) coefficient of variation of vegetation height, which is a measure of horizontal heterogeneity; (4) proportion of ground cover; (5) number of vegetation contacts ≤ 25 cm; (6) number of vegetation contacts > 25 cm; (7) total vegetation contacts; (8) total forb contacts; (9) total grass contacts; (10) total shrub contacts; (11) total dead contacts; and (12) total number of shrub stems intersected by the transects.

In 1995 we quantified 10 landscape-level variables using a combination of Geographic Information Systems (GIS) technology and interpretation of U.S. Department of Agriculture Agricultural Stabilization and Conservation Service (ASCS) 1:20,000 aerial photographs. For each field we calculated three variables: field area (which was log transformed before use in subsequent analyses), field perimeter, and distance from the center of the field to the nearest field-forest edge. We quantified seven additional landscape-matrix variables in a 500-m radius from the edge of each field. These variables were measured from ASCS aerial photographs with a simple dot grid transparent overlay and were based on the proportion of area occupied by seven different habitat types: (1) old field with shrubs, (2) forb-dominated field, (3) cool-season grassland and pasture, (4) wetland, (5) cropland, (6) deciduous forest, and (7) warm-season grassland. Habitat types were determined during ground surveys; patches were then classified based on the predominant habitat type (> 50%) in the patch.

The vegetation and landscape measurements from 1995 produced sets of 12 and 10 variables, respectively. We used Principal Components Analysis (PCA) to simplify the structure in each variable set by reducing the original number of variables to a smaller set of new, uncorrelated variables or axes (factors). All vegetation and landscape variables except proportion of ground cover were used in the PCAs; ground cover was excluded because it showed almost no variation among fields. PCAs were performed on correlation matrices; the initial solution was then rotated to provide a clearer interpretation of the loadings, and those factors with eigenvalues greater than 1.0 were used in subsequent analyses of bird-habitat relationships (Wiens and Rotenberry 1981, Pearson 1993). We then constructed statistical models to describe the variation in bird communities using factor scores and abundance/species-richness data for each field; abundance/species-richness data were based on means for all 1995 censuses in each field. We focused primarily on grassland birds, which included species in the North American grassland avifauna of Mengel 1970 (see also Knopf 1994), with the addition of Bobolink (*Dolichonyx oryzivorous*). Response variables included number of grassland species (hereafter referred to as "species") observed in the field during the season; mean number of grassland birds per census per point for each field; and for each common grassland species in the study area (Savannah Sparrow [*Passerculus sandwichensis*], Bobolink, and Eastern Meadowlark [*Sturnella magna*]), mean number of individuals per census per point for the field. Stepwise multiple regression was then used to select and evaluate the power of specific vegetation and landscape factors in explaining variation among fields in 1995 response variables. In addition, correlation coefficients were calculated for the relationship between the abundance of individual bird species and scores for each field on the most important factors (Wiens and Rotenberry 1981); for comparative purposes, nongrassland species were included in this analysis.

Although we restricted most bird-habitat analyses to the larger 1995 data set, we did test the 1994 data on species richness and abundance for their response to field area using simple linear regression.

RESULTS

SPECIES RICHNESS AND ABUNDANCE

We observed five grassland bird species in the study area in 1994 and 1995: Northern Harrier (*Circus cyaneus*), Upland Sandpiper, Savannah Sparrow, Eastern Meadowlark, and Bobolink. Only the last three species were observed regularly (> 0.5 individuals/census/point) in at least one field.

Savannah Sparrows and Bobolinks were widely distributed throughout the study area, but Eastern Meadowlarks were observed regularly in only 4 of 34 fields censused in 1994 and in 4 of 43 fields censused in 1995. Other grassland species of management concern in the region, including Henslow's Sparrow, Grasshopper Sparrow (*Ammodramus savannarum*), and Vesper Sparrow (*Pooecetes gramineus*), were not observed in the study area, although Henslow's and Grasshopper sparrows have occurred sporadically at Iroquois NWR in the past (E. Derleth, pers. comm.).

The total number of species observed in a field and the average number of individuals per census per point increased with field area in both 1994 and 1995 (Table 2). We saw few species

TABLE 2. LINEAR CORRELATIONS (R^2) BETWEEN LOG OF FIELD AREA AND VARIOUS INDICES OF GRASSLAND BIRD ABUNDANCE IN WESTERN NEW YORK, 1994 AND 1995

	1994 (N = 34)	P	1995 (N = 43)	P
Species richness[a]	0.591	< 0.001	0.508	< 0.001
Number of individuals/census/point[a]				
Total grassland birds	0.604	< 0.001	0.365	< 0.001
Savannah Sparrow	0.551	< 0.001	0.354	< 0.001
Bobolink	0.395	< 0.001	0.261	< 0.001
Eastern Meadowlark	0.144	0.051	0.077	0.065

[a] Grassland species only (Northern Harrier, Upland Sandpiper, Savannah Sparrow, Bobolink, and Eastern Meadowlark).

or individuals in fields smaller than 5 ha (Fig. 1). The mean number of Savannah Sparrows and Bobolinks per census per point increased with area in 1994 and 1995 (Table 2, Fig. 2), with few individuals occurring in fields smaller than 5 ha. Abundance of these species did not increase, however, in larger old-field or warm-season grassland habitats (Fig. 2). The relationship between area and abundance was weak for Eastern Meadowlarks (Table 2), although this result may have been affected by the small number of fields where this species was recorded; it was not observed in fields smaller than 13 ha in either 1994 or 1995 (Fig. 2).

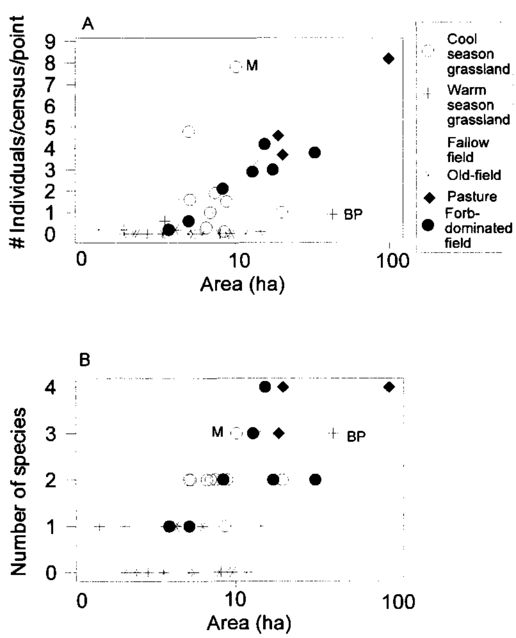

FIGURE 1. Mean number of grassland individuals per census per point (A) and number of grassland species (B) plotted against area (log transformed) in western New York fields, 1995. M = abandoned hayfield at Montezuma NWR; BP = Beattie Point warm-season grassland at Braddock Bay WMA (see "Results").

Grassland bird abundance and species richness were consistently lower in warm-season grasslands, including in the 44-ha field at Braddock Bay WMA, than in cool-season grasslands and pastures in the study area (Figs. 1 and 2). Common species in warm-season grasslands in-

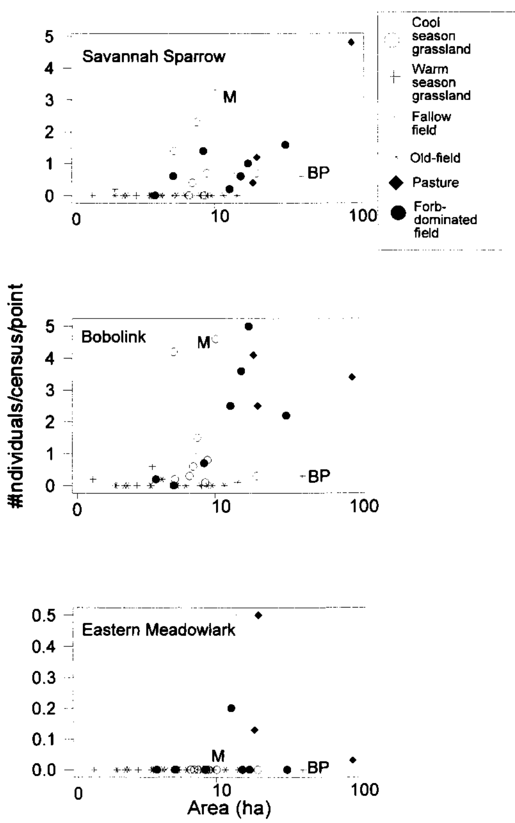

FIGURE 2. Mean number of individuals per census per point plotted against field area (log transformed) for Savannah Sparrows, Bobolinks, and Eastern Meadowlarks in western New York grasslands, 1995. M = abandoned hayfield at Montezuma NWR; BP = Beattie Point warm-season grassland at Braddock Bay WMA (see "Results").

TABLE 3. LANDSCAPE (L) FACTORS AND FACTOR LOADINGS GENERATED BY PRINCIPAL COMPONENTS ANALYSIS FOR GRASSLAND BIRDS IN WESTERN NEW YORK IN 1995

	Landscape factors				
	L1	L2	L3	L4	L5
Eigenvalue	2.831	2.676	1.291	1.276	1.221
Proportion of total variance explained	0.283	0.168	0.129	0.128	0.122
Cumulative proportion of variance explained	0.283	0.451	0.580	0.708	0.830
Variable					
Field area	0.551	−0.085	0.049	−0.180	−0.013
Field perimeter	0.532	−0.071	0.108	−0.279	−0.079
Distance to nearest field/forest edge	0.512	0.054	0.129	0.098	−0.106
Proportion warm-season grassland	−0.214	0.047	0.169	0.560	0.196
Proportion deciduous forest	0.192	−0.625	0.024	−0.035	−0.011
Proportion cool-season grassland	−0.150	−0.437	0.074	0.076	0.564
Proportion cropland	−0.148	0.014	−0.702	−0.189	−0.278
Proportion forb-dominated field	−0.114	0.203	−0.267	0.653	−0.098
Proportion old field	0.082	−0.019	0.576	0.052	−0.614
Proportion wetland	0.058	0.599	0.199	−0.308	0.402

Note: Only factors with eigenvalues > 1.0 are shown.

cluded Swamp Sparrow (*Melospiza georgiana*), Song Sparrow (*M. melodia*), and Field Sparrow (*Spizella pusilla*). Two species of management concern in the Northeast (Schneider and Pence 1992) used switchgrass fields during the study: Northern Harriers nested in switchgrass fields at Tonawanda and Braddock Bay WMAs, and Sedge Wrens (*Cistothorus platensis*) held territories in switchgrass fields at Iroquois NWR and at Braddock Bay WMA. The one field in the study area with a dense growth of alfalfa (*Medicago sativa*), a 10.1-ha former hayfield at Montezuma NWR, supported a much greater abundance of grassland birds than predicted on the basis of area alone (Fig. 1).

MULTIVARIATE ANALYSIS OF BIRD-HABITAT RELATIONSHIPS

PCA produced five landscape and three vegetation factors with eigenvalues greater than 1.0; these accounted for 83.0 and 77.6% of the total variation, respectively (Tables 3 and 4). These factors were interpreted by examining loadings on the original variables. Among the landscape factors, L1 clearly represented area, with three variables related to field area (field area, field perimeter, and distance from the center of a field to the nearest field/forest edge) having high positive loadings on the axis (Table 3). Fields with high scores on factor L2 were surrounded by

TABLE 4. VEGETATION (V) FACTORS AND FACTOR LOADINGS GENERATED BY PRINCIPAL COMPONENTS ANALYSIS FOR GRASSLAND BIRDS IN WESTERN NEW YORK IN 1995

	Vegetation factors		
	V1	V2	V3
Eigenvalue	4.299	3.136	1.214
Proportion of total variance explained	0.391	0.285	0.110
Cumulative proportion of variance explained	0.391	0.676	0.776
Variable			
Total vegetation contacts	−0.430	−0.229	0.027
Vegetation contacts > 25 cm	−0.415	−0.074	0.151
Mean vegetation height	−0.413	0.145	0.129
Total dead contacts	−0.402	−0.184	0.207
Maximum vegetation height	−0.323	0.351	0.180
Vegetation contacts ≤ 25 cm	−0.320	−0.293	−0.084
Total shrub contacts	−0.192	0.373	−0.533
Total shrub stems	−0.184	0.374	−0.523
Coefficient of variation of vegetation height	−0.126	0.391	0.209
Total grass contacts	−0.106	−0.365	−0.404
Total forb contacts	0.080	0.336	0.337

Note: Only factors with eigenvalues > 1.0 are shown.

TABLE 5. STEPWISE MULTIPLE REGRESSION MODELS OF GRASSLAND BIRD-HABITAT RELATIONSHIPS IN WESTERN NEW YORK

Bird variable	Habitat variables entered into model[a]	Partial r^2	r^2
Species richness	L1	0.43	0.51
	V2	0.08	
Abundance	L1	0.60	0.66
	V1	0.06	
Savannah Sparrow	L1	0.57	0.62
	V1	0.05	
Bobolink	L1	0.43	0.43
Eastern Meadowlark	No variables entered into model at $P < 0.05$		

Note: All variables given have $P < 0.05$; r^2 is the proportion of the total variation in the particular bird variable explained by the model.
[a] L1 = area, V2 = vegetation heterogeneity/shrub density, V1 = vegetation height/density.

large amounts of wetland habitat and small amounts of deciduous forest habitat. Factor L3 represented a gradient from increased shrubby old-field habitat to increased cropland. Fields with high positive scores on L4 had large amounts of forb-dominated fields and warm-season grasslands surrounding them; fields with high positive scores on L5 were surrounded by relatively large amounts of cool-season grassland and small amounts of old-field habitat (Table 3).

Vegetation factor V1 appeared to represent a gradient from tall, dense vegetation with a small amount of standing dead vegetation (negative factor scores on V1) to low, less dense vegetation (positive scores on V1; Table 4). Factor V2 represented a gradient from areas with less heterogeneous vegetation (negative scores on V2) and fewer shrubs to areas with greater horizontal heterogeneity, more shrubs, and less dense grass (positive scores on V2). Fields with high positive scores on factor V3 had greater forb cover and low grass and shrub cover. The vegetation factors should be interpreted cautiously, however, as loadings on the original variables were generally ≤ 0.500 (Table 4).

Bird-habitat models generated by stepwise multiple regression analysis suggested that most variation in grassland bird abundance and species richness was accounted for by the area variables (Table 5). Species richness was most strongly related to area (L1; partial $r^2 = 0.43$), with V2 (vegetation heterogeneity and shrub density) explaining an additional 8% of the variation (Table 5). Thus, larger areas with fewer shrubs, and consequently lower horizontal heterogeneity, tended to have more grassland birds species. A model incorporating area (L1) and vegetation height and density (V1) explained 66% of the among-field variation in grassland bird abundance (Table 5); larger fields with lower, less dense vegetation tended to have more individuals than did smaller fields with taller, dense vegetation. The variable related to field area (L1) was also most important in accounting for variation in abundance of Savannah Sparrows and Bobolinks; vegetation height and density (V1) explained only 5% of the variation in Savannah Sparrow abundance (Table 5). No model explained a significant amount of the variation in Eastern Meadowlark abundance. When variables L1 and V1 were forced into a stepwise multiple regression, they accounted for only 3.9% of the variation in Eastern Meadowlark abundance, even though the species was not seen in fields smaller than 13 ha (Fig. 2). This result may have been due to the small number of fields with meadowlarks. Although the vegetation heterogeneity and shrub density factor (V2) explained a significant amount of variation only in species richness (Table 5), there was no significant correlation between shrub density and grassland bird species abundance ($r^2 = 0.063$, $P = 0.109$). In general, fields with the most shrubs supported few grassland birds.

The distribution of bird species along gradients in habitat structure can also be illustrated with a three-dimensional plot of correlation coefficients for the relationship between the abundance of individual species and the L1, V1, and V2 factors (Fig. 3). Grassland birds were most abundant in large fields (high positive correlations with L1 factor scores), shorter, less dense vegetation (high positive correlations with V1 factor scores), and less shrub cover (negative correlations with V2 factor scores). In contrast, old-field species such as Song Sparrow, Common Yellowthroat (*Geothlypis trichas*), and Yellow Warbler (*Dendroica petechia*) were most abundant in smaller fields with denser vegetation and more shrubs (Fig. 3).

BREEDING BIOLOGY

Evidence of breeding (nests with eggs or young, or fledged young) was noted for Northern Harriers, Savannah Sparrows, Bobolinks, and Eastern Meadowlarks. In 1994, 1995, and 1996, we determined the outcome of 109 nests of three grassland bird species at Iroquois NWR (Table 6). The combined (1994–1996) proportion of successful nests was 0.76 for Savannah Sparrows, 0.54 for Bobolinks, and 0.67 for Eastern Meadowlarks (Table 6). The probability of survival to fledging (Mayfield 1975) was higher for Savannah Sparrows than for Bobolinks in both 1994 (0.795 vs. 0.646, respectively) and 1995 (0.709 vs. 0.139, respectively). The low survival probability for Bobolinks in 1995 was

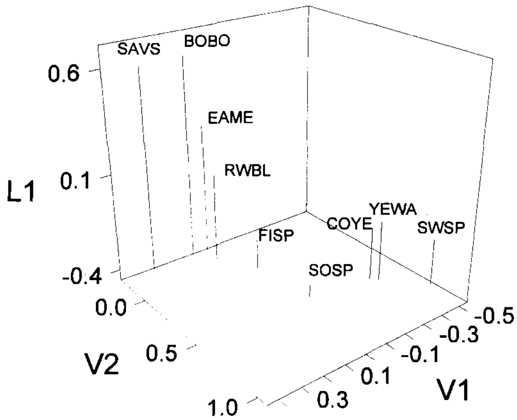

FIGURE 3. Plot of correlation coefficients for abundance (mean number of individuals/census/point) of individual species and L1, V1, and V2 factor scores for fields in western New York, 1995. See text for interpretation of axes. BOBO = Bobolink, COYE = Common Yellowthroat, EAME = Eastern Meadowlark, FISP = Field Sparrow, RWBL = Red-winged Blackbird (*Agelaius phoeniceus*), SAVS = Savannah Sparrow, SOSP = Song Sparrow, SWSP = Swamp Sparrow, YEWA = Yellow Warbler.

due to a high rate of nest loss early in the nestling period (five of nine active nests were depredated 1–5 d after hatching). There were no significant differences between the proportion of successful nests in pastures versus cool-season grasslands for either Savannah Sparrows (χ^2 = 0.781, df = 1, P = 0.377) or Bobolinks (χ^2 = 0.626, df = 1, P = 0.429) for all nests found in 1994–1996 (Table 6). None of the 109 nests located during the study were parasitized by Brown-headed Cowbirds.

Combined data on grassland bird breeding chronology for the 3-yr period indicated that most pairs initiated clutches during the second half of May and fledged young in mid-June. Bobolinks tended to initiate nesting somewhat later than Eastern Meadowlarks or Savannah Sparrows; median fledging dates for 1994–1996 were 10 June for Eastern Meadowlarks, 12 June for Savannah Sparrows, and 20 June for Bobolinks. Late fledging dates for known nests were 30 June for Bobolinks, 2 July for Eastern Meadowlarks, and 6 July for Savannah Sparrows. A pair of Northern Harriers nesting at Braddock Bay WMA initiated a clutch on 21 May 1995; fledging would have occurred at the end of July.

DISCUSSION

Our results suggest that the more widely distributed grassland species in western New York, especially Savannah Sparrow and Bobolink, have been sustaining breeding populations on state and federally administered lands in the study area. In 1994–1995, fields larger than 10 ha generally supported both species, with mean abundances of three or more individuals per census per point and relatively high rates of nest success. The proportion of successful Savannah Sparrow nests (0.76) was higher than has been reported for this species in Maine (0.33; Vickery et al. 1992), New Brunswick (0.40; Dixon 1978), or Michigan (0.52; Potter 1974). The proportion of successful Bobolink nests at Iroquois NWR (0.54) was within the range of values (< 0.38 to < 0.88) reported for sites in New York (Gavin and Bollinger 1988) and Wisconsin (Martin 1974). The proportion of successful Eastern Meadowlark nests (0.67) was higher than observed in three other studies (Lanyon 1957, Roseberry and Klimstra 1970, Granfors et al. 1996), although the sample size (N = 12) was too small to confidently evaluate nest success.

MANAGEMENT IMPLICATIONS

Our results emphasize the importance of habitat area for grassland bird species richness and abundance. This relationship has been observed elsewhere in the Northeast (Bollinger and Gavin 1992, Smith and Smith 1992, Vickery et al. 1994), and it suggests that managers should consider practices that will increase grassland area, such as hedgerow removal and consolidation of adjacent fields, as means of increasing grassland bird populations.

Increasing the size of fields in our study area may not attract species of management concern such as Grasshopper and Henslow's sparrows, however. Because fields of up to 98 ha already occur at Iroquois NWR, and because both Grass-

TABLE 6. PROPORTION OF SUCCESSFUL NESTS (AND SAMPLE SIZES) BY YEAR AND HABITAT TYPE FOR GRASSLAND SPECIES AT IROQUOIS NWR IN WESTERN NEW YORK, 1994–1996

	Proportion of successful nests					
Species	1994	1995	1996	Combined	Pasture	Cool-season grassland
Savannah Sparrow	0.81 (26)	0.72 (25)	0.71 (7)	0.76 (58)	0.77 (47)	0.64 (11)
Bobolink	0.63 (24)	0.40 (10)	0.40 (5)	0.54 (39)	0.47 (19)	0.60 (20)
Eastern Meadowlark	0.67 (3)	0.50 (2)	0.71 (7)	0.67 (12)	0.57 (7)	1.00 (2)

hopper and Henslow's sparrows have bred at Iroquois NWR in the past, their absence cannot be attributed to area effects alone. These species are found in fields as small as 11 and 30 ha, respectively, in the Finger Lakes National Forest in central New York (Smith and Smith 1990, 1992), and Grasshopper Sparrows have nested and fledged young in fields as small as 4 ha at Mendon Ponds County Park, near Rochester, New York (C. Norment, pers. obs.). The absence of these two species from our study area is more likely due to a combination of their specific habitat requirements (Wiens 1969, Smith and Smith 1990, Delaney and Linda 1994, Herkert 1995b) and their sporadic occurrence in the region. Given the absence of these species from Iroquois and Montezuma NWRs, attempting to manage primarily for species of concern at these refuges does not appear to be a reasonable objective. Habitat requirements and management options for these species should still be considered when developing management plans, however (Swanson 1996, Jones and Vickery 1997). Additionally, more effort should be devoted to analyzing the habitat preferences and management needs of the Eastern Meadowlark, which is declining across much of its range in the Northeast (Robbins et al. 1986, Bollinger and Gavin 1992). Although once described as "one of the commonest birds of the fields of western New York" (Beardslee and Mitchell 1965), this species is relatively uncommon in the study area.

Few vegetation variables significantly increased the explanatory power of the bird-habitat models. Shrub density, however, did appear to have a negative effect on both grassland bird species richness and abundance. Vegetation factor V2, which appeared to be related to shrub density, explained a significant amount of variation in species richness, and fields with large numbers of shrubs supported few grassland birds (Fig. 3). Also, the three-dimensional plot of the correlations between bird species abundances and L1 (area), V1 (vegetation height and density), and V2 (horizontal heterogeneity and shrub density) factor scores (Fig. 3) suggests that grassland birds are more abundant in fields with fewer shrubs and shorter, open vegetation. These observations indicate that increasing the frequency of disturbance by mowing may increase the abundance and richness of grassland birds in the study area.

Several fields on state and federal land in our study area have been planted in dense switchgrass monocultures to provide nesting cover for waterfowl (Iroquois NWR 1990). Our results indicate that switchgrass does not provide favorable habitat for most grassland birds; even the largest warm-season grassland (44 ha) had few Bobolinks or Savannah Sparrows, and individuals of both species were confined to portions of the field with lower, less dense cover. In other regions, switchgrass also appears to support low numbers of grassland birds, especially of species that require open habitats (Volkert 1992; Prescott and Murphy 1995; R. C. Gatti, unpubl. data). Thus, although switchgrass fields may be more productive for nesting waterfowl than are cool-season grasslands in our study area (Estel 1989), they are not suitable for most grassland birds. The decision as to whether or not to plant and maintain fields with switchgrass monocultures should be based on the overall management goals for the area.

The relatively high abundance of grassland birds in pastures (Fig. 1) and the increased abundance of grassland birds observed in pastures in 1995 versus 1994, as opposed to the trend in cool-season grasslands (Table 3), suggest that grazing as practiced at Iroquois NWR is not detrimental to grassland birds in the area. The combination of low- to moderate-intensity grazing and mowing may be beneficial to grassland birds at Iroquois NWR because these practices retard succession and shrub establishment. Currently, cattle are allowed onto pastures at Iroquois NWR in mid-July and remain there until the end of October. Stocking rates range from 0.60 to 0.83 cattle per ha, which is similar to stocking rates at Finger Lakes National Forest in central New York, where species such as Grasshopper and Henslow's sparrows are relatively common (Smith and Smith 1990, 1992). Pastures at Iroquois NWR are also mowed, usually in August or September (S. Lor, pers. comm.). The absence at Iroquois NWR of cattle and other forms of disturbance, such as mowing, until at least mid-July means that grassland birds are able to raise at least one brood undisturbed. This observation supports the point that all forms of disturbance should be prohibited on pastures and other grasslands at least until birds have fledged their first broods (Andrle and Carroll 1988, Bollinger and Gavin 1992). For most species in the study area, an appropriate date for this would be 15 July, although switchgrass fields where Northern Harriers nest should not be mowed until early August (Beardslee and Mitchell 1965, Andrle and Carroll 1988).

Finally, management agencies should attempt to standardize field treatments such as mowing, herbicide application, and seeding. The current landscape on state and federally managed lands in our study area is a complex mosaic of deciduous forests, wetlands, and open fields in various stages of succession. Successional patterns have been influenced by a variety of treatments, with apparently little consideration given to replication and standardization of methods. Thus, understanding how succession and treatment effects influence grassland bird species richness and abundance in the study area has been complicated by the large number of treatment variables. For example, mowing has occurred with and without herbicide application, with and without disking, and with and without planting a variety of native or introduced cool-season grasses, thus making it difficult to separate the effects of the treatment variables. Successfully managing for grassland birds, or for any other wildlife, requires a clear understanding both of objectives and of how particular methods influence succession, habitats, and species.

ACKNOWLEDGMENTS

Funding for this project was provided by the U.S. Fish and Wildlife Service, New York State Department of Environmental Conservation, and Office of the Vice President for Academic Affairs and Scholarly Incentive Award Program of the State University of New York College at Brockport. D. Robinson, Jr., J. Romaneo, and B. Sheppard assisted with fieldwork. D. Tiller, S. Lor, and P. Caldwell of the U.S. Fish and Wildlife Service assisted with the project, as did D. Carroll and D. O'Dell of the New York State Department of Environmental Conservation. P. D. Vickery and two anonymous reviewers greatly improved the manuscript.

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APPENDIX. DESCRIPTION OF HABITAT TYPES OF FIELDS CENSUSED FOR GRASSLAND BIRDS IN WESTERN NEW YORK, 1994–1995

Habitat type	Description
Warm-season grassland	Grassland dominated by switchgrass (*Panicum virgatum*), which produces most or all of its growth in late spring or summer.
Cool-season grassland	Ungrazed grassland dominated by plants that produce the major portion of their growth in spring. Common grasses include timothy (*Phleum pratense*), brome-grass (*Bromus inermis*), orchard grass (*Dactylis glomerata*), and redtop (*Agrostis gigantea*). Common forbs include alfalfa (*Medicago sativa*), clover (*Trifolium* spp.), and birds-foot trefoil (*Lotus corniculatus*).
Pasture	Grazed grassland; common species are similar to those found in cool-season grasslands.
Fallow farm field	Agricultural land no longer being cultivated; dominated by early-successional grasses and forbs. Vegetation may be similar to that in cool-season grasslands, forb-dominated fields, or old fields with shrubs.
Forb-dominated field	May contain species found in cool-season grasslands, but forbs such as goldenrod (*Solidago* spp.), wild carrot (*Daucus carota*), and milkweed (*Asclepias* spp.) are common. Shrubs may also be present (cover $< 5\%$).
Old field with shrubs	Formerly open habitat with a mix of grasses, forbs, and shrubs (cover $> 5\%$). Common species include bramble (*Rubus* spp.), willow (*Salix* spp.), red osier dogwood (*Cornus stolonifera*), choke cherry (*Prunus virginiana*), Russian olive (*Elaeagnus angustifolia*), narrowleaf meadowsweet (*Spirea alba*), and arrowwood (*Viburnum* spp.).

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