FINAL REPORT

EFFECTS OF GRASSLAND BIRD MANAGEMENT ON NONGAME BIRD COMMUNITY STRUCTURE AND PRODUCTIVITY

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PREFACE

This report presents the results of five field seasons of research (1994-1998) on the ecology of grassland birds in western New York. Most of the research was conducted at Iroquois and Montezuma National Wildlife Refuges, although additional study sites were located on lands owned by the New York State Department of Environmental Conservation, Monroe County, and private individuals. The field work was funded in large part by a series of Challenge Grants from Region 5 of the United States Fish and Wildlife Service, with additional financial support from the New York State Department of Environmental Conservation and the State University of New York College at Brockport.

The report includes data on bird/habitat relations, breeding biology, and effects of succession and current management practices on grassland bird communities in the study area. I use these data, along with the results of other studies, to produce a set of general management recommendations designed to encourage grassland bird populations in the Northeast, as well as specific recommendations for important grasslands at Iroquois and Montezuma National Wildlife Refuges. *However, these management recommendations should be considered only in the light of the assumptions used in their formulation.* Consequently, it is important for land managers and biologists to review the assumptions given on pages 90-93 of the report. I also believe that it is important for anyone interested in promoting grassland bird populations in the Northeast to consider the issues raised in the section, "On the Need to Develop a Comprehensive USFWS Management Plan for Grassland Birds in the Northeast Region." This section discusses grassland birds in the Northeast in the context of the vegetation history of the region, and the principles of

ecosystem management. If the conservation of grassland birds is to be a priority in the region, then we will need to develop a comprehensive management plan for them – one incorporating an explicit temporal and spatial perspective, and the recognition that grasslands and the birds that they support cannot be managed in isolation from other habitats and taxa.

INTRODUCTION

Populations of many grassland birds in North America have declined significantly during the last 30 years (Robbins et al. 1986, Knopf 1994, Sauer et al. 1997). Although declines of many groups of North American breeding birds vary across geographic regions (James et al. 1992, Peterjohn and Sauer 1994, Herkert 1995a), the continental trend evident for grassland birds is consistent across much of North America, including the Northeast (Robbins et al. 1986, Bollinger and Gavin 1992, Vickery 1992, Askins 1993, Sauer et al. 1997). By the early 1990s, birds of grassland and open habitats were the most frequently listed species in the Northeast, with 12 species of grassland and other open habitats listed by three or more states (Vickery 1992). Reasons for the decline of grassland birds in the northeastern United States include farmland abandonment, decline of hayfield area, and early season, more frequent haycropping schedules (Andrle and Carroll 1988, Bollinger and Gavin 1992, Askins 1997, Vickery and Dunwiddie 1997). As many grassland bird species are area-sensitive, these species are particularly vulnerable to loss of grassland habitat (Vickery et al. 1994, Smith 1997). In the Northeast, grassland area has declined by about 60% since the 1930s (Vickery et al. 1994).

Given the concern over declining grassland birds in the Northeast, in 1994 I began a long-term study of grassland bird populations in western New York, with funding support provided by the United States Fish and Wildlife Service (USFWS), the New York State Department of Environmental Conservation (NYSDEC), and the Office of the Vice President for Academic Affairs at the State University of New York College at Brockport. Major objectives of the study were to determine grassland bird species

richness and abundance, breeding biology, and habitat relations in the region. Breeding biology studies focused on determining nest success and chronology, while bird-habitat relations were examined at the local (vegetation) and landscape levels, in both unmanipulated and manipulated upland habitats. Results of the study were to 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. Data presented here were gathered between 1994 and 1998, under Challenge Cost Share Agreement No. 14-48-0005-94-9005 between the USFWS and The Research Foundation of State University of New York, which involved four years of funding through the USFWS Challenge Grant Program. Some data gathered in 1998, under another Challenge Cost Share Agreement (1448-5018-98-J-047) are also included. This report includes material presented in Ardizzone (1996), Norment et al. (1999, in press) and Ardizzone and Norment (1999, in press).

STUDY AREA

I began the study in May 1994 at Iroquois National Wildlife Refuge (NWR) and contiguous NYSDEC Tonawanda and Oak Orchard Wildlife Management Areas (WMAs), located approximately 65 km west of Rochester, NY, in the Great Lakes Plain ecozone of New York (Andrle and Carroll 1988). These areas consist of approximately 8,000 ha of wetland and upland habitat, which historically have been managed to provide habitat for breeding and migratory waterfowl (Iroquois NWR 1993). However, > 1,000 ha of potential upland habitat for grassland birds exist in the Iroquois NWR – Oak Orchard and Tonawanda WMA complex. 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, and pastures (Iroquois NWR 1990); see Appendix 1 for a description of habitat types. Fields examined in the vicinity of Iroquois NWR ranged in size from 0.5 ha to 98 ha, interspersed in a landscape matrix of wetlands, croplands, and hardwood forests. (See Table 1 for types and size ranges of fields in the study area censused for birds in 1995.) Continued funding in 1995 allowed me to expand the scope of the project to include the 44 ha warm season grassland at Beattie Point at the NYSDEC Braddock Bay WMA, 11 km west of Rochester New York, and upland habitat in the vicinity of Montezuma NWR, Seneca County, on lands administered by the USFWS and NYSDEC. The grassland at Braddock Bay is located adjacent to the southern shore of Lake Ontario, and is surrounded by extensive wetlands, small patches of deciduous forest, and the Lake Ontario Parkway. A mixture of wetlands, agricultural fields, and deciduous forest surrounds upland habitat in the Northern Montezuma Wetlands Complex. Finally, several patches of grassland habitat at Mendon Ponds County Park, Monroe County, about 10 km southeast of Rochester, NY were included in the study area during the 1996 - 1998 field seasons. These fields were located in a landscape matrix of deciduous forest, old fields, agricultural fields (both active and fallow), and suburban housing developments.

CHRONOLOGICAL RECORD OF GRASSLAND BIRD RESEARCH ACTIVITIES, 1994-1998.

Grassland bird research activities between 1994-1997 were related to the Challenge Cost Share Agreement discussed in this report, although not all were funded by the USFWS. Activities in 1998 were funded primarily by other grants. During the 1994-1997 period,

Table 1. Types and size ranges for fields censused for grassland birds in western New York, 1995.

Habitat type	Iroquois NWR[1]	Montezuma NWR[2]	Braddock Bay WMA	Total	Range of area (ha)
Cool season grassland[3]	8	1		9	5.1-20.1
Warm season grassland	6		1	7	1.3 - 44
Pasture	3			3	19.0 - 98.4
Fallow 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

1. Includes Oak Orchard and Tonawanda Wildlife Management Areas.

2. Includes New York State Department of Environmental Conservation lands within the Northern Montezuma Wetlands Complex.

3. Habitat descriptions given in Appendix 1.

two SUNY Brockport Masters students and nine undergraduate students were employed in various aspects of the research.

1994:
*Initiated project with fieldwork on the breeding biology and habitat selection of grassland birds at Iroquois NWR and Oak Orchard and Tonawanda WMAs.

1995:
*Continued fieldwork at Iroquois NWR; expanded study to include study sites at Montezuma NWR, adjacent NYSDEC lands, and Braddock Bay WMA.
*Presented two papers on grassland bird research at the International Conference and Training Workshop on Conservation and Ecology of Grassland Birds in Tulsa, Oklahoma in October, 1995.

1996:
*Continued fieldwork in all parts of the study area; expanded study to included sites at Mendon Ponds County Park.
*Attended a Northeast Partners in Flight meeting, and another meeting on grassland bird research, at Cornell University.
*Submitted two manuscripts related to presentations made at the grassland bird research and conservation in Tulsa, Oklahoma; papers to be published in *Studies in Avian Biology* in 1999:
Ardizzone, C. D. and C. J. Norment. 1999. Experimental analysis of nest predation: Effects of habitat and nest distribution (in press).
Norment, C. J., C. D. Ardizzone, and K. Hartman. 1999. Habitat relations and breeding biology of grassland birds in western New York: Management implications (in press).
*Attended the New York Natural History Conference IV in Albany, and presented two papers on grassland bird research.
*Traveled to Fort Drum and Carleton Hills WMA to evaluate grassland habitat in other parts of New York.
*Presented talks on grassland bird conservation at Hamilton College, and to the Onondaga Audubon Society, Syracuse.
*M.S. thesis completed by Charles Ardizzone, SUNY College at Brockport: Experimental Analysis of Nest Predation in a New York Grassland and Habitat Relations of Grassland Birds in Western New York.

1997
*Continued fieldwork in all parts of the study area.
*Began supervising work on an associated thesis project on the spatial structure of Grasshopper Sparrow populations in the Mendon Ponds, Monroe County, New York area.
*Presented a talk on grassland bird conservation to the Genesee Ornithological Society.

1998
*Continued work in all parts of the study area.
*Prepared final report on project.

*Began a supervising research on a Department of Defense-sponsored thesis project on the breeding biology of Henslow's Sparrow on the Ft. Drum Military Reservation.
*Surveyed grassland birds in a portion of the St. Lawrence River Valley Grassland Management Area.

METHODS

Bird Species Richness and Abundance.-- We determined grassland bird species richness and abundance using fixed, 50-m radius point counts. The 50-m radius was chosen instead of the 100-m radius recommended for standardized grassland bird censuses in the northeast (Vickery and Jones 1995) so that fields < 200 m in width could be included in the study. Each point was censused for 10 min/census between 0600 and 1000 hours EST from 15 May to 1 July. Each point was censused five times/year in 1994 and 1995. Because there was little change in either mean abundance or species richness as the number of censuses increased from three to five, I reduced the number of censuses/point to three in 1996, 1997, and 1998. In order to partially control for area-related differences in sampling intensity, no more than one census point was placed in fields < 10 ha, while a density of approximately once census point/7ha was maintained in larger fields. In fields with > 1 census point, point centers were separated by at least 200 m to minimize recounts. The number of fields and points censused differed among years (Appendix 2), with a maximum of 82 points in 43 fields censused in 1995, and 65 points in 41 fields censused in 1996. We also searched the general study area for grassland species of management concern at either the state or federal level by walking transects and broadcasting taped songs in likely habitat. Although we recorded all species seen at our census points, most analyses presented in this report focus on "grassland species," which include the Northern Harrier (*Circus cyaneus*), Upland Sandpiper (*Bartramia*

longicauda), Eastern Meadowlark (*Sturnella magna*), Bobolink (*Dolichonyx oryzivorous*), Grasshopper Sparrow (*Ammodramus savannarum*), Henslow's Sparrow (*Ammodramus henslowii*), and Savannah Sparrow (*Passerculus sandwichensis*) (Knopf 1994).

Breeding Biology.—We monitored nests of grassland and old-field species to determine nest success and chronology for grassland birds. Because of time constraints, intensive nest searches and monitoring were limited to Iroquois NWR. The most intensive nest searches and monitoring occurred in 1994, 1995, and 1996; we found smaller numbers of nests in 1997 and 1998. We marked all known nests with a small piece of flagging placed 5 m from the nest, and checked them at approximately 3-d intervals until fledging. Number of eggs and/or nestlings were recorded, along with any evidence of brood parasitism by Brown-headed Cowbirds (*Molothrus ater*). I used the program MAYFIELD (Hines 1999), which is based on the method of Bart and Robson (1983), to calculate the daily probability of nest survival during the incubation and nestling phases, based on exposure, for species with adequate sample sizes (≥ 10): Bobolink, Eastern Meadowlark, and Savannah Sparrow. Data on the proportion of nests fledging at least one nestling are also presented.

We conducted two sets of nest predation experiments using artificial nest cups and quail (*Coturnix coturnix*) eggs in both 1994 and 1995; details of the methods are given in Ardizzone and Norment (1999, in press). Briefly, the first experiment was designed to examine the effect of distance from the nearest forest edge on nest success in pastures and cool season grasslands. Twenty-one transects of seven nest cups, each with one quail

egg, were placed at distances of 0, 25, 50, 75, 100, 125, and 150 m from the forest edge; transects were separated from one another by at least 100 m. The second experiment, in conjunction with the first, was designed to examine effects of dense nesting cover (DNC) on nest success. In this experiment nests were placed perpendicular to boundaries between forests and adjacent warm season grasslands dominated by switchgrass. Transects were set up as in the first experiment, but because of the relatively small size of switchgrass fields, all nest cups in the experiment were within 100m of the nearest field-forest boundary.

Habitat Relations.-- I evaluated data on grassland bird/habitat relations at both the local, or within-field, and landscape scales using methods similar to those in Wiens and Rotenberry (1981), and Pearson (1993).

Vegetation Variables: We measured vegetation at each census point in late May and early June of 1994 through 1998, although the methods used to measure vegetation were changed after the 1995 field season. In 1994 and 1995, we measured vegetation at 10-m intervals along 50-m transects extending outward from each census point in the four cardinal directions ($n = 20$ samples/point). At each sampling point, a 3-mm diameter, 1-m rod was passed vertically through the vegetation perpendicular to the ground. The number of contacts made by four classes of vegetation (grass, forb, shrub, dead) were counted. These measurements were used to derive 13 within-field variables: (1) mean vegetation height (MNHT); (2) maximum vegetation height (MXHT); (3) standard deviation of vegetation height (SDHT), which is a measure of horizontal heterogeneity; (4) coefficient of variation of vegetation height (CVHT), a second measure of horizontal heterogeneity; (5) proportion of ground cover (GRCV); (6) number of vegetation contacts

≤ 25 cm (CT≤25); (7) number of vegetation contacts > 25 cm (CT>25); (8) total vegetation contacts (TOTCT); (9) total forb contacts (FORB); (10) total grass contacts (GRAS); (11) total shrub contacts (SHRB); (12) total dead contacts (DEAD); and (13) total number of shrub stems intersected by the transects (SBCOV).

Because relatively few vegetation variables measured in 1994-1995 proved useful in explaining among-point variation in grassland bird abundance and species richness, I adopted a method similar to that of Bollinger (1995) in subsequent years of the study. We sampled vegetation at five points along 50-m transects extending outward from each census point in the four cardinal directions (n = 20 samples/point); sampling points were located 49, 41, 33, 25, and 15 m from each census point. These distances were selected to produce approximately equal sampling intensity, on an area basis, within each circular plot. At each point, the 3-mm diameter, 1-m rod was passed vertically through the vegetation perpendicular to the ground and the number of contacts in 0-25 cm and > 25 cm height intervals were counted. In addition, we measured litter depth to the nearest 1 cm at the point where the rod intersected the ground. We then centered a 0.25 m^2 (50 cm X 50 cm) sampling frame on the point to visually estimate coverage classes for various vegetation variables. For each variable, the following six coverage classes were used: < 5%; 5 to < 25%; 25 to < 50%; 50 to < 75%; 75 to < 95%; > 95%. The variables that we measured were: percent total cover; percent legume cover; percent goldenrod (*Solidago* spp.) cover; percent dead grass cover; percent dead forb cover; % live grass cover; percent live forb cover; percent shrub cover; and % canopy cover. Midpoint values for each cover class then were used in subsequent statistical analyses. We also counted the number of plant genera, and measured the tallest shrub, within the quadrat. Finally, we

tallied the number of shrub species (without attempting to distinguish among species of willow [*Salix*] or hawthorn [*Crataegus*]), and visually estimated total shrub cover within a 50-m radius of the bird census point.

These measurements were used to derive 19 within-field variables for subsequent analyses: (1) mean vegetation height (MNHT); (2) coefficient of variation of vegetation height (CVHT); (3) mean shrub height (SHBHT); (4) number of vegetation contacts ≤ 25 cm (CT≤25); (5) number of vegetation contacts > 25 cm (CT>25); (6) total vegetation contacts (TOTCT); (7) mean litter depth; (8) mean percent legume cover (%LEG); (9) mean percent *Solidago* cover (%SOL); (10) mean percent dead grass cover (%DGRA); (11) mean percent live grass cover (%LGRA); (12) mean percent shrub cover within quadrats (%SHBC); (13) mean percent live forb cover (%LFOR); (14) mean percent dead forb cover (%DFOR); (15) mean total cover (%TCOV); (16) mean genus richness (GENUS); (17) percent total shrub cover in 50-m radius census plots (TSHBC); (18) total shrub species richness (SHBSP); and (19) number of quadrats with shrubs (NQSHB). Mean values for cover variables were calculated based on midpoint values for each cover class.

Landscape Variables: In 1994, 1995 and 1996, ten landscape-level variables were quantified using a combination of geographic system (GIS) technology and interpretation of USDA Agricultural Stabilization and Conservation Service (ASCS) 1:20,000 aerial photographs. For each field, we calculated three variables: (1) field area (AREA), which was log-transformed before use in subsequent analyses; (2) field perimeter (PERM); and (3) distance from the center of the field to the nearest field-forest edge (EDGE). Eight additional landscape matrix variables were quantified in a 500-m radius extending from

the edge of each field. These variables were based on the proportion of area occupied by eight habitat types, and were measured from ACSC aerial photographs with a simple dot grid transparent overlay: (1) old field with shrubs (POLD); (2) forb-dominated field (PFRB); (3) cool season grasslands and pastures (PCSG); (4) wetland (PWSG); (5) cropland (PCRP); (6) deciduous forest (PDEC); (7) warm season grassland (PWSG); and (8) human habitation (PHUM), which was almost nonexistent in most parts of the study area. Habitat types were determined during ground surveys; patches were then classified based upon the predominant habit type (> 50%) within the patch. In 1996, an additional landscape-level variable was measured for each field, based upon readings for the angle between the ground and the tallest vegetation on the horizon; all readings were taken at height of 1 m. We made eight measurements at each bird census point, one within each of the eight octants within the circular plot. These were averaged to produce a mean angle between the ground and the tallest vegetation on the horizon for the point.

Statistical Analyses of Bird/Habitat Relationships: The vegetation and landscape measurements from 1994 and 1995 produced sets of 13 and ten variables, respectively. Those measurements in 1996 produced sets of 19 and 11 variables, respectively. I then used Principle Components Analysis (PCA) to simplify the structure within each year's data set by reducing the original number of variables to a smaller set of new, uncorrelated variables or axes (factors). In 1995 all variables except ground cover and human habitation were used in the PCAs; ground cover was excluded because it showed almost no variation among fields, while the proportion of area in human habitation within 0.5 km of the field was close to 0 for all fields. In 1996, all variables except human habitation were used in the PCAs, while in 1997 and 1998, analyses were restricted to a more

detailed examination of vegetation variables. PCAs were performed on correlation matrices; the initial solution was then rotated to provide a clearer interpretation of the loadings; factors with eigenvalues > 1.0 were used in subsequent analyses of bird-habitat relationships (Wiens and Rotenberry 1981, Pearson 1993). Statistical models to describe within-year variation in bird communities were then constructed using factor scores and data on bird abundance/species richness for each field; abundance/species data were based on within-year means for all censuses in each field. For purposes of this study I focused primarily on grassland birds. Response variables included total number of grassland species observed in the field during the season, mean number of grassland bird species/census/point for each field, mean number of grassland birds/census/point for each field; and, for each common grassland species in the study area [Savannah Sparrow, Bobolink, and Eastern Meadowlark], mean number of individuals/census/point for the field. Stepwise multiple regression was used to select and evaluate the power of specific vegetation and landscape factors in explaining variation among fields in response variables (Pearson 1993). 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, some common oldfield species were included in the analysis. Finally, I evaluated the relationship between grassland bird response variables and individual landscape and vegetation variables with simple regression analysis.

Although most bird/habitat analyses focused on the larger 1995, 1996, and 1997 data sets, 1994 data on grassland bird species richness and abundance were also tested for their response to field area using simple linear regression.

RESULTS

Occurrence of Grassland Species in the Study Area.-- Seven grassland species were observed in the study area between 1994 and 1998: Northern Harrier, Upland Sandpiper, Grasshopper Sparrow, Henslow's Sparrow, Savannah Sparrow, Bobolink, and Eastern Meadowlark. Of these, only the latter three species were observed regularly (> 0.5 individuals/census/point) in fields at Iroquois NWR and Montezuma NWR. Savannah Sparrows and Bobolinks were widely distributed and abundant throughout the study area, while Eastern Meadowlarks were generally less common. Meadowlarks were observed in only four of 34 fields in 1994, four of 43 fields in 1995, 10 of 41 fields in 1996, 12 of 27 fields in 1997, and 10 of 24 fields in 1998. Henslow's Sparrows and Grasshopper Sparrows were not observed at either Iroquois NWR or Montezuma NWR between 1994 and 1997, although both species were found in fields at Mendon Ponds County Park in 1996 and 1997. Five territorial male Grasshopper Sparrows also occurred in recently restored fields at Iroquois NWR near Long Marsh (Upland Management Unit B) in 1998; one nest was found in field B12. Northern Harriers were observed hunting over 2 of 34 fields in 1994, 7 of 43 fields in 1995, 2 of 41 fields in 1996, and 3 of 27 fields in 1997. The species nested in the warm season grassland at Beattie Point in 1996, and in the former hayfield (Waugh 1) at Montezuma NWR in 1997. Finally, an Upland Sandpiper may have nested in a fallow field at Iroquois NWR in 1994 (Upland Management Unit D13), but the species was not observed anywhere in the study area in 1995, 1996, 1997, or 1998.

Between 1994 and 1998, 56 species of birds, including 12 only seen flying over study plots, were observed in Iroquois NWR and adjacent NYSDEC fields (Appendix 3).

Pastures and cool season grasslands contained the most breeding species (both with ten), while warm season grasslands supported the fewest breeding species (five; Appendix 3). In 1995 – 1998 we observed 50 species, including 20 only seen flying over the study plots, during timed censuses in fields in the Northern Montezuma Wetlands Complex with 50-m radius circular plots (Appendix 4).

Nongrassland species of federal management concern (Schneider and Pence 1992) noted during the study included the American Bittern (*Botaurus lentiginosus*) and Sedge Wren (*Cistothorus platensis*). Bitterns were observed at Iroquois NWR in two fields with census points near wetlands in 1994. In 1995, a bittern nested in a moist, cool season grassland plot on Tonawanda WMA. In 1996 bitterns were seen in Upland Management Units A2 and Q15 at Iroquois NWR. Sedge Wrens were not seen in any fields with bird census points in 1994 or 1995. However, approximately five males held territories in a small warm season grassland at Iroquois NWR (Upland Management Unit N1) in 1994. The field was burned in the spring of 1995 and no wrens were present during the 1995, 1996, 1997, or 1998 breeding seasons. Territorial male Sedge Wrens also were present in dense *Panicum* at the Beattie Point grassland in 1996 and 1997.

Bird/Habitat Relationships – Richness and Abundance

Univariate Analyses

Field area was the single most important factor affecting grassland bird species richness and abundance. Total number of grassland species observed in a field, average number of grassland species observed/census, and average number of grassland individuals/census/point increased with field area in all years of the study, in spite of

large among-field differences in vegetation (Table 2; examples of these relationships are shown in Figure 1 for 1995 data on total number of grassland species and average number of grassland individuals/census/point). Mean numbers of Savannah Sparrows, Bobolinks, and Eastern Meadowlarks/census/point also tended to increase with field area (Table 2, Figure 2). Few Bobolinks and Savannah Sparrows were seen in fields < 5 ha (Figure 2), while Eastern Meadowlarks were not seen in fields < ca. 9 ha (Figure 2; see Figure 3 for 1996 data, the year in which the species was more widely distributed than in other years of the study). Incidence functions (see Vickery et al. 1994) calculated for 1996 census data suggested that Bobolinks and Savannah Sparrows reached a 50% probability of occurrence at about 8 ha, while Eastern Meadowlarks reached a 50% probability of occurrence at around 15 ha (Table 3). In 1996 – 1998, Grasshopper Sparrows and Henslow's Sparrows were present in fields of 4.6 – 8.7 ha at Mendon Ponds County Park, while in 1998 the former species occurred in two fields of 8.4 and 17.4 ha at Iroquois NWR.

Grassland bird abundance and species richness were consistently lower in warm season grasslands than in cool season grasslands and pastures in the study area (Figures 1 and 2), even in the 44 ha warm season grassland at Braddock Bay WMA. Common species in warm season grasslands included Common Yellowthroats (*Geothlypis trichas*), Swamp Sparrows (*Melospiza georgiana*), and Song Sparrows (*Melospiza melodia*). However, as mentioned above, two species of federal management concern in the Northeast did use *Panicum* fields during the study: Northern Harriers nested in switchgrass fields at Tonawanda and Braddock Bay WMAs, and Sedge Wrens held territories in *Panicum* fields at Iroquois NWR and Braddock Bay WMA. Conversely, the

Table 2. Coefficients of determination (r^2) between log of field area and various indices of grassland abundance, 1994-1997.

Variable	1994	*P*	1995	*P*	1996	*P*	1997	*P*
Species richness[1]	0.591	<0.001	0.508	<0.001	0.325	<0.001	0.457	<0.001
Number of individuals/census/point[1]								
Total grassland birds	0.604	<0.001	0.365	<0.001	0.292	<0.001	0.237	0.018
Savannah Sparrow	0.551	<0.001	0.354	<0.001	0.314	<0.001	0.439	<0.001
Bobolink	0.395	<0.001	0.261	<0.001	0.203	0.003	0.776	<0.001
Eastern Meadowlark	0.144	0.051	0.077	0.065	0.169	0.009	0.149	0.062

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

Figure 1. Mean number of grassland individuals/census/point vs. field area (A), and total number of grassland species vs. field area (B), 1995. M = abandoned hayfield at Montezuma NWR; BP = warm season grassland at Beattie Point, Braddock Bay WMA.

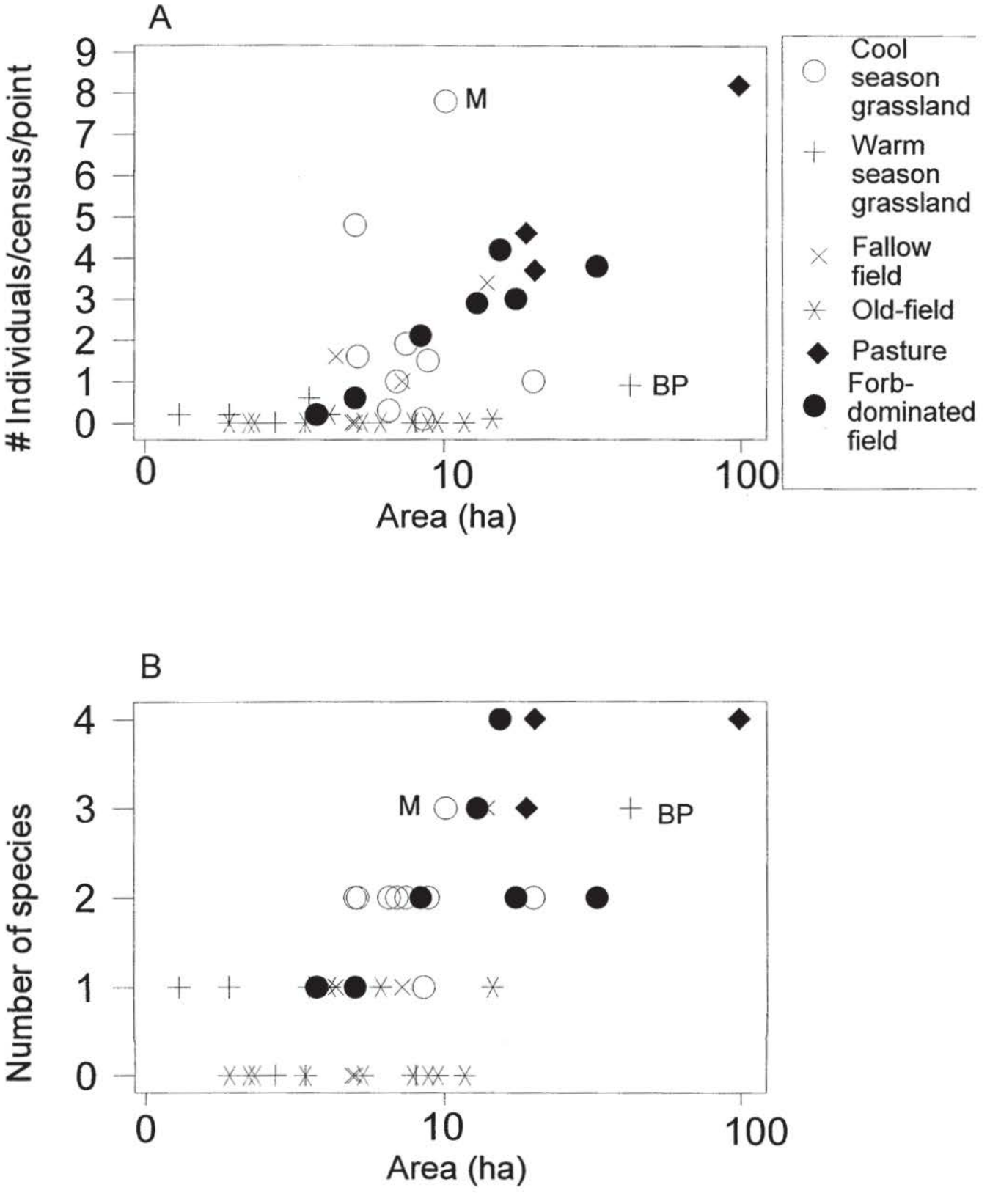
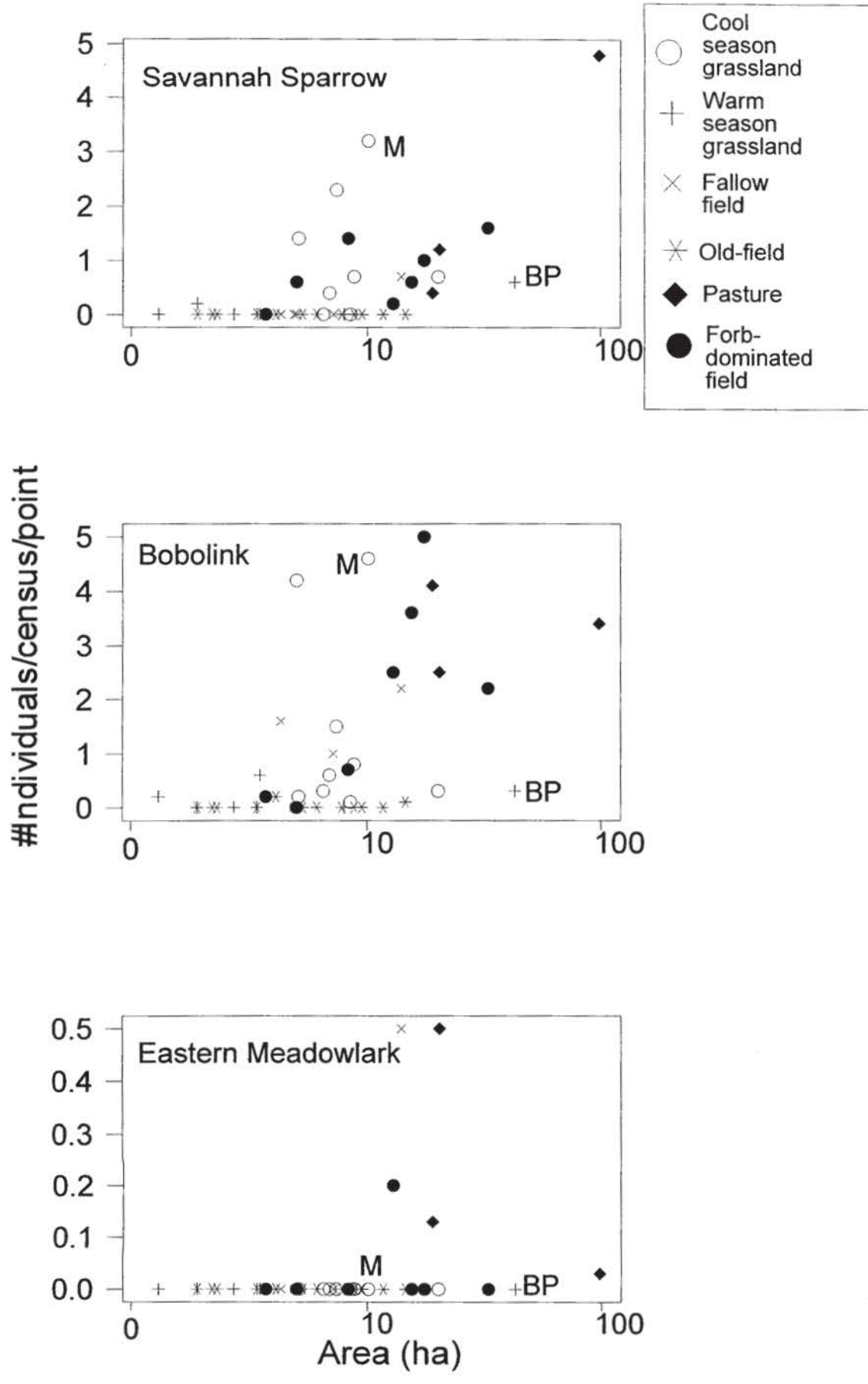

A
Individuals/census/point
0
1
2
3
4
5
6
7
8
9
M
BP
0
10
100
Area (ha)
Cool season grassland
Warm season grassland
Fallow field
Old-field
Pasture
Forb-dominated field
B
Number of species
0
1
2
3
4
M
BP
0
10
100
Area (ha)

Figure 2. Mean number of grassland individuals/census/point vs. field area for Savannah Sparrows (top), Bobolinks (middle), and Eastern Meadowlarks (bottom), 1995. M = abandoned hayfield at Montezuma NWR; BP = warm season grassland at Beattie Point, Braddock Bay WMA.


Savannah Sparrow
Bobolink
Eastern Meadowlark
M
BP
#ndividuals/census/point
Area (ha)
0
10
100
0.0
0.1
0.2
0.3
0.4
0.5
1
2
3
4
5
Cool season grassland
Warm season grassland
Fallow field
Old-field
Pasture
Forb-dominated field

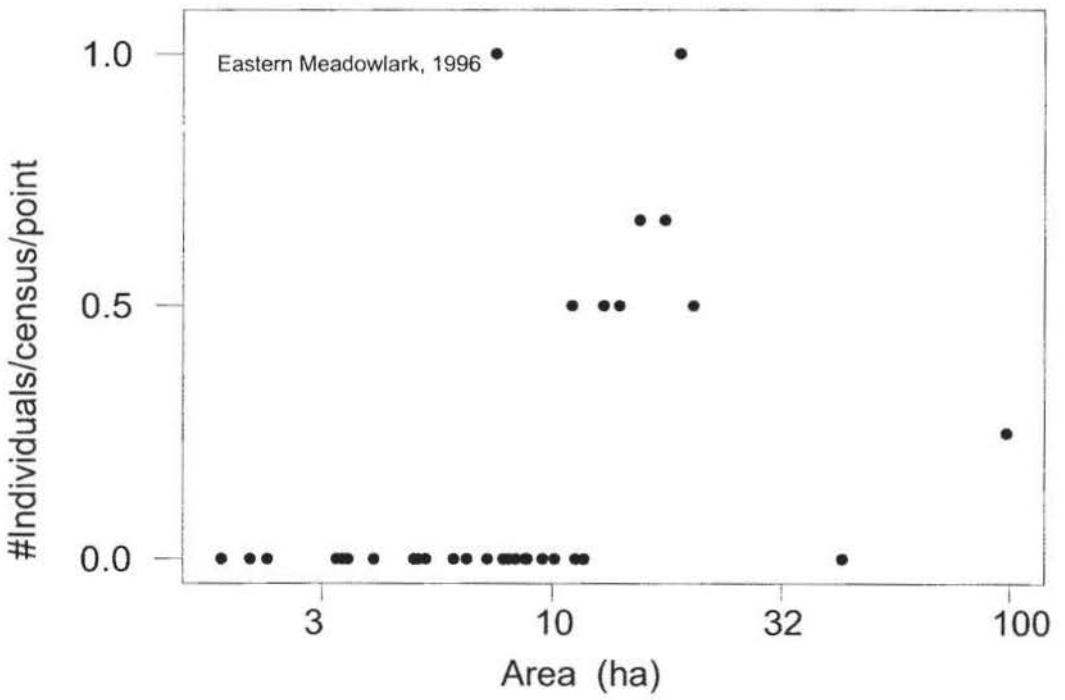


Figure 3. Mean number of Eastern Meadowlarks/census/point vs. field area, 1996.

Table 3. Incidence functions (probability of occurrence; Vickery et al. 1994) for Bobolinks, Eastern Meadowlarks, and Savannah Sparrows, based on census data for 1996.

	Area				
	0 – 3 ha	3 – 5 ha	5 – 10 ha	10 – 20 ha	> 20 ha
Bobolink	0.02	0.18	0.69	0.96	0.99
Eastern Meadowlark	0.01	0.04	0.17	0.50	0.83
Savannah Sparrow	0.08	0.28	0.63	0.88	0.97

one field in the study area with a relatively dense growth of alfalfa (*Medicago sativa*), along with introduced cool season grasses, a 14.1 ha former hayfield at Montezuma NWR, supported a greater abundance of grassland birds than predicted on the basis of area alone in 1995 (Figure 1).

Using simple univariate procedures to analyze large sets of potentially correlated variables presents certain statistical problems, and may confound interpretation of results (Sokal and Rohlf 1996). However, I used simple linear regression analysis to examine the relationship between bird response variables (total number of grassland bird species/field, etc.) and vegetation variables (mean vegetation height, % live grass cover, etc.) in order to identify habitat variables of potential importance to grassland birds. Although some of the habitat variables used in my analyses differed between 1994-1995 and 1996-1997 (see Methods), certain relationships tended to be consistent across all years of the study (Tables 4, 5 and 6). For example, grassland bird species richness and abundance, and abundance of Bobolinks, Savannah Sparrows, and Eastern Meadowlarks, tended to increase as variables related to vegetation height and/or density decreased in all years of the study, although there were fewer significant relationships for these variables in 1996 (Tables 4, 5 and 6). In 1996 and 1997, grassland bird species richness and abundance tended to increase as the percentage of live grass cover increased, and the percentage of dead grass cover (primarily *Panicum*) decreased (Tables 5 and 6). Although in 1994 and 1995 no variables related to shrubs explained a significant amount of the variation in grassland bird species richness and abundance, few grassland birds were found in fields with high shrub cover (Figure 4). In 1996 and 1997, however, grassland bird species richness and abundance showed significant decreases in richness

Table 4. Correlations between grassland bird response variables and vegetation structural variables in the study area, 1994 and 1995. Only significant r values are indicated; vegetation structural variables coded as in Methods (pp. 8-9). Bird species response codes: GRSP = Total number of grassland species; GRIND = mean number of grassland individuals/census; BOBO = Bobolink; EAME = Eastern Meadowlark; SAVS = Savannah Sparrow. *= $P \leq 0.05$; ** = $P \leq 0.01$; *** = $P \leq 0.001$.

Variable	MNHT	SDHT	CVHT	MXHT	CT≤25	CT>25	TOTCT	FORB	GRAS	SHRB	DEAD	SBCOV
1994												
GRSP									0.346*			
GRIND		-0.330*		-0.335*								
BOBO		-0.341*		-0.344*								
EAME												
SAVS												
1995												
GRSP	-0.307*	-0.392**		-0.305*					0.467**			
GRIND		-0.298*										
BOBO												
EAME												
SAVS	-0.329*	-0.339*		-0.315*							-0.365*	

Table 5. Correlations between grassland bird response variables and vegetation structural variables in the study area, 1996. Only significant r values are indicated; vegetation structural variables coded as in Methods (p. 10). Bird species response codes: GRSP = Total grassland species; AVGSP = mean number grassland species/census/point; GRIND = mean number of grassland individuals/census/point; BOBO = mean number of Bobolinks/census/point; EAME = mean number of Eastern Meadowlarks/census/point; SAVS = mean number of Savannah Sparrows/census/point. *= $P \leq 0.05$; ** = $P \leq 0.01$; *** = $P \leq 0.001$.

Variable	MNHT	CVHT	SHBHT	CT≤25	C>25	TOTCT	LITD	%LEG	%GOLD	%DGRA	%LGRA	%SHBC
GRSP			-0.326*							-0.311*	0.454**	-0.450**
AVGSP		-0.402**	-0.343*					0.313*		-0.298*	0.545**	-0.327*
GRIND		-0.462**	-0.395**					0.486**		-0.292*	0.594**	-0.326*
BOBO		-0.409**	-0.467**					0.437**		-0.313*	0.464**	
EAME											0.491**	
SAVS		-0.376*	-0.411**					0.428**		-0.292*	0.476**	

Table 5 (continued). Correlations between grassland bird response variables and vegetation structural variables in the study area, 1996. Only significant r values are indicated; vegetation structural variables coded as in Methods (p. 10). Bird species response codes: GRSP = Total grassland species; AVGSP = mean number grassland species/census/point; GRIND = mean number of grassland individuals/census/point; BOBO = mean number of Bobolinks/census/point; EAME = mean number of Eastern Meadowlarks/census/point; SAVS = mean number of Savannah Sparrows/census/point. *= $P \leq 0.05$; ** = $P \leq 0.01$; *** = $P \leq 0.001$.

Variable	%LFOR	%DFOR	%TCOV	GENUS	PSHBC	SHBSP	NQSHB
GRSP				-0.316*	-0.327*	-0.308*	-0.467**
AVGSP						-0.381*	-0.410**
GRIND						-0.378*	-0.421**
BOBO					-0.308*	-0.354*	-0.409**
EAME							
SAVS					-0.321*	-0.371*	-0.378*

Table 6. Correlations between grassland bird response variables and vegetation structural variables in the study area, 1997. Only significant r values are indicated; vegetation structural variables coded as in Methods (p. 10). Bird species response codes: GRSP = Total grassland species; AVGSP = mean number grassland species/census/point; GRIND = mean number of grassland individuals/census/point; BOBO = mean number of Bobolinks/census/point; EAME = mean number of Eastern Meadowlarks/census/point; SAVS = mean number of Savannah Sparrows/census/point. *= $P \leq 0.05$; ** = $P \leq 0.01$; *** = $P \leq 0.001$.

Variable	MNHT	CVHT	SHBHT	CT≤25	CT>25	TOTCT	LITD	%LEG	%GOLD	%DGRA	%LGRA	%SHBC
GRSP	-0.414*									-0.579**		
AVGS	-0.602**				-0.361*						0.532**	
GRIND	-0.517**		-0.434*							-0.423*	0.470*	
BOBO	-0.405*		-0.487*		-0.348*							
EAME	-0.405*											
SAVS	-0.489**									-0.481*		

Table 6 (continued). Correlations between grassland bird response variables and vegetation structural variables in the study area, 1997. Only significant r values are indicated; vegetation structural variables coded as in Methods (p. 10). Bird species response codes: GRSP = Total grassland species; AVGSP = mean number grassland species/census/point; GRIND = mean number of grassland individuals/census/point; BOBO = mean number of Bobolinks/census/point; EAME = mean number of Eastern Meadowlarks/census/point; SAVS = mean number of Savannah Sparrows/census/point. *= $P \leq 0.05$; ** = $P \leq 0.01$; *** = $P \leq 0.001$.

Variable	%LFOR	%DFOR	%TCOV	GENUS	PSHBC	SHBSP	NQSHB
GRSP							
AVGSP							-0.566**
GRIND							-0.588**
BOBO							-0.577**
EAME							
SAVS							

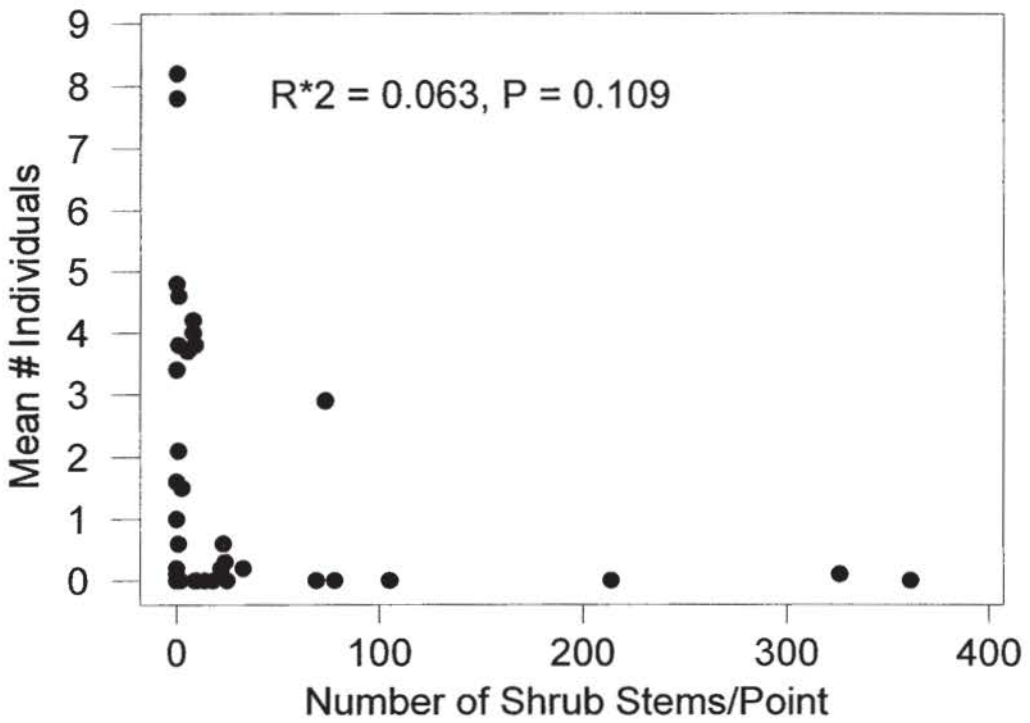


Figure 4. Mean number of grassland birds/census/point vs. number of shrub stems, 1995.

and abundance with increases in shrub cover, shrub species richness, and shrub height (Tables 5 and 6). Because I used midpoint values for coverage classes (see Methods), the plotted data suggest that few grassland birds occurred in plots with > approximately 3 % shrub cover, with maximum abundances occurring in fields with ≤ 1 % shrub cover (Figures 5 and 6 for 1996 and 1997). The final vegetation variable that appeared to influence grassland bird response variables was percent legume cover; in 1996, but not in 1997, grassland bird species richness and abundance was higher in fields with more legume cover, although legume cover was < 20 % in all fields surveyed in 1996 (Table 5).

A few landscape variables other than those related directly to field area appeared to influence grassland bird species richness and abundance in the study area. In 1995, average number of grassland individuals/census/point and number of Bobolinks/census/point were positively and significantly correlated with the amount of cropland surrounding fields, and negatively correlated with the amount of deciduous forest surrounding fields (Table 7). In 1996, no landscape variables related to the proportion of a habitat type surrounding a field explained a significant amount of the variation in any grassland bird response variable (Table 8). However, in 1996 grassland bird abundance and species richness were related to those variables associated with field area, and with the angle between the ground and skyline, as influenced primarily by the height and distribution of deciduous forest (see Methods; Table 8). The total number of grassland species was positively correlated with the harmonic mean of the angle, which decreases with increasing angle between the ground and skyline. Five grassland bird response variables, including average number of individuals/census/point, and average

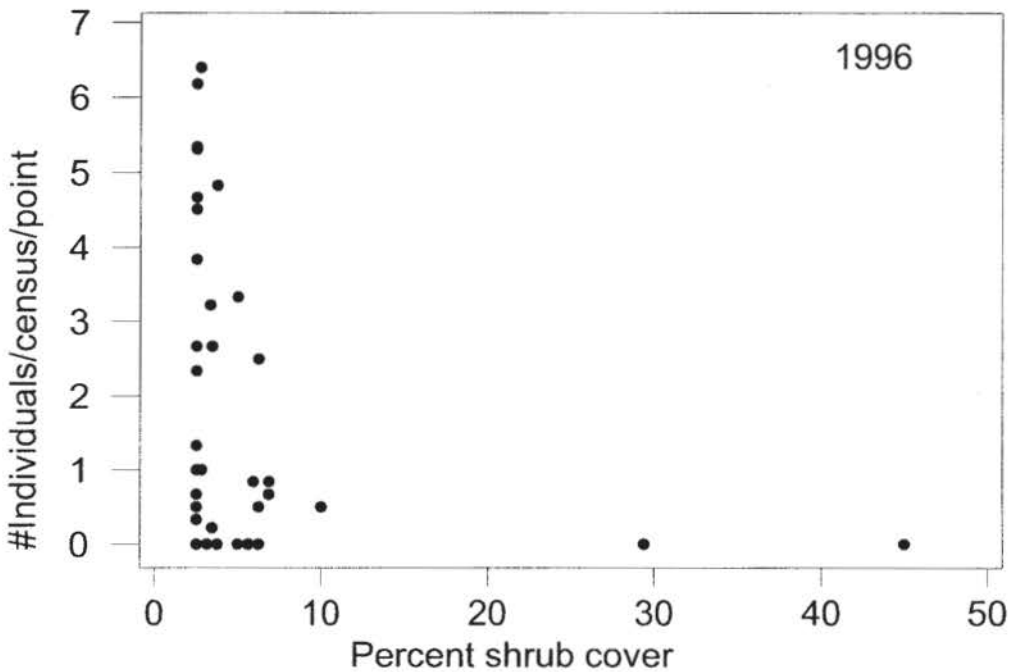


Figure 5. Mean number of grassland birds/census/point vs. percent shrub cover, 1996.

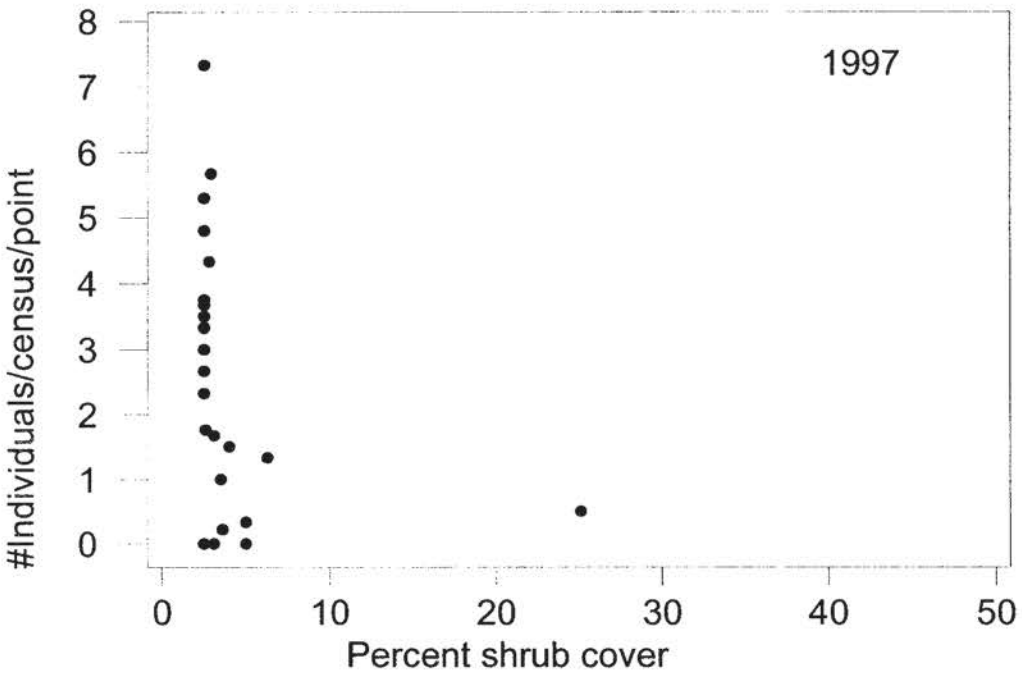


Figure 6. Mean number of grassland birds/census/point vs. percent shrub cover, 1997.

Table 7. Correlations between grassland bird response variables and landscape variables in the study area, 1995. Only significant r values are indicated; landscape variables coded as in Methods (pp. 10-11). Bird species response codes: GRSP = Total grassland species; AVGSP = mean number grassland species/census/point; GRIND = mean number of grassland individuals/census/point; BOBO = mean number of Bobolinks/census/point; EAME = mean number of Eastern Meadowlarks/census/point; SAVS = mean number of Savannah Sparrows/census/point. *= $P \leq 0.05$; ** = $P \leq 0.01$; *** = $P \leq 0.001$.

Variable	PERM	EDGE	AREA	POLD	PFRB	PCSG	PWSG	PWET	PCRP	PDEC
GRSP	0.486**	0.503**	0.571**						0.298*	
GRIND	0.437**	0.628**	0.604**		0.316*				0.295*	-0.339*
BOBO	0.346*	0.583**	0.451**		0.326*				0.339*	-0.327*
EAME										
SAVS	0.409**	0.477**	0.561**							

Table 8. Correlations between grassland bird response variables and landscape variables in the study area, 1996. Only significant r values are indicated; landscape variables coded as in Methods (pp. 10-11). Bird species response codes: GRSP = Total grassland species; AVGSP = mean number grassland species/census/point; GRIND = mean number of grassland individuals/census/point; BOBO = mean number of Bobolinks/census/point; EAME = mean number of Eastern Meadowlarks/census/point; SAVS = mean number of Savannah Sparrows/census/point. *= $P \leq 0.05$; ** = $P \leq 0.01$; *** = $P \leq 0.001$.

Variable	PERM	EDGE	AREA	POLD	PFRB	PCSG	PWSG	PWET	PCRP	PDEC	MNAN	MAXA
GRSP	0.424**	0.427**	0.570**								0.475*	-0.488**
AVGSP	0.351*	0.481**	0.525**									-0.483**
GRIND	0.349*	0.508**	0.540**									-0.468**
BOBO		0.490**	0.451**									-0.400*
EAME			0.411**									
SAVS	0.468**	0.538**	0.560**									-0.390*

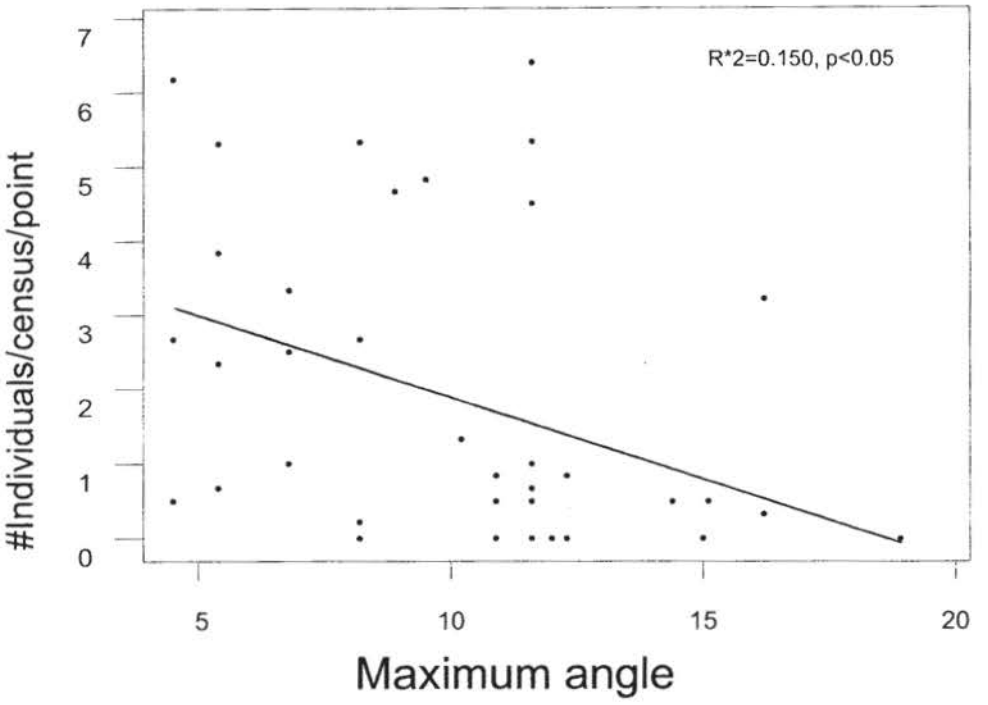


Figure 7. Mean number of grassland birds/census/point vs. maximum angle between the ground and horizon, 1996.

number of species/census/point, showed a significant negative relationship with increasing maximum angle between the ground vegetation and the skyline (Table 8, Figure 7).

Multivariate Analyses

1995: PCA produced five landscape and three vegetation factors with eigenvalues > 1.0; these accounted for 83.0 % and 77.6% of the variation respectively (Tables 9 and 10). 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 to the nearest field/forest edge) having high positive loadings on the axis (Table 9). Fields with high scores on factor L2 were surrounded by large amounts of wetland habitat and small amounts of deciduous forest habitat. Factor L3 represented a gradient from increased shrubby oldfield habitat to decreased cropland. Fields with high scores on L4 had large amounts of forb-dominated fields and warm season grasslands surrounding them; fields with high scores on L5 were surrounded by relatively large amounts of cool season grassland and small amounts of old-field habitat (Table 9).

Vegetation factor V1 appeared to represent a gradient from tall, dense vegetation with a small amount of standing dead vegetation (low factor scores on V1) to low, less dense vegetation (high scores on V1) (Table 10). Factor V2 represented a gradient from areas with less heterogeneous vegetation (low scores on V2) and fewer shrubs to areas with greater horizontal heterogeneity (CVHT), more shrubs and less dense grass (high scores on V2). Fields with high scores on factor V3 had greater forb cover, and low grass and shrub cover. However, the vegetation factors should be interpreted cautiously, as loadings on the original variables were generally < ±0.500 (Table 10).

Bird-habitat models generated by stepwise regression analysis suggested that most

Table 9. Landscape (L) factors generated by Principal Components Analysis of 1995 data. Only factors with eigenvalues > 1.0 are shown.

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 boundary	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

Table 10. Vegetation (V) factors generated by Principal Components Analysis of 1995 data. Only factors with eigenvalues > 1.0 are shown.

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 > 25cm	-0.415	-0.074	0.151
Mean height of vegetation	-0.413	0.145	0.129
Number of dead contacts	-0.402	-0.184	0.207
Maximum height of vegetation	-0.323	0.351	0.180
Vegetation contacts < 25 cm	-0.320	-0.293	-0.084
Number of shrub contacts	-0.192	0.373	-0.533
Number of shrub stems	-0.184	0.374	-0.523
Coefficient of variation of vegetation height	-0.126	0.391	0.209
Number of grass contacts	-0.106	-0.365	-0.404
Number of forb contacts	0.080	0.336	0.337

variation in grassland bird abundance and species richness was accounted for by the area variables (Table 11). 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 11). 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 11); 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 an additional 5% of the variation in Savannah Sparrow abundance (Table 11). No model explained a significant amount of the variation in Eastern Meadowlark abundance. When variables L1 and V1 were forced into a stepwise regression, they accounted for only 3.9% of the variation in Eastern Meadowlark abundance, even though the species was not seen in fields < 13 ha (Figure 2). This result may have been due to the small number of fields with meadowlarks in 1995. Although the shrub density factor (V2) explained a significant amount of variation only in species richness (Table 11), and there was no significant correlation between shrub density and grassland bird species abundance, fields with the most shrubs supported few grassland birds in 1995 (Figure 4).

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 (Figure 8). Grassland birds had higher abundances 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 Sparrows, Common Yellowthroats and Yellow Warblers

Table 11. Grassland bird-habitat models for 1995 generated by stepwise multiple regression. 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. Interpretation of variables generated by Principal Components Analysis given in ( ).

Bird variable[1]	Habitat variables entered into model	Partial r^2	r^2
Species richness	L1 (area)	0.43	0.51
	-V2 (vegetation heterogeneity/ shrub density)	0.08	
Abundance	L (area)	0.60	0.66
	V1 (Vegetation height/density)	0.06	
Savannah Sparrow	L1 (Area)	0.57	0.62
	V1 (Vegetation height/density)	0.05	
Bobolink	L1 (Area)	0.43	0.43
Eastern Meadowlark	No variables entered into model at $P < 0.05$		

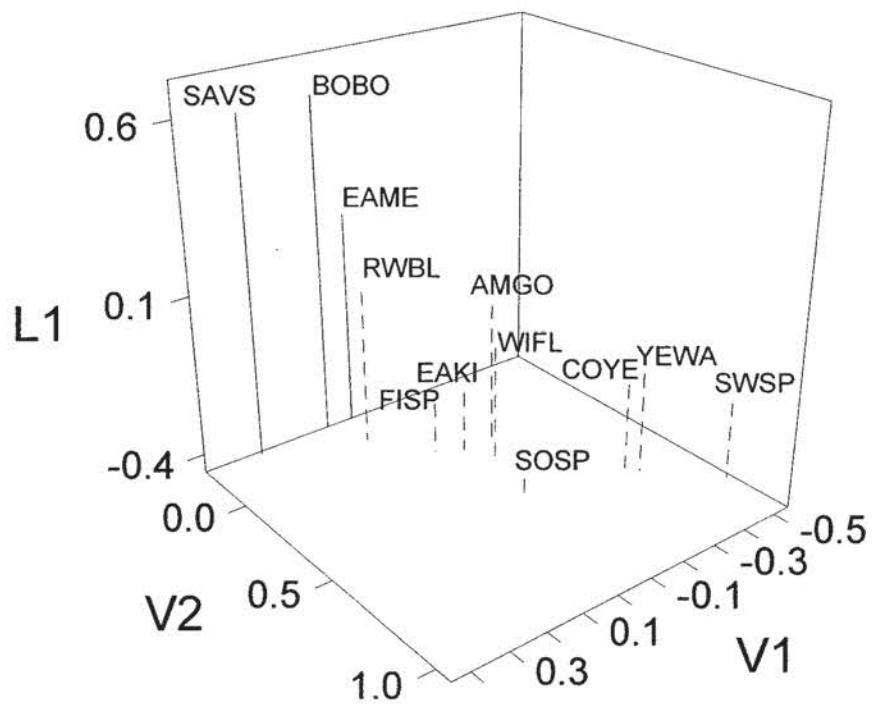


Figure 8. Correlations (r) between bird species abundance and principal component scores on PC axes L1, V2, and V1, 1995 census data. SAVS = Savannah Sparow, BOBO = Bobolink, EAME = Eastern Meadowlark, RWBL = Red-winged Blackbird, FISP = Field Sparrow, EAKI = Eastern Kingbird, AMGO = American Goldfinch, WIFL = Willow Flycatcher, SOSP = Song Sparrow, COYE = Common Yellowthroat, YEWA = Yellow Warbler, and SWSP = Swamp Sparrow.

(*Dendroica petechia*) were most abundant in smaller fields with more dense vegetation and more shrubs, while species that used both grassland and shrubby habitats (Eastern Kingbird [*Tyrannus tyrannus*] and Red-winged Blackbird [*Agelaius phoeniceus*]) had an intermediate location in the three-dimensional habitat space depicted by L1, V1, and V2 (Figure 8). Also, species that occurred frequently in warm season grasslands, such as Common Yellowthroats and Swamp Sparrows, were clustered far from Bobolinks, Eastern Meadowlarks, and Savannah Sparrows (Figure 8).

1996: In 1996 PCA produced three landscape and five vegetation factors with eigenvalues > 1.0; these accounted for 86.8 % and 72.6 % of the variation respectively (Tables 12 and 13). Among the landscape factors, L1 represented a variable related to percentage of surrounding habitat type, with proportion of old field, cool season grassland, wetland, deciduous forest and warm season grassland having high positive loadings on the axis (Table 12). Factor L2 and L3 both appeared to be related to field area. Fields with high scores on factor L2 tended to have a short distance to the nearest field/forest edge, small area, and small perimeter. Fields with high scores on factor L3 tended to have a high perimeter/ distance to the nearest forest edge ratio.

Vegetation factor V1 appeared to represent a gradient from high vegetation with many shrubs (high factor scores on V1) to low vegetation with few shrubs (Table 13). Factor V2 represented a gradient from fields with short, less dense vegetation, thin litter, and low dead grass cover (high scores on V2) to fields with thick litter, more dense vegetation, and high dead grass cover. Fields with high scores on factor V3 had relatively low live grass cover and a high coefficient of variation in vegetation height,

Table 12. Landscape (L) factors generated by Principal Components Analysis of 1996 data. Only factors with eigenvalues > 1.0 are shown.

Landscape Factors	L1	L2	L3
Eigenvalue	4.299	3.136	1.214
Proportion of total variance explained	0.551	0.204	0.113
Cumulative proportion of variance explained	0.551	0.755	0.868
Variable			
Log area	0.285	-0.873	0.026
Perimeter	0.135	-0.922	0.317
Edge	-0.111	-0.854	-0.407
Perimeter/edge ratio	0.398	-0.048	0.880
Proportion old field	0.987	-0.081	0.118
Proportion forb-dominated field	-0.076	-0.016	-0.171
Proportion cool season grassland	0.985	-0.084	0.122
Proportion wetland	0.986	-0.083	0.132
Proportion cropland	0.972	-0.128	0.167
Proportion forest	0.987	-0.070	0.123
Proportion warm season grassland	0.987	-0.88	0.121
Maximum angle	-0.064	0.181	0.060

Table 13. Vegetation (V) factors generated by Principal Components Analysis of 1996 data. Only factors with eigenvalues > 1.0 are shown.

Vegetation Factors	V1	V2	V3	V4
Eigenvalue	4.474	3.642	2.659	2.285
Proportion of total variance explained	0.249	0.202	0.148	0.127
Cumulative proportion of variance explained	0.249	0.451	0.599	0.726
Variable				
Mean height vegetation	0.742	-0.606	-0.092	-0.021
CV vegetation height	0.208	-0.004	0.907	0.016
Vegetation contacts ≤ 25 cm	0.144	-0.779	-0.456	-0.140
Vegetation contacts > 25 cm	0.627	-0.630	0.005	-0.077
Litter depth	-0.071	-0.706	-0.030	-0.216
Proportion legume cover	-0.175	0.015	-0.385	0.301
Proportion *Solidago* cover	0.064	0.067	0.126	0.918
Proportion dead grass cover	0.039	-0.896	0.295	-0.112
Proportion live grass cover	-0.159	0.152	-0.836	-0.334
Proportion dead forb cover	0.560	0.067	0.036	0.084
Proportion live forb cover	0.179	0.266	-0.071	0.831
Proportion shrub cover	0.925	0.096	0.095	0.090
Mean shrub height	0.732	-0.308	0.186	0.243
Number shrub species	0.812	-0.184	0.036	0.124

Table 13 (continued). Vegetation (V) factors generated by Principal Components Analysis of 1996 data. Only factors with eigenvalues > 1.0 are shown.

Vegetation Factors	V1	V2	V3	V4
Number shrub quadrats	0.917	0.023	0.049	0.032
Genus richness	0.342	0.405	0.046	0.530

while fields with high scores on factor V4 had relatively high *Solidago* cover and total forb cover.

1996 bird-habitat models generated by stepwise regression analysis generally explained somewhat less variation in response variables than in 1995 (Tables 11 and 14). However, these models still suggested that most variation in species richness and abundance was accounted for by variables related to area (Table 14). Total grassland species richness was most strongly related to area (L2, partial $r^2 = 0.264$), with V1 (high vegetation and increased shrub cover) explaining an additional 8.7% of the variation. A model incorporating L2, V3, and V1 explained 43.3 % of the variation in average number of grassland species/census/point. These same variables explained 51.9 % of the variation in grassland bird abundance (Table 14). Thus, larger fields with more live grass cover, vegetation which was less variable in height, and with fewer shrubs tended to have more grassland birds. L2 was also most important in accounting for the variation in Savannah Sparrow and Bobolink abundances (Table 14). A model incorporating L2, another area-related variable (L3), shrub height and cover (V1), and live grass cover and the coefficient of variation of vegetation height explained 55.6% of the variation in Savannah Sparrow abundance, with more Savannah Sparrows occurring in large fields with more grass and cover, lower vegetation, and fewer shrubs. A model incorporating L2, and V1 and V3 accounted for 43.1 % of the variation in Bobolink abundance. As with Savannah Sparrows, greater numbers of Bobolinks/census/point occurred in larger fields with more grass cover, lower vegetation, and fewer shrubs. A model incorporating V3 and L2 (Table 14) accounted for 22.0% of the variation in Eastern Meadowlark abundance.

Table 14. Grassland bird-habitat models for 1996 data generated by stepwise multiple regression. 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. Interpretation of variables generated by Principal Components Analysis given in ( ).

Bird variable[1]	Habitat variables entered into model	Partial r^2	r^2
Total species richness			
	L2 (area)	0.26	0.35
	-V1 (high vegetation / increased shrub cover)	0.09	
Mean species richness			
	L2 (area)	0.22	0.43
	-V3 (low live grass cover / high CV height)	0.13	
	-V1 (high vegetation / increased shrub cover)	0.08	
Abundance			
	L2 (area)	0.27	0.52
	-V3 (low live grass cover / high CV height)	0.15	
	-V1 (high vegetation / increased shrub cover)	0.10	
Savannah Sparrow			
	L2 (area)	0.36	0.56
	-V1 (high vegetation / increased shrub cover)	0.11	
	-V3 (low live grass cover / high CV height)	0.09	
Bobolink			
	L2 (area)	0.20	0.43
	-V1 (high vegetation / increased shrub cover)	0.12	
	-V3 (low live grass / high CV cover)	0.11	

Table 14 (continued). Grassland bird-habitat models for 1996 data generated by stepwise multiple regression. 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. Interpretation of variables generated by Principal Components Analysis given in ( ).

Bird variable[1]	Habitat variables entered into model	Partial r^2	r^2
Eastern Meadowlark			
	-V3 (low live grass / high CV cover)	0.13	0.22
	L2 (area)	0.09	

1997: In 1997 I confined the PCA to vegetation data. Four variables, which explained 78.3 % of the variation in field vegetation, were generated by PCA (Table 15). Fields with high scores on V1 had high shrub cover, shrub height, and shrub species richness. Fields with high scores on V2 had high amounts of live grass cover and more dense vegetation. Fields with high scores on V3 had relatively high ground cover, low legume cover, and low total forb cover. V4 represented a gradient from high, more dense vegetation and high dead grass (high scores on V4) to low, less dense vegetation with low dead grass cover. Finally, fields with high scores on V5 had relatively high *Solidago* cover.

1997 bird-habitat models generated by stepwise multiple regression and using the vegetation factors V1-V5 plus log of field area produced results that generally were similar to those for 1995 and 1996 (Table 16). Total grassland species richness was most strongly related to field area (partial $r^2 = 0.325$), with V4 (vegetation height and density and dead grass) explaining an additional 21.5 % of the variation; large fields with lower, less dense vegetation and less dead grass had more grassland bird species. A model incorporating area and V4 explained 50 % of the variation in average number of grassland species/ census/point. These same variables explained 36 % of the variation in grassland bird abundance (Table 16). Thus, larger areas with less dead grass cover and lower, less dense vegetation tended to have more grassland birds. A model incorporating area and V4 were also explained 44 % of the variation in Savannah Sparrow abundance (Table 16). The only variable explaining a significant portion of the variation in Bobolink abundance ($r^2 = 0.209$) was V1; more Bobolinks occurred in fields with fewer

Table 15. Vegetation (V) factors generated by Principal Components Analysis of 1997 data. Only factors with eigenvalues > 1.0 are shown.

Vegetation Factors	V1	V2	V3	V4	V5
Eigenvalue	4.729	3.308	2.608	2.025	1.925
Proportion of total variance explained	3.541	2.979	2.919	2.739	1.925
Cumulative proportion of variance explained	0.197	0.362	0.524	0.676	0.783
Variable					
Mean height vegetation	0.372	-0.169	0.101	0.842	0.196
CV vegetation height	0.353	-0.629	0.187	-0.233	0.071
Vegetation contacts ≤ 25 cm	-0.008	0.771	0.258	-0.360	-0.117
Vegetation contacts > 25 cm	0.229	0.374	-0.168	0.813	-0.064
Total vegetation contacts	0.085	0.880	0.176	-0.017	-0.137
Litter depth	-0.395	0.123	0.594	0.202	-0.305
Ground cover	-0.050	0.298	0.890	0.078	0.132
Proportion legume cover	-0.130	-0.063	-0.962	-0.060	-0.028
Proportion *Solidago* cover	0.072	-0.120	0.041	0.063	0.913
Proportion dead grass cover	-0.138	-0.303	0.254	0.831	-0.129
Proportion live grass cover	-0.227	0.751	0.155	-0.076	-0.076
Proportion dead forb cover	0.020	-0.186	0.372	-0.116	-0.116
Proportion live forb cover	0.053	-0.149	-0.644	0.018	0.018
Proportion shrub cover	0.829	-0.010	-0.117	0.098	0.098
Mean shrub height	0.771	-0.264	0.134	0.243	-0.057

Table 15 (continued). Vegetation (V) factors generated by Principal Components Analysis of 1997 data. Only factors with eigenvalues > 1.0 are shown.

Vegetation Factors	V1	V2	V3	V4	V5
Number shrub species	0.937	-0.035	-0.037	0.023	-0.022
Number shrub quadrats	0.640	-0.337	0.164	0.394	0.309
Genus richness	0.630	0.164	-0.204	-0.433	0.408

Table 16. Grassland bird-habitat models for 1997 data generated by stepwise multiple regression. 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. Interpretation of variables generated by Principal Components Analysis given in ( ).

Bird variable[1]	Habitat variables entered into model	Partial r^2	r^2
Total species richness			
	Log area	0.33	0.55
	-V4 (high, dense vegetation/increased dead grass)	0.22	
Mean species richness			
	-V4 (high, dense vegetation/increased dead grass)	34.0	0.50
	Log area	0.16	
Abundance			
	-V4 (high, dense vegetation/increased dead grass)	0.19	0.36
	Log area	0.17	
Savannah Sparrow			
	Log area	0.22	0.44
	-V4 (high, dense vegetation/increased dead grass)	0.22	
Bobolink			
	-V1 (high shrub cover, height)	0.21	0.21
Eastern Meadowlark			
	No variables entered into model		

and lower shrubs. No variables generated by PCA of 1997 data explained a significant proportion of the variation in Eastern Meadowlark abundance.

Summary of Bird-Habitat Analyses, 1994-1997: Although details of the relationship between grassland bird species richness and abundance and habitat characteristics varied from year to year, a general pattern was clearly evident. Variables directly related to field area had the greatest influence on grassland bird species richness and abundance, with few grassland birds occurring in fields < 5 ha. However, much of the variation in grassland bird species richness and abundance was not explained by field area alone, and vegetation characteristics also affected the distribution of grassland birds in the area. In general, higher grassland bird species richness and abundance occurred in fields with lower, less dense vegetation, more live grass cover, little dead grass cover, and few shrubs. Analyses of 1996 data also suggested that fields with relatively high legume cover (but still < 20%) also had more grassland birds. However, relatively small amounts of shrub cover (± 3< %) and some forb cover (20<%) do not appear to negatively effect grassland bird distribution. For example, the 8.7 ha field at Mendon Ponds that supported more species of grassland birds (five) than any other field in the study area, including Henslow's Sparrows and Grasshopper Sparrows, had relatively high shrub (3%) and *Solidago* (10%) cover surrounding one census point, along with large amounts of standing dead stalks of milkweed (*Asclepias* spp.) and wild carrot (*Daucus carota*). Grassland birds often use scattered shrubs and standing dead forbs as song perches, and Bobolinks often nest in small goldenrod clumps. Thus, given sufficient field area and grass cover, grassland birds can generally tolerate some forb and shrub cover.

Detailed analyses of 1995 and 1996 data sets containing a number of landscape variables suggested that few landscape variables other than those related to field area affected grassland bird distribution in the study area. For 1995, there was some evidence from univariate analyses that more grassland birds occurred in fields surrounded by increased cropland and less deciduous forest, but this effect was not supported by multivariate analysis, nor was it found in 1996. In addition, univariate and multivariate analyses of 1996 data suggested that grassland bird species richness and abundance tended to increase in fields where the angle between the ground and horizon was lower, which would occur in larger fields bordered by few tall trees.

Effects of Succession on Grassland Bird Species Richness and Abundance.-- The influence of shrub cover and height, and grass cover, on grassland bird distribution suggests that fields in the study area not subject to periodic disturbance should experience a decline in grassland bird species richness and abundance through time. However, any changes in numbers should be evaluated against a control – a large field or fields with a large number of census points, and which experiences little change in vegetation through time. This situation occurs in grassland management unit I at Iroquois NWR, which is composed of four fields; these are periodically grazed and mowed in late summer. Between 1994 and 1998, grassland bird abundance in I showed no clear trends, with numbers fluctuating between 5.1 (1996) and 9.1 (1998) grassland bird individuals/ census/point (Figure 9). Examples of several fields in which changes in grassland bird abundance were correlated with vegetation changes due to succession are discussed below.

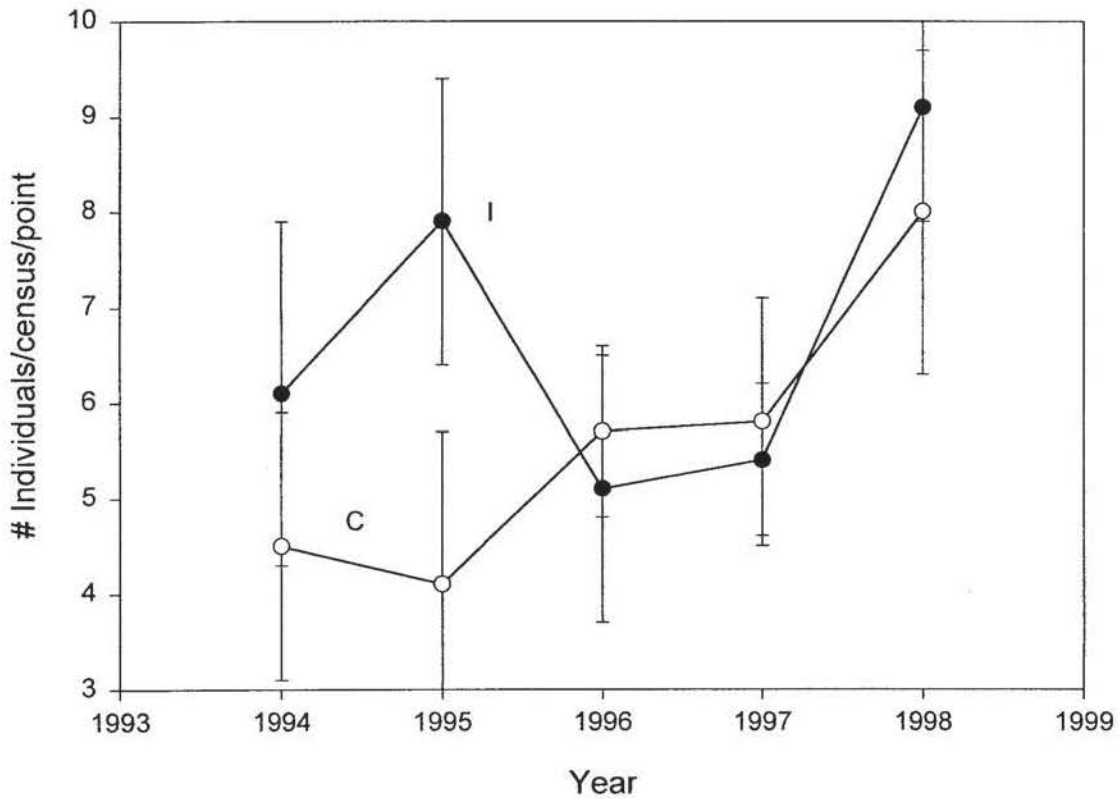


Figure 9. Mean number of grassland birds/census/point, I and C5 fields, Iroquois National Wildlife Refuge, 1994-1998. Error bars = ± 1 SD.

Iroquois NWR

Unit K, Field 9: This 13.6 ha field initially provided good habitat for grassland birds (Figure 10). However, increases in shrub cover since 1994, particularly in the northern part of the field, have negatively affected grassland birds. Data for one census point, which was not subject to shrub removal and subsequent replanting in 1996-1997 (see below), show a consistent decline in number of individuals/census/point, coupled with an increase in shrub cover (Figure 10).

Unit P, Field 4: This 5.8 ha field was last planted in 1993 and became fallow in 1994. In 1994 there was much bare ground (30%) and no grassland birds were observed (Figure 11). The amount of bare ground decreased to < 5% in 1995, and a few grassland birds (Bobolinks and Savannah Sparrows) were counted during timed censuses. Grassland bird abundance peaked in 1996, when forb cover remained < 30 %; by 1998, with forb cover at approximately 60%, Savannah Sparrows had abandoned the field and only a few Bobolinks were still present (Figure 11). This trend contrasts with that for Unit I, and for Unit C, Field 5. The latter field was once a pasture, and was last grazed in 1992. Annual mowing and haying by a farmer has prevented shrub and forb encroachment, and numbers of grassland birds have not declined (Figure 9).

Montezuma NWR

Waugh 2: Up until 1995, when this 14.3–ha field was acquired by the United States Fish and Wildlife Service, it had been maintained as a hayfield, and was dominated by introduced cool season grasses [timothy (*Phleum pratense*); orchard grass (*Dactylis*

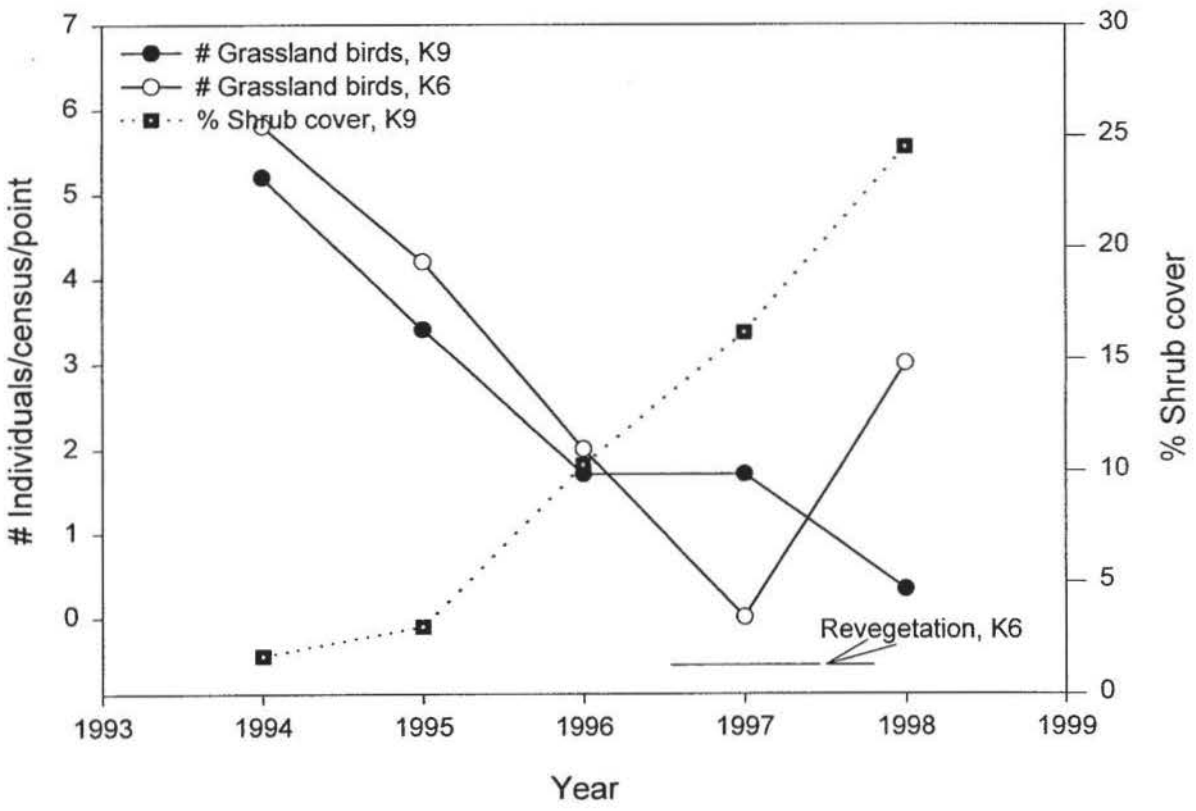


Figure 10. Mean number of grassland birds/census/point, K6 and K9 fields, Iroquois National Wildlife Refuge, 1994-1998; % shrub cover for undisturbed portion of K9 also shown.

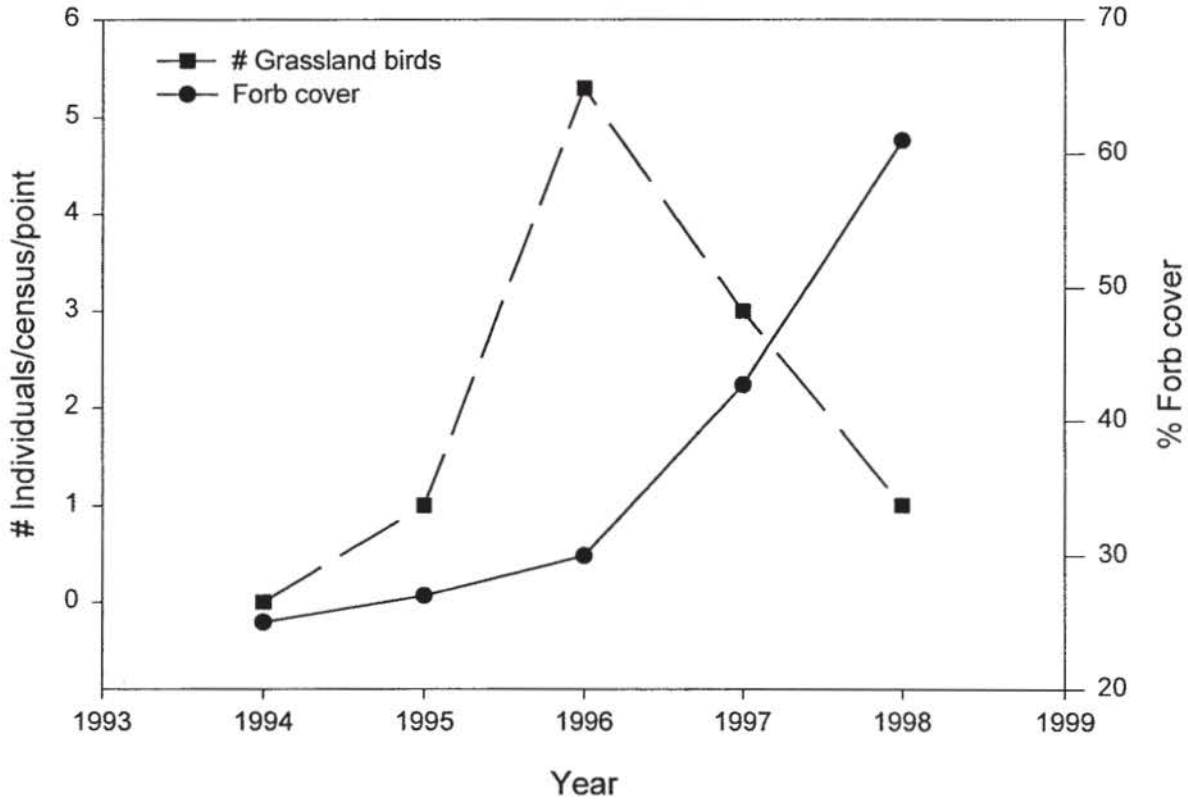


Figure 11. Mean number of grassland birds/census/point, and % forb cover, P field, Iroquois National Wildlife Refuge, 1994-1998.

glomerata); brome grass (*Bromus ciliatus*)], along with some alfalfa. Grassland bird abundance was among the highest in the study area (Figures 1 and 12), when forb cover was approximately 25%, but began to decline as forb cover (primarily goldenrod and milkweed) increased to 40% by 1997. A control burn in April 1998 had little effect on initial forb cover, but grassland bird numbers increased somewhat following the burn. However, it is difficult to prove that this increase was due to the burn, because in 1998 grassland bird numbers in the study area were generally higher in large fields not experiencing invasion by shrubs or goldenrod.

Effects of Management Practices on Grassland Bird Species Richness and Abundance.-- Upland fields at Iroquois NWR, Montezuma NWR, and on NYSDEC lands in the study area have been managed in a variety of ways to retard succession, which in most parts of western New York progresses through a series of plant communities dominated in turn by perennial forbs, shrubs, and finally deciduous trees. Among the methods used, alone or in combination, to enhance grassland habitat and retard succession are mowing and haying; grazing; prescribed burning; herbicide application; mechanical disturbance; revegetation, which may involve some combination of tillage, fertilization, weed control, and planting; and field enlargement through hedgerow removal. In the following section, I will briefly describe some management techniques that have been used in the study area, and their apparent effects on grassland bird populations. In the discussion, the difference between grassland maintenance and grassland revegetation should be kept in mind, as techniques that work well for grassland maintenance, such as biennial mowing,

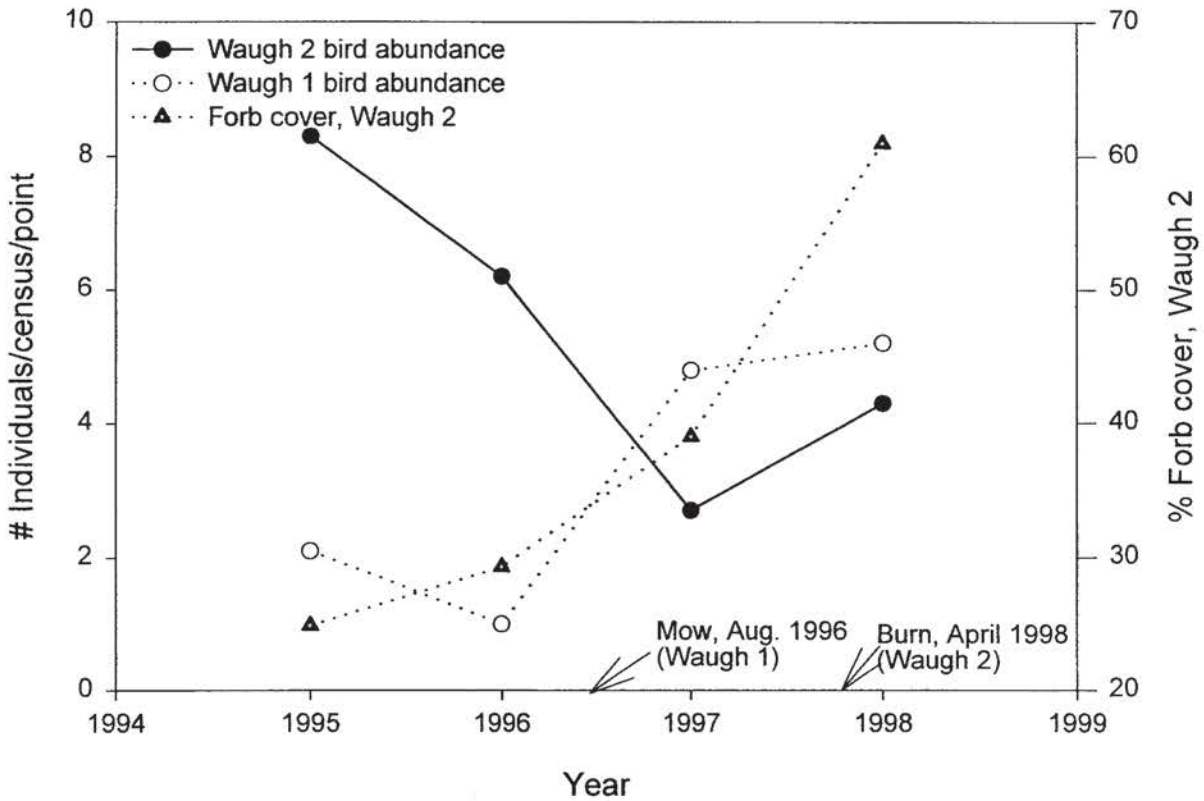


Figure 12. Grassland bird abundance, forb cover, and habitat manipulations, Waugh 1 and Waugh 2 fields, Montezuma National Wildlife Refuge, 1995-1998.

may not work well for revegetation, which involves the reestablishment (or initial establishment) of grassland vegetation on a site.

Grazing: Current grazing activity in the study area is limited to upland management unit I at Iroquois NWR. Two other units were grazed until recently: C5 (last grazed in 1992) and E6 (last grazed in 1995). Cattle are brought onto I in mid- to late July, and maintained at low stocking rates of approximately 0.60 – 0.83 animals/ha (Soch Lor, Iroquois NWR, personal communication). I is divided into four pastures, which are grazed on a rotational basis; cattle are allowed on only two pastures in any one year. Only two of the four pastures are grazed in any one year, and grazing generally is followed by autumn mowing of all four pastures. Unit I has experienced very little shrub invasion, and shrub cover remains at < 1%. Grassland bird abundance on I fluctuated, but remained relatively high between 1994 and 1998 (Figure 9). Grassland bird abundance also was generally high on C5 (Figure 9) and E6 during the first few years of the study, when grazing was on-going or recently had been curtailed. These data suggest that current grazing practices at Iroquois NWR, when combined with mowing, do not negatively affect grassland bird populations, but most likely benefit them by maintaining grasslands by retarding shrub invasion and increases in forb cover.

Mowing: A number of fields in the study area are mowed at irregular intervals to retard shrub invasion and promote the growth of herbaceous vegetation, including Units H11, L3, and Q15 at Iroquois NWR and the Esker Brook, Subheadquarters, and Waugh 1 fields at Montezuma NWR. Mowing may be an effective way for discouraging the

growth of unwanted plants, such as shrubs and goldenrod, although it has several potential drawbacks, including increased accumulation of litter and poor ability to rejuvenate grassland vegetation (Kahl, no date)

The effectiveness of mowing as a management tool in promoting grassland bird populations appears to vary with the frequency of mowing, and characteristics of the particular field under consideration, including area, shape, and pre-treatment vegetation composition. For example, grassland management units L3 (7.2 ha) at Iroquois NWR and Subheadquarters North (10.7 ha) at Montezuma NWR were both mowed twice in recent history – both in the late summer of 1993 and again in the late summer of 1996. Neither field has supported many grassland birds at any time during the study. In L3, abundance ranged from 0.84 to 1.5 individuals/census/point between 1994 and 1998, with only 1.0 ± 1.41 (SD) individuals/census/point counted in 1998, following mowing in 1997. Grassland bird abundance in the Subheadquarters North field ranged from 0 to 0.5 individuals/census/point between 1995 and 1998, with 0 individuals/census/point observed in 1998, following mowing and plowing, when the field was dominated by legumes and introduced species of mustard (Brassicacaea). Conversely, numbers of grassland birds at Waugh 1 at Montezuma NWR (21.5 ha, but contiguous with another field of 14.3 ha) were low in 1995 and 1996 (2.2 and 1.0 individuals/ census/point, respectively), but increased to 4.8 individuals/census/ point in 1997, following mowing in the late summer of 1996 (Figure 12). In the year after mowing, Waugh 1 experienced an increase in grass cover, and a decrease in shrub and forb cover. Also, parts of the large (98 ha) grassland at Iroquois NWR (management unit I) are mowed and hayed annually, and this field has maintained high populations and nest productivity during the study

(Figure 9). The relative lack of grassland birds in L3 and Subheadquarters North fields, either before or after mowing, may be due in part to factors unrelated to vegetation in the fields themselves. Although these fields are above the minimum size necessary to support grassland birds, both are bordered on one or more sides by tall trees (>15 m), and are not much more than 150 m at their widest points – two characteristics that function to increase the vertical angle between the ground and the horizon, and decrease the suitability of the area for grassland birds.

A detailed look at the Esker Brook field at Montezuma NWR provides valuable information on the effects of mowing on grassland birds. The Esker Brook field is a long, narrow field of ± 17 ha running in a north-south direction; distance from the middle of the field to the nearest field-forest edge is nowhere greater than ca. 75 m. It is divided into three management units: South, Central, and North, each of which contains a bird census point established in May 1995. Prior to 1995, the units were last mowed in 1992 or 1993. In May 1995 all three management units had vigorous growths of shrubs and forbs (primarily goldenrod), and there were no grassland birds in the field (Table 17). The Central unit was mowed in August 1996; shrub cover decreased and grassland bird numbers increased to 3.0 individuals/census/point in 1997. However, grassland bird abundance declined to almost 0 in 1998, following regrowth of shrubs (Table 17). The North unit was mowed in August 1995. Shrub cover was low in 1996, but there were few grassland birds counted in the unit, and by 1997 shrub cover had once again increased on the unit. However, a second mowing in August 1997 resulted in an increase in grassland birds the following summer (Table 17). The South unit was mowed in August 1996, and grassland birds responded favorably the following summer. In June and July 1997

Table 17. Grassland bird abundance (mean number of grassland birds/census/point), shrub cover (number of quadrats/census point), and mowing schedule for Esker Brook North, Central and South Units, Montezuma National Wildlife Refuge, 1995-1998.

Year	North Unit	Central Unit	South Unit
1995			
Grassland bird abundance	0	0	0
Number of quadrats with shrubs[1]	high	high	high
Mowing date	August	None	None
1996			
Grassland bird abundance	0.33	0.33	0.33
Number of quadrats with shrubs[1]	1	14	18
Mowing date	None	August	August
1997			
Grassland bird abundance	0.50	3.00	4.00
Number of quadrats with shrubs[1]	18	3	2
Mowing date	August	None	June, July[2]
1998			
Grassland bird abundance	4.33	0.33	2.00
Number of quadrats with shrubs[1]	2	16	10

1. Data on number of sampling quadrats with shrubs were not gathered in 1995, but shrub cover was high in all three units.
2. In 1997, some portions the South Unit was mowed three times between 5 June and 31 July. Some portions of the unit were left unmowed, and about 50% of the grassland bird census plot had heavy shrub cover.

different parts of the South unit were either mowed, mowed and sprayed with an herbicide, sprayed with an herbicide, or not mowed, and shrubs were either retarded or eliminated from treated sections of the unit. Mowing in this unit occurred three times between 5 June and 31 July. These treatments were followed by an increase in grassland bird abundance in 1998, to 2.0 individuals/census/point (Table 17), although shrub growth was vigorous in the untreated part of the unit.

Another interesting example of how shrub removal may (or may not) affect grassland birds occurred in Upland Management Unit G2 (7.2 ha) at Iroquois NWR, which was cleared with a hydroax machine in late July 1996. Prior to treatment, G2 supported a dense growth of shrubs ± 2 m high. At the beginning of the breeding season following treatment, grass cover increased, and there were no shrubs in the field taller than ca. 20 cm. However, no grassland birds settled in the plot, which was bordered on three sides by deciduous forest, with the central point of the field within 100 m of the nearest forest edge; the most common birds were Yellow Warblers, Common Yellowthroats and Song Sparrows. By 1998, shrub cover and height had once again increased, to over 30% and 100 cm, respectively.

Results of habitat manipulations at Esker Brook, as well as those at G2, L3 and Subheadquarters North (Iroquois and Montezuma NWR, see above) should be followed for several more breeding seasons, but the available data illustrate several points about mowing, and grassland management in general. First, a single annual late summer mowing obviously reduces shrub coverage in the year following treatment, but this effect may disappear in the second year following mowing if pretreatment shrub densities are high. Second, creating "good" grassland habitat with high grass cover and few shrubs

may not lead to substantial increases in grassland birds if the field is either too small, or has a high perimeter/area ratio, particularly if the surrounding habitat is mature forest. Mowing a field three times early in the growing season, as was done in portions of the Esker Brook South Unit and Q 15 at Iroquois NWR, may have longer-lasting effects on shrub regrowth, but we will have to monitor the unit for several more years in order to tell. It should also be noted that early-season mowing will adversely affect any breeding species in the treated area.

Herbicide Application: Herbicides such as Roundup® (a broad-spectrum glyphosate herbicide which kills both grasses and broadleaf plants) and 2, 4 D amine 500 (which kills only broadleaf plants) have been used, in combination with other management techniques such as mowing, to promote grassland vegetation. Among the fields in the study area that have been treated with herbicides in recent years are Esker Brook (South Unit) at Montezuma NWR in 1997, and K9, L3, Q12 and Q13 at Iroquois NWR, all of which were either sprayed, or mowed and then sprayed, in 1993. Because I do not have pretreatment vegetation or bird data for Iroquois NWR, and herbicide application was often combined with mowing, it is difficult to evaluate the efficacy of herbicide application alone as a management technique for increasing grassland birds.

Prescribed Burning: Prescribed burning can reduce shrub and forb cover, standing dead vegetation, and litter, and increase nutrient recycling, and it has been used as an effective management tool to maintain grasslands in many parts of North America (Pauley 1997). Within the study area, prescribed burning has most often been used to maintain

switchgrass stands. Waugh 2, the abandoned hayfield dominated by cool season grasses at Montezuma NWR, was burned in April 1998, while three switchgrass fields at Iroquois NWR (B6, N1, and Q13) were burned during the spring of 1995 or 1996. Grassland bird abundance (8.3 individuals/census/point) at Waugh 2 was among the highest found in the study area when the field was initially censused in 1995 (Figures 1 and 12). At that time, the field was dominated by introduced cool season grasses, along with alfalfa. However, shrubs and broadleafed forbs such as goldenrod increased in the field in 1996 and 1997, and grassland bird abundance decreased to 2.8 individuals/census/point in 1997. Following burning, the field still supported large amounts of goldenrod, although grassland bird abundance increased to 4.4 individuals/census/point. The vegetation and grassland bird populations in Waugh 2 should be followed through several more breeding seasons to evaluate the effects of prescribed burning on introduced cool season grasslands in the study area.

Mature switchgrass monocultures contained few or any true grassland birds, and following prescribed burning, neither B6 nor N1 were colonized by Bobolinks, Eastern Meadowlarks, or Savannah Sparrows. However, these are small fields (< 3 ha), and area undoubtedly influenced these results. Although Q13 is only 3.4 ha, it has a central, ± 1.0 ha area of cool season grass, and is part of a much larger (69 ha) grassland (Unit Q); thus it might be expected to contain some grassland birds. High numbers of Bobolinks (4.0 individuals/census/point) were observed in 1996, following burning and removal of standing dead *Panicum* stems in April, 1995, but numbers had declined to 0 individuals/census/point by 1998, when standing dead *Panicum* cover had increased to over 20% (Figure 13). At this time, Common Yellowthroats, Swamp Sparrows, and Song

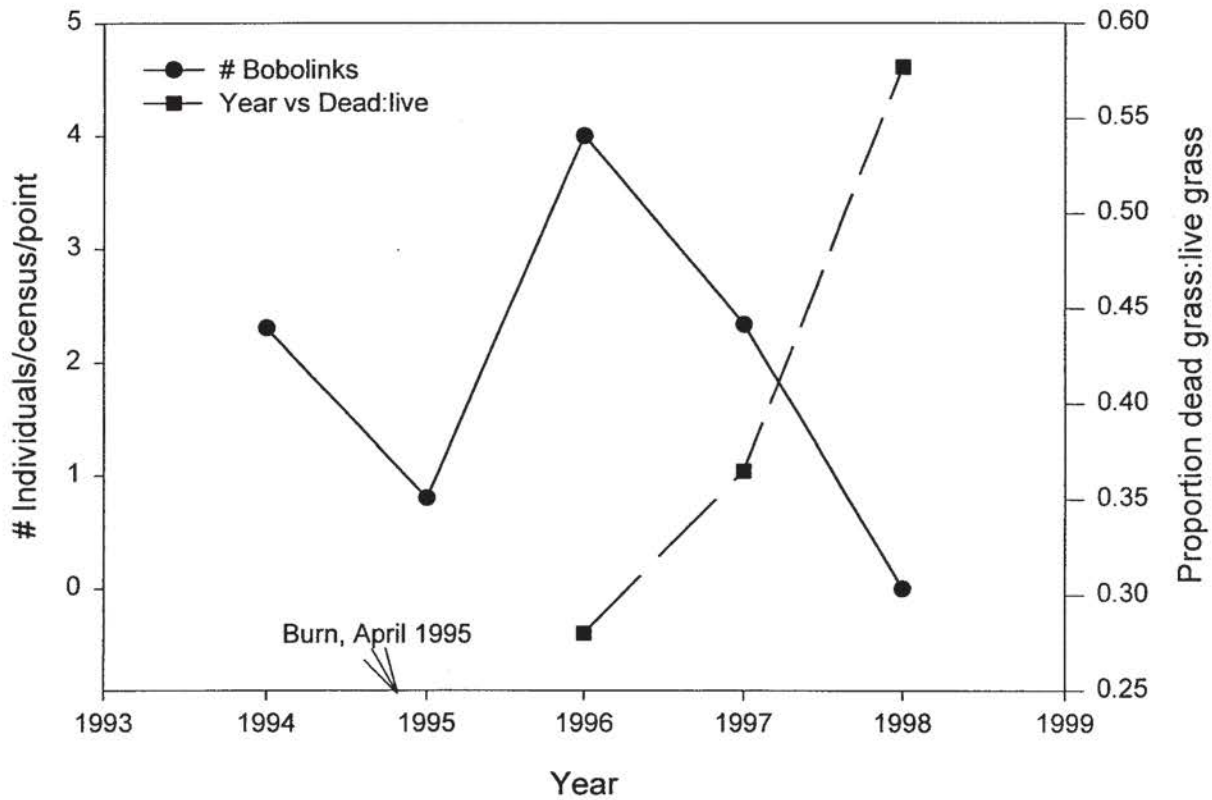


Figure 13. Mean number of Bobolinks/census, and proportion dead grass: live grass, Q 13 field, Iroquois National Wildlife Refuge.

Sparrows were once again the most abundant species in the field. Spring burns in switchgrass fields resulted in the absence of birds during the same year. For example, B6 and N1 supported Yellow Warblers, Common Yellowthroats, Song Sparrows, and Swamp Sparrows prior to burning. Bird abundance decreased to 0, then increased again in the year following the burn.

In conclusion, because prescribed burning has only been applied to one cool season grassland in the study area, and switchgrass stands generally support few grassland bird species other than the Sedge Wren (not generally classified as a grassland specialist; Knopf 1994), it is difficult to evaluate the effectiveness of prescribed burning as a grassland management tool in the study area. Tracking grassland bird abundance in the Waugh 2 field at Montezuma NWR may provide some information on the effects of controlled burns on introduced cool season grasslands and promoting grassland birds. In addition, there are plans to conduct some control burns on cool season grasslands at Iroquois NWR (Soch Lor, personal communication).

Revegetation and Field Enlargement: During the study complete grassland revegetation was attempted in four upland management units at Iroquois NWR: B12/13/5/14, K6, K9, and Q. In addition to revegetation, hedgerow and tree removal was used to increase the size of the B12/13/5/14 and Q grasslands. Because these manipulations were time and labor intensive, and were aimed at creating relatively large expanses of grassland, each will be discussed separately and in detail.

B12/13/5/14: These fields, which lie just north of Long Marsh, were last farmed in 1988. Prior to manipulation, they were dominated by forbs and shrubs. No grassland birds were observed at census points in B12 and B13 in 1994, 1995, or 1996; common species included Song Sparrows and Field Sparrows (*Spizella pusilla*). In 1996 and 1997, hedgerows and several trees separating the relatively small fields (± 2 ha) were removed, creating a larger field of 8.4 ha, which was bordered on the north, west and east by tall trees, and on the south by Long Marsh. In the spring of 1997 the field was then tilled and planted in strips of yellow sweet clover (*Melilotus officinalis*) and big bluestem (*Andropogon gerardii*); little bluestem (*Schizachyrium scoparius*) and Indian grass (*Sorghastrum nutans*); and switchgrass. In 1998, the new grassland attracted Savannah Sparrows and Grasshopper Sparrows, and supported 1.83 grassland birds/census/point. One Grasshopper Sparrow nest was found in low, sparse vegetation of the middle (Indian grass) strip. However, grassland birds tended to avoid portions of the field dominated by the taller (> 1 m) big bluestem and yellow sweet clover.

K6: This 13.6 ha field, which lies east of the Iroquois NWR headquarters, supported relatively high abundances of grassland birds in 1994 (Figure 10), but numbers decreased to 2.0 individuals/ census/point in 1996 as shrub invasion proceeded, and goldenrod became more abundant. A portion of the field was tilled to remove shrubs in late 1996 and planted to big bluestem, Virginia wild rye (*Elymus virginicus*), tall wheat grass (*Agropyron elongatum* [?]), and Indian grass in the summer of 1997. Although introduced mustard was abundant in some parts of K6 in 1998, 3.0 individuals/census/point were observed, including Savannah Sparrows, Bobolinks, and Eastern Meadowlarks.

K9: This 13.6 ha field lies just east of the Iroquois NWR headquarters, and is separated from K6 by a narrow band (<50 m) of cattails (*Typha latifolia*). Shrubs were removed from most of this field in 1996, although a portion of the area containing one bird census point was not disturbed. Most of the field was then tilled and planted in June 1997. Two mixtures were used: a mixture of yellow sweet clover, Indian grass, big bluestem, and tall fescue (*Festuca arundinacea*) in the portion of K9 nearest headquarters, and a mixture of eastern gama grass (*Tripsacum dactyloides*), yellow sweet clover, and Virginia wild rye in the area nearest the cattails. Prior to treatment, grassland bird abundance in the portion of the field to be revegetated had declined from 4.5 to 1.0 individuals/census/point between 1994 and 1996, following shrub invasion. By 1998, grassland bird abundance had increased to 4.66 individuals/census/point at the point (#44) in the revegetated grassland, while remaining much lower (0.4 individuals/census/ point) at the point (#45) in the remaining shrubs. As with B12/13/5/14, grassland birds using the area near point #44 tended to avoid the tall, dense stands big bluestem, tall fescue; a non grassland species (Red-winged Blackbird) was also abundant at the point.

Q: In 1994 this complex of fields contained a variety of habitat types, including introduced cool season grasslands, forb and shrub-dominated old fields, and warm season grasslands. The complex was also partially subdivided by a long, north-south running hedgerow between fields Q5 and Q16. Grassland bird abundance varied among fields and habitat types, but was generally low (< 3.0 individuals/census/point). An ambitious grassland vegetation and hedgerow removal effort resulted in creation of a relatively

large (69 ha) grassland dominated by introduced cool season grasses in 1998. Beginning in the summer of 1995 and continuing through 1996, shrubs were removed from Q16, fields were tilled, and all except Q16 were planted in various mixtures of clover (*Trifolium)*, alfalfa, birdsfoot trefoil (*Lotus corniculatus*), and tall wheatgrass. In some parts of Q, the initial seeding produced poor results, and in 1997 the vegetation was dominated by a tall (> 1 m) mixture of several exotic mustard species that supported few grassland birds; the mustard had almost completely disappeared by the spring of 1998. Average grassland bird abundance increased from a low of 1.3 individuals/census/point in 1995 to 3.6 individuals/census/point in 1998 (Figure 14), although the efficacy of management treatments varied from field to field within Q. For example, after revegetation no grassland birds were observed in Q16, a former shrubby field bordered on two sides by tall deciduous trees, and dominated by tall (> 1.0 m) forbs and grass. Conversely, 6.3 grassland individuals/census/point were counted at census point 50, located in field Q5, an increase of 5.3 individuals/ census/point from a low in 1997, when the area surrounding the point was mostly bare ground following tillage (Figure 14). Prior to 1996, Q15 was dominated by shrubs and forbs, and Red-winged Blackbirds were the most abundant species. The field was mowed three times in 1996, and grassland bird abundances increased to 2.67 individuals/census/point in 1998. By June 1998, management efforts had resulted in a large grassland dominated by grasses up to 1 m tall. Most importantly, grassland bird abundance was significantly higher at points in Q with lower, less dense vegetation (Figures 15 and 16).

Results of revegetation and hedgerow removal treatments suggest that such efforts can have a beneficial effect of grassland bird abundances, although effects may vary,

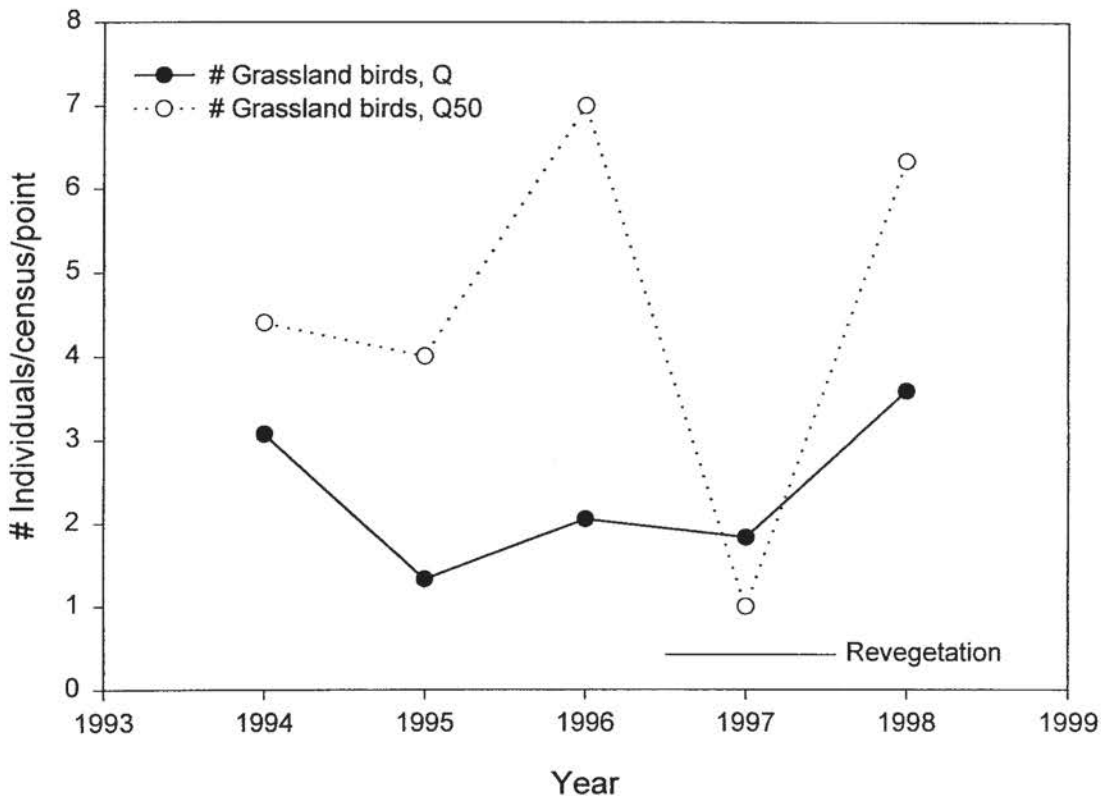


Figure 14. Mean number of grassland birds/census/point for Unit Q, and for one census point within Q (Q50), Iroquois National Wildlife Refuge. Timing of revegetation work also shown.

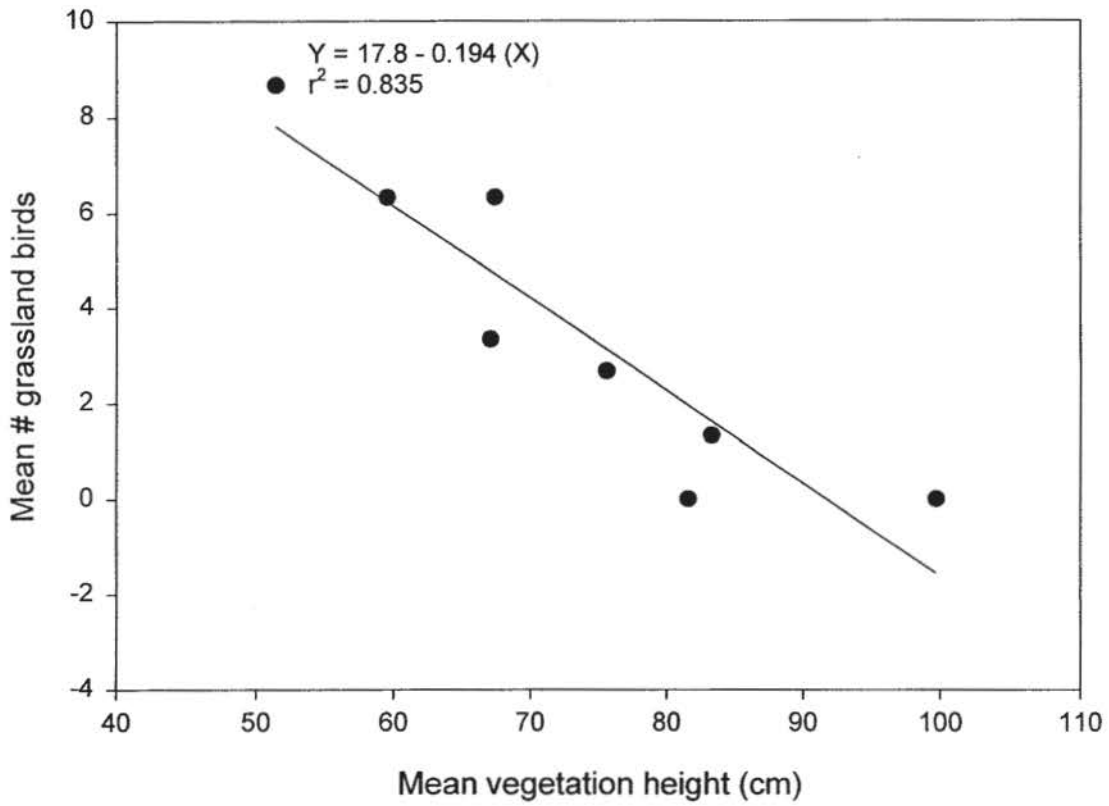


Figure 15. Mean number of grassland birds/census/point vs. mean vegetation height for Unit Q, Iroquois National Wildlife Refuge, 1998.

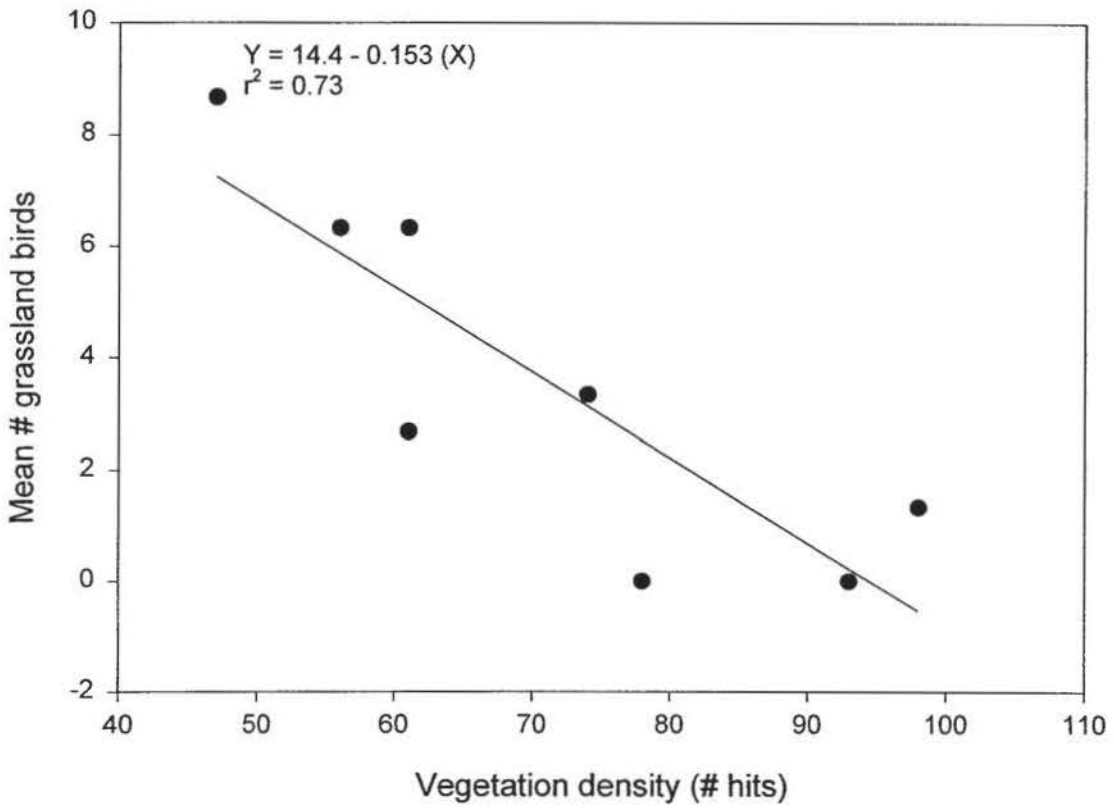


Figure 16. Mean number of grassland birds/census/point vs. vegetation density for Unit Q, Iroquois National Wildlife Refuge, 1998.

depending upon field size and location, and the species of grasses and forbs used in planting mixtures. The tendency for grassland bird numbers to decrease with increasing vegetation height and density suggest (see the section *Bird/Habitat Relationships – Richness and Abundance*, and Figures 15 and 16 for Unit Q) that fields should be planted with seed mixtures that produce relatively short, less dense vegetation if the goal is to encourage grassland birds.

Breeding Biology

Nest Success: Conclusive evidence of breeding at both Iroquois and Montezuma NWRs (nests with either eggs or young, parents feeding young, or recently fledged young) was noted for Northern Harriers, Savannah Sparrows, Bobolinks, and Eastern Meadowlarks. Grasshopper Sparrows bred only at Iroquois NWR (in 1998) and at Mendon Ponds, while Henslow's Sparrows bred only at Mendon Ponds. From 1994 through 1998 we determined the outcome of 132 nests of passerine grassland birds (as defined in Methods) at Iroquois NWR (Table 18). Combined proportion of successful nests was 0.77 for Savannah Sparrows, 0.60 for Bobolinks, and 0.66 for Eastern Meadowlarks (Table 18). The probability of nest survival/day during the incubation and nestling phases (Mayfield 1975, Bart and Robson 1982) was higher for Savannah Sparrows than for Bobolinks in both 1994 (0.9893 vs. 0.9676) and 1995 (0.9903 vs 0.9341; Table 18). The lower survival probability for Bobolink nests in 1995 was due to a high rate of nest loss early in the nestling period (five of nine active nests were depredated between days 1 and 5 after hatching). Cumulative nest survival probabilities/day (± 1 SE), based on all nests found between 1994 and 1998, were 0.9856 ± 0.0048 for Savannah Sparrows, 0.9622 ± 0.0086

Table 18. Proportion of successful nests by year and habitat type, and probability of nest survival/day, for grassland species at Iroquois National Wildlife Refuge, 1994-1998. For proportion of successful nests, sample sizes given in ( ). Probability of nest survival during the incubation and nestling phases calculated only for years and species with $n \geq 10$.

Species	1994	1995	1996	1997/98	Combined	Pasture	Cool season grassland
Proportion of successful nests							
Bobolink	0.63 (24)	0.40 (10)	0.40 (5)	0.82 (11)	0.60 (50)	0.60 (30)	0.60 (20)
Eastern Meadowlark	0.67 (3)	0.50 (2)	0.71 (7)	0.67 (3)	0.67 (15)	0.57 (7)	0.60 (5)
Savannah Sparrow	0.81 (26)	0.72 (25)	0.71 (7)	0.87 (8)	0.77 (66)	0.80 (55)	0.64 (11)
Grasshopper Sparrow	--	--	--	0.00 (1)	0.00 (1)	--	0.00 (1)
Total					0.69 (132)		
Probability of nest survival							
Bobolink	0.9676	0.9341	--	0.9899	0.9622		
Eastern Meadowlark	--	--	--	--	0.9804		
Savannah Sparrow	0.9893	0.9903	--	--	0.9856		

for Bobolinks, and 0.9804 ± 0.0102 for Eastern Meadowlarks. There were no significant differences between the proportion of successful nests in pastures vs. cool season grasslands (Table 18) for either Savannah Sparrows ($\chi^2 = 1.398$, $df = 1$, $P = 0.237$) or Bobolinks ($\chi^2 = 0.000$, $df = 1$, $P = 1.000$) for all nests found in 1994-1998.

We also found and monitored 29 passerines nests in oldfield or warm season grasslands. Combined proportion of successful nests was greater for grassland passerines (0.689, $n = 132$) than for passerines in oldfield or warm season grasslands (0.379, $n = 29$) ($\chi^2 = 9.847$, $df = 1$, $P = 0.002$). None of the 132 grassland bird nests found during the study were parasitized by Brown-headed Cowbirds. Of the 161 passerine nests found in 1994-1998 (including those in oldfield and warm season grassland habitats) only 1.2% ($n = 2$), both belonging to Field Sparrows, were parasitized by cowbirds.

Nest Predation Experiments: Results of the first nest predation experiment with quail eggs and artificial nest cups placed in pastures and cool season grasslands indicated that nest predation rates were highest at the field-forest boundary, where 43 % and 57 % of the nests were destroyed, respectively (Figure 17). Predation rates differed significantly among distances in 1994 ($\chi^2 = 16.24$, df = 6, p = 0.0125), but not in 1995 ($\chi^2 = 4.311$, df = 6, p = 0.635). However, there was no correlation between predation rate and distance from the field-forest boundary in 1994 ($r_s = -0.324$, $p > 0.05$) or 1995 ($r_s = -0.073$, $p > 0.05$). Overall predation rate on artificial nests was higher in 1995 than in 1994 (Figure 17; $\chi^2 = 10.59$, df = 1, p = 0.001), which mirrored the trend in nest success for grassland birds in these years (Table 18).

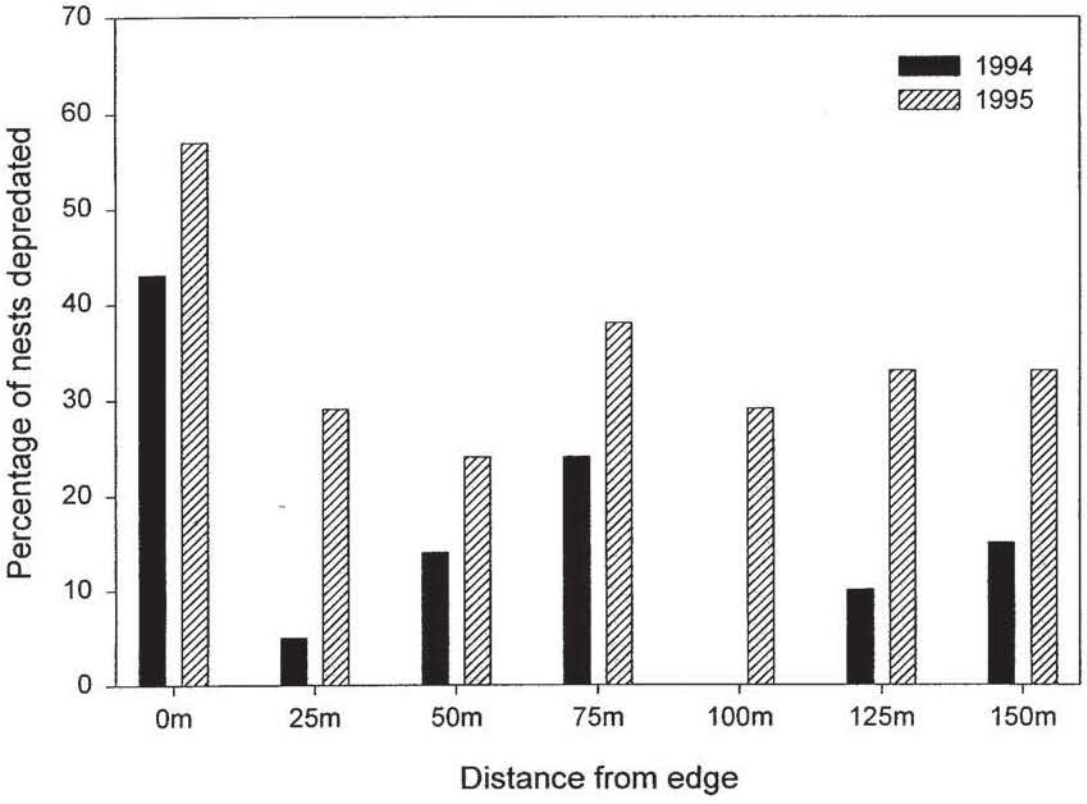


Figure 17. Nest predation rates for articficial nests in pastures and cool season grasslands at Iroquois National Wildlife Refuge; n = 21at each distance for each year.

In the second experiment, which involved placing nest cups in warm season grasslands, predation rates were highest at the field-forest boundary in 1995, but not in 1994 (Figure 18). Predation rates differed significantly across the range of distances used in the experiment in 1995 ($\chi^2 = 11.95$, df = 3, p = 0.008), and approached significance in 1994 ($\chi^2 = 6.74$, df = 3, p = 0.081). As with artificial nests placed in cool season grasslands, overall predation rates were higher in 1995 than in 1994 ($\chi^2 = 5.01$, df = 1, p = 0.025). Experimental rates of nest predation for all nests between 0 and 50 m from the nearest forest edge did not differ significantly between those placed in pastures/cool season grasslands and in warm season grasslands in 1994 ($\chi^2 = 0.82$, df = 1, p = 0.775) and 1995 ($\chi^2 = 2.108$, df = 1, p = 0.147).

Breeding Chronology: Combined data on grassland bird breeding chronology for the period between 1994 and 1997 indicated that most pairs initiated first clutches during the second half of May, and fledged young in the second or third week of June. Bobolinks tended to initiate nesting somewhat later than either Eastern Meadowlarks or Savannah Sparrows (Figure 19). Savannah Sparrow clutch initiation dates ranged from 8 May to 13 June; the range of initiation dates for Bobolinks was 17 May to 5 June, while the range of clutch initiation dates for Eastern Meadowlarks was 6 May to 5 June (Figure 19). Later clutch initiation dates for Savannah Sparrows and Eastern Meadowlarks probably represent clutches replacing earlier ones destroyed during the egg stage. Mean fledging dates for 1994-1997 were 15 June for Savannah Sparrows, 21 June for *Bobolinks*, and 17 June for Eastern Meadowlarks. Late fledging dates for known nests were 6 July for Savannah Sparrows, 30 June for Bobolinks, and 2 July for Eastern Meadowlarks. A

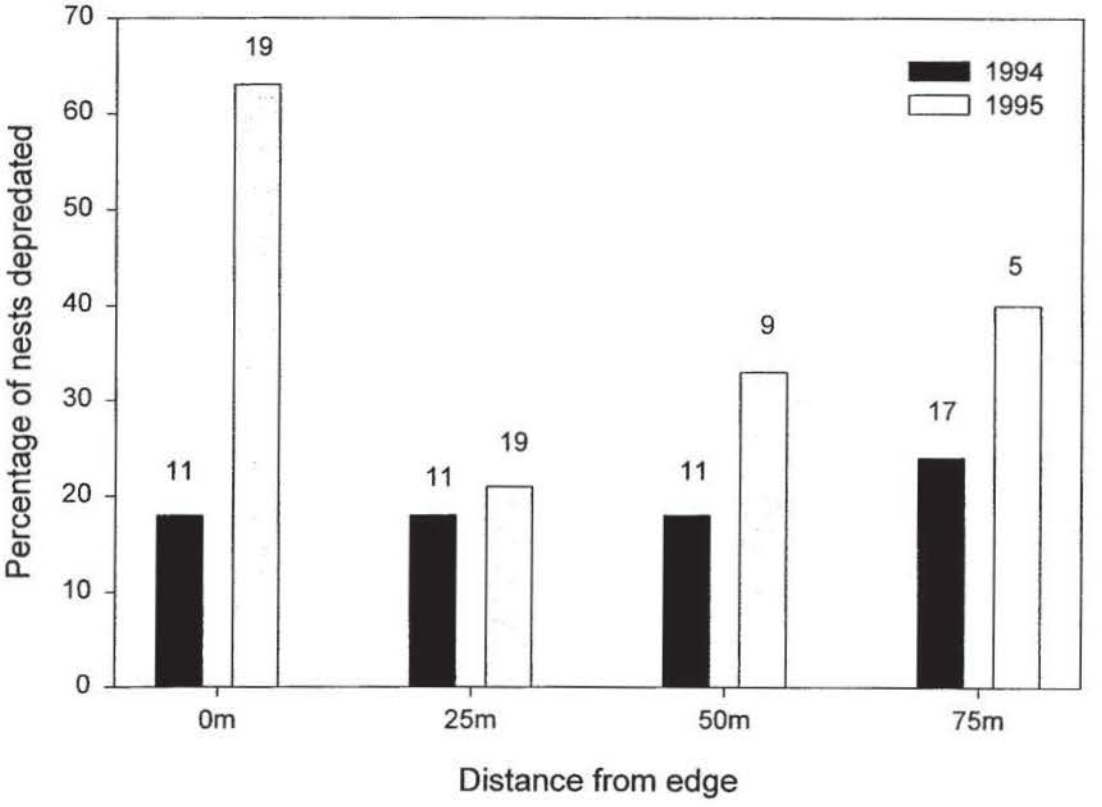


Figure 18. Nest predation rates for artificial nests in warm season grasslands at Iroquois National Wildlife Refuge. Sample sizes indicated above the bars.

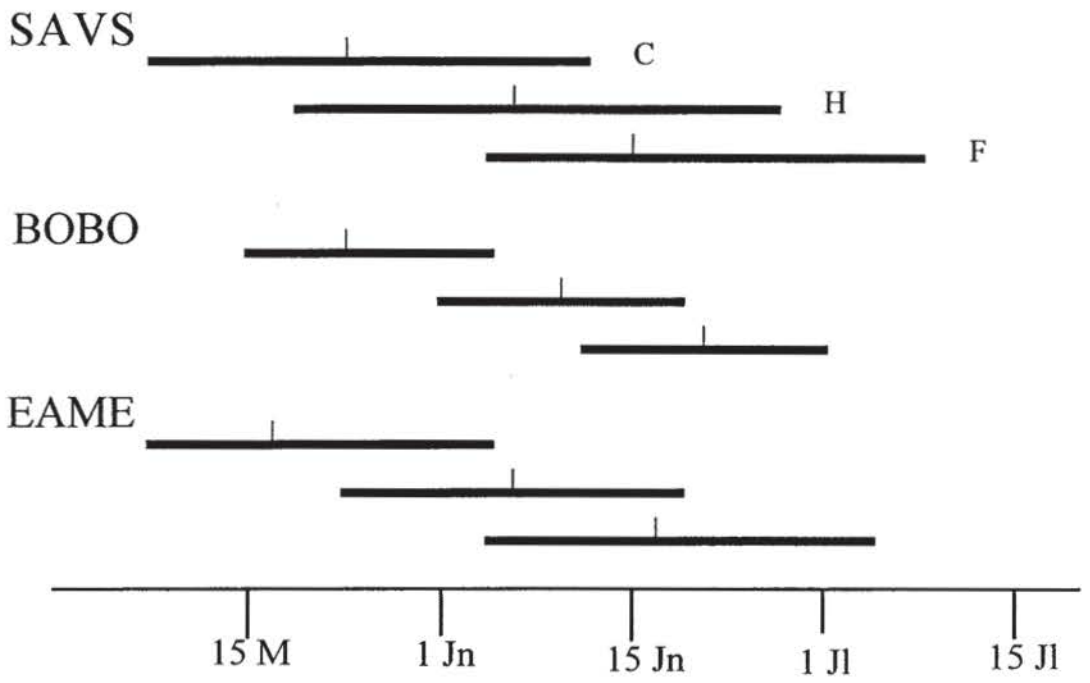


Figure 19. Nesting chronology for Savannah Sparrows (SAVS), Bobolinks (BOBO), and Eastern Meadowlarks (EAME), Iroquois National Wildlife Refuge; based on data for 1994-1997. C= clutch initiation; H = hatching; F = fledging. Horizontal bars equal range of dates; vertical lines give mean dates.

Northern Harrier at Braddock Bay WMA initiated a clutch on 21 May 1995; fledging would have occurred at the end of July, while a Northern Harrier at Montezuma NWR initiated a clutch no later than 22 May, 1997.

Behavioral observations and the presence of newly fledged young in August indicate that some Savannah Sparrows at Iroquois NWR are double-brooded, as are some Grasshopper Sparrows in the Mendon Ponds area (K. Balent, personal communication).

DISCUSSION

The regional obligate grassland bird fauna of New York and other parts of the Northeast is relatively depauperate, as illustrated by the 1997 report on the Northeast Grassland Bird Survey (Shriver et al. 1997). Shriver et al. (1997) present data on only seven obligate grassland species (Upland Sandpiper, Savannah Sparrow, Grasshopper Sparrow, Henslow's Sparrow, Vesper Sparrow (*Pooecetes gramineus*), Bobolink, and Eastern Meadowlark, although other obligate grassland species, including the Northern Harrier and Horned Lark (*Eremophila alpestris*), may also occur in the region. Although authors may differ in whish species they classify as grassland birds (for example, some authors classify the Sedge Wren as a grassland bird), the obligate grassland bird fauna of the Northeast clearly contains fewer species than does the grassland bird fauna of the Midwest (Knopf 1994). Consequently, the relatively small number of obligate grassland birds (≤ five, and generally ≤ three) found in any one field in the study area is not surprising. Low grassland bird species richness (≤ 3 species/field) also occurs on most pastures in the Finger Lakes National Forest (Smith and Smith 1990) and hayfields (Bollinger 1995) in central New York. Individual fields in Maine (Vickery at al. 1994)

also generally support relatively few grassland bird species. As in my study area, Bobolinks, Savannah Sparrows, and Eastern Meadowlarks are the most widely distributed grassland bird species in the Northeast as a whole (Shriver et al. 1997), Massachusetts (Jones and Vickery 1997) and Vermont (Darmstadt et al. 1997). However, Grasshopper Sparrows are more widely distributed in central New York (Smith and Smith 1990) than in my study area.

The only grassland species of either New York State or federal management concern known to breed in the study area were the Northern Harrier, Grasshopper Sparrow, and Henslow's Sparrow. None of these species were common or widely distributed. Northern Harriers were observed hunting over seven fields in the study area, while Grasshopper Sparrows were found in five of 54 different fields surveyed during the course of the study. The Henslow's Sparrow, which has been the focus of a status assessment by the U. S. Fish and Wildlife Service (Pruitt 1996), and is the least abundant grassland bird in the Northeast (Shriver et al. 1997), was found in only two of the 54 fields. The Sedge Wren, which is not listed by Knopf (1994) as part of the North American grassland avifauna, but which is listed in six of seven states in the Northeast, including New York (Vickery 1992), was found in two of seven switchgrass fields surveyed during the study.

Grassland Bird Populations and Breeding Biology.-- My census data suggest that populations of the more widely distributed grassland birds in western New York, including the Savannah Sparrow, Bobolink, and perhaps the Eastern Meadowlark, sustained breeding populations from 1994-1998 on state and federally administered lands

in the study area. Fields ± > 15 ha generally supported all three species, with mean abundances of ± ≥ 3 individuals/census/point.

However, density (or abundance) by itself may be a misleading indicator of habitat quality (Van Horne 1983, Vickery et al. 1992a), as areas with high densities may function as "sinks," where reproductive rates are below replacement levels (Pulliam 1996). In this study, rates of nest success for Savannah Sparrows, Eastern Meadowlarks, and Bobolinks were relatively high, which suggests that cool season grasslands in the study area currently function as good habitat for grassland birds. The proportion of successful Savannah Sparrow nests (0.77) was greater than for Savannah Sparrow populations in Maine (0.33, Vickery et al. 1992b), New Brunswick (0.40, Dixon 1978), and Michigan (0.52, Potter 1974). The proportion of successful Bobolink nests at Iroquois NWR (0.60) was within the range of values reported for hayfields in central New York (< 0.38 - < 0.88, Gavin and Bollinger 1988) and Wisconsin (0.72, Martin 1974). Although sample size was relatively small for Eastern Meadowlarks (n = 15), the proportion of successful nests (0.67) was higher than observed in three other studies (0.33, Lanyon 1957; 0.37, Roseberry and Klimstra 1970; 0.44, Knapton 1988).

There also was no evidence that brood parasitism by Brown-headed Cowbirds affects grassland bird nest success in the study area, in contrast to the situation in the Midwest, where rates of cowbird parasitism may reach 40 % of nests in some species and habitats (Johnson and Temple 1990). A final piece of evidence suggesting that rates of nest failure are lower in the study area than in many other grassland bird populations is the absence of any evidence for distance-dependent predation rates on artificial ground nests in cool season grasslands (Ardizzone and Norment 1999, in press). In contrast, nest predation

rates in the Midwest are generally higher nearer field-forest boundaries, both for artificial nests (Burger et al. 1994) and real nests (Johnson and Temple 1986, 1990), and Belding's Savannah Sparrows (*P. s. beldingi*) nesting in California salt marshes have reduced breeding success in smaller, more isolated habitat patches (Powell and Collier 1998).

Bird-Habitat Relations. -- My results emphasize the importance of habitat area for increased grassland bird species richness and abundance, as has been observed elsewhere in the Northeast (Smith and Smith 1992, Bollinger and Gavin 1992, Vickery et al. 1994) and Midwest (Herkert 1994a). Grassland species identified as area-sensitive include the Upland Sandpiper, Savannah Sparrow, Grasshopper Sparrow, Henslow's Sparrow, Vesper Sparrow, Bobolink, and Eastern Meadowlark (Vickery et al. 1994, Herkert 1994a, Smith 1997), although minimum field size apparently varies widely among species and regions (see review by Swanson 1996).

Although the relationship between increased field area and increased grassland species richness and abundance in my western New York study area has been found elsewhere, specifics related to minimum field size and incidence functions differ from other studies in the Northeast and Midwest. For example, minimum field size was around 5 ha for Savannah Sparrows and Bobolinks, and 9 ha for Eastern Meadowlarks, although scattered individuals were sometimes present in smaller fields. Savannah Sparrow and Bobolink incidence reached 50 % at 8 ha, while Eastern Meadowlark incidence reached 50% at about 15 ha. In Maine, incidence of Savannah Sparrows reached 50% at around 10 ha, while Bobolink and Eastern Meadowlark incidence remained low (< 40 %) at 500

ha (Vickery et al. 1994). In Illinois, minimum field area was 10 to 30 ha for Savannah Sparrows and Bobolinks, and at least 10 ha for Eastern Meadowlarks (Herkert 1991); 50 % incidence levels were estimated to be 5 ha for Eastern Meadowlarks, 30 ha for Savannah Sparrows, and 50 ha for Bobolinks (Herkert 1994a). In central New York, Bobolinks occupied hayfields as small as ca. 2 ha (Bollinger and Gavin 1992).

Although Henslow's Sparrows and Grasshopper Sparrows were uncommon in the study area, both species bred in smaller fields (4.6-8.7 ha) than might be expected from most other studies. Grasshopper Sparrows occur in pastures as small as 11.6 ha in central New York (Smith 1997), and have relatively small minimum areas of < 20 ha in Missouri (Samson 1980) and 10-30 ha in Illinois (Herkert 1994a), and larger minimum areas in Wisconsin (Johnson and Temple 1986) and Maine (Vickery et al. 1994). Henslow's Sparrows occur only in pastures ≥ 30 ha in central New York (Peterson 1983, Smith 1997), but occupy fields of 3-20 ha (mostly > 8 ha) at Saratoga National Historical Park (Mazur 1996). In Kansas and Illinois, the species is rare in fields of < 30 and 100 ha, respectively (Zimmerman 1988, Herkert 1995b). Although the species has bred in fields as small as 3.6 ha in Pennsylvania (Graber 1968), larger fields apparently are preferred nesting habitat, and are usually occupied first (Smith and Smith 1992, Mazur 1996).

In addition to habitat area, vegetation characteristics also affect grassland bird species richness and abundance (Wiens 1969 and 1974, Herkert 1994a, Bollinger 1995), although the precise nature of the relationship between species abundance and vegetation characteristics may vary from region to region (Herkert 1994a, Bollinger 1995). In western New York grasslands, overall grassland bird species richness and abundance was higher in fields with lower, less dense vegetation, more live grass cover, little dead grass

cover, and few shrubs; these relationships also held for Savannah Sparrows and Bobolinks, and to a lesser extent, Eastern Meadowlarks. Bollinger (1995) also found that Upland Sandpipers, Henslow's Sparrows, Grasshopper Sparrows, Eastern Meadowlarks, and Bobolinks were most abundant in central New York hayfields with shorter, sparser, grass-dominated cover. Savannah Sparrows appeared less sensitive to vegetation differences than other grassland birds, and were equally abundant in hayfields with very different characteristics (Bollinger 1995). Results of my analysis of grassland bird/habitat relationships, and those of Bollinger (1995), differ from the general trend for grassland birds in the Midwest, where most species tend to be more abundant in taller, more dense vegetation (Kantrud 1981, Zimmerman 1988, Herkert 1994a, Bollinger 1995), although individual species may respond to habitat features in different ways (Wiens 1969, Herkert 1994). Bollinger (1995) feels that these differences in habitat selection are due to differences in the geographic locations of the studies (Wiens 1981), and perhaps the greater primary production of some eastern grasslands. *Whatever the causes of regional differences in grassland bird habitat selection – both in terms of field area and vegetation characteristics – these differences emphasize that the best management methods for grassland birds in New York and other parts of the Northeast should not be determined solely by reference to studies conducted in the Midwest.*

Several additional points need to be made about the results of the bird-habitat analyses. First, indices of grassland bird species richness and abundance tend to decrease with increasing horizontal and/or vertical vegetation heterogeneity (Wiens 1974, Herkert 1994a, Bollinger 1995, this study). Although shrub and forb cover tend to increase spatial heterogeneity, and data from the current study suggest that increased forb and

shrub cover may negatively affect grassland bird abundance in western New York, these are statistical relationships that may explain only a small portion of the total variation in grassland bird abundance across a range of field types. Most species of grassland birds display *some* tolerance of forbs and shrubs in fields that they occupy (Renken and Dinsmore 1987, Smith and Smith 1990, Swanson 1996, Pruitt 1996), and some relatively large fields in the study area with scattered shrubs (< 3% cover) and patches of forbs (< 20% cover) supported healthy grassland bird populations.

Second, landscape characteristics other than area may influence grassland bird communities (Helzer 1996; Norment et al. 1999, in press). In the current study, the amount of cropland surrounding a field had a positive effect, and the amount of deciduous forest had a negative effect, on grassland bird abundance in one year (1995). Additionally, field shape and the type of vegetation immediately bordering the field may also influence grassland bird abundance. Some moderate-sized fields (5–9 ha), bordered on one or more sides by tall trees or with high perimeter/edge ratios (e.g., Subheadquarters North at Montezuma NWR, and L3 at Iroquois NWR) had few grassland birds. Although few studies have investigated the relationship between habitat patch perimeter/area ratios and grassland bird abundance, this variable was a better predictor of grassland bird species richness and probability of occurrence than field area in wet meadows in central Nebraska (Helzer 1996). Finally, isolation may also affect bird community composition and breeding success within habitat patches. Although we found that in 1995 and 1996 amount of cool season grassland area within 500 m of a field had no effect on grassland bird abundance or species richness, isolation has not been directly investigated in many published grassland bird studies. Most studies of the effects

of habitat fragmentation on grassland birds have focused on area effects alone (cf. Johnson and Temple 1990, Herkert 1994a), although fragmentation leads to both a decrease in average habitat patch size and increased isolation of patches (Forman 1995). Metapopulation theory and data from several bird studies (see papers in McCullough 1996, especially Stith et al. 1996; Villard et al. 1993, Van Horn et al. 1995, Roberts and Norment 1999) suggest that isolation *per se* should affect grassland bird community composition and breeding success. Current studies on Grasshopper Sparrow metapopulation dynamics in Massachusetts and New York should add to our meager knowledge of how grassland birds respond to increased isolation of habitat patches.

Synthesis: Management Recommendations Relative to Habitat Relations, Breeding Biology, and Management Effects. – Data from the current study on grassland bird populations, breeding biology, and management effects, when combined with published information, can be used to make management recommendations for grassland habitats at Iroquois and Montezuma NWRs, and for other federal and state-owned lands in the Northeast with significant amounts of grassland. However, before proceeding, it is important to outline the assumptions that underlie my management recommendations.

Assumptions:

1. Grassland bird conservation is a regional priority for both the United States Fish and Wildlife Service and the New York State Department of Environmental Conservation, and grassland bird populations in the region should be encouraged. This priority is driven by concern over the regional and continent-wide decline in grassland birds since 1966.

As evidence of this concern, grassland bird ecology and conservation has been the focus of much recent research and management-related activity. Two recent conferences have focused on the topic, one dealing with the Northeast (Vickery and Dunwiddie 1997b) and one with North America as a whole (Vickery and Herkert 1999), and a session at the 1998 North American Ornithological Conference was devoted to the topic. However, Region 5 of the USFWS has not developed a rationale for emphasizing grassland bird conservation in the Northeast (Dianne Pence, USFWS, personal communication).

2. Although I will focus on management goals and methods designed to benefit grassland birds, other management options may be more appropriate for a given site (see Assumptions 3 and 4).

3. The management goals for any National Wildlife Refuge, or for other public lands, should be determined by reference to both regional priorities and the specific characteristics of the area. Thus grassland bird conservation may be an important regional priority, and might be emphasized on a refuge with much open, upland habitat, such as Iroquois NWR. It may be less important at a refuge with less upland habitat, and relatively more wetland, such as Montezuma NWR.

4. An assumption related to number 2 is that any managed natural area cannot be all things to all organisms. Decisions about land use are a crucial aspect of natural resource management, and will often involve trade-offs (Hunter and Calhoun 1996). Priorities for land-use must be established, hopefully while considering the principles of ecosystem

management (Christensen et al. 1996). Attempts to create a plethora of habitats and conserve all native taxa found in an area could lead to habitat fragmentation, one of the most severe threats to biodiversity (Primack 1998), and will benefit few, if any populations.

5. The time, money, equipment, and manpower that can be devoted to research and management are limited, and agencies such as the United States Fish and Wildlife Service may have to make difficult decisions about the allocation of these resources. At the regional level, these decisions may involve allocation of funds for grassland acquisition or research (such as the Challenge Grant program). At the refuge level, these decisions may involve whether to maintain or create grasslands on particular sites.

6. Management methods for grassland birds in other regions of the country besides the Northeast – or even some habitats in the Northeast that are absent from the study area – may not be appropriate for western New York grasslands.

7. Wherever possible, management methods used to promote grassland birds should minimize impact on other *desirable* taxa, and should have minimal adverse impacts on overall environmental quality.

8. Scientific knowledge is imperfect. Conservation biology has been described as a "crisis discipline," and there is often a need to proceed rapidly if biodiversity is to be protected (Primack 1998). Such an argument can effectively be made for grassland birds,

but resource agencies still must have good data on which to base management decisions, and proceed cautiously in the face of limited knowledge and the unpredictability of natural ecosystems (Ludwig et al. 1993, Christensen 1997).

Management Recommendations Related to Grassland Bird/Habitat Relationships and Breeding Biology: The most obvious recommendation is that upland areas should be managed to maximize field area, through hedgerow removal and consolidation of adjacent grasslands, establishment of grasslands on sites formerly dominated by shrubs and forbs, etc. Fields < 8 ha should generally receive lower priority for grassland maintenance and establishment, while the largest fields in an area should receive the highest priority. The major exception to this rule would be for smaller fields known to support species of management concern, such as Grasshopper Sparrows and Henslow's Sparrow. Field shape and the surrounding vegetation should also be taken into account when establishing management priorities. Resources should first be allocated to fields that have a minimal perimeter/area ratio, are not surrounded by tall stands of trees, and are surrounded by other types of open habitats, such as croplands and wetlands. Finally, although there has been little published work to date on the spatial structure of grassland bird populations, metapopulation theory and data on the spatial structure of bird populations in other habitats (McCullough 1996) suggest that grassland bird populations will benefit from situations in which suitable habitat patches are in close proximity to one another. These landscape features may help contribute to the "habitat gestalt" (James 1971) of grassland birds (Bollinger 1995).

Management practices for management units to be maintained as grassland should seek to encourage growth of diverse native warm season grasses (Titus and Haas 1998, Jones and Vickery, no date) minimize standing dead vegetation, and promote relatively short, less dense vegetation. However, grassland birds in the region may also do well in fields dominated by an assortment of introduced cool season grasses (Mazur 1996). In general, most grassland birds in the study area appear to do best in vegetation with an average height of < ca. 60-70 cm in early June. The only possible exception to this rule is the Henslow's Sparrow, which tends to prefer taller, more dense vegetation, with relatively high amounts of standing dead forbs and grasses (Herkert 1995b, Pruitt 1996). However, Henslow's Sparrows settle in census plots at Mendon Ponds where the average vegetation height at the end of May is only 40-60 cm, and Mazur (1996) found that Henslow's Sparrows generally were restricted to fields with vegetation heights < 70 cm. Also, monotypic stands of either introduced cool season grasses or warm season grasses are not desirable for grassland birds. Some shrub cover (< 1 %) and even widely scattered trees, along with moderate (< 20-30%) amounts of forbs (especially legumes, but including goldenrod, wild carrot and milkweed) will help create a diverse grassland, with lots of song perches and desirable nest sites (Kahl et al. 1985). In fact, persistent use of herbicides may remove all shrubs from some grasslands and reduce small mammal populations, rendering the grasslands less suitable for raptors such as Northern Harriers and Short-eared Owls (Vickery et al. 1992b, Vickery et al. 1994). Kahl (no date) has expressed concern that scattered trees or hedgerows may provide perches for predators and Brown-headed Cowbirds, but the low rates of nest predation and absence of brood

parasitism suggest that these are not a major problem for grassland birds in the study area.

The dense switchgrass monocultures that have been planted in some areas (e.g., A2, B6, G6, N1, Q13 at Iroquois NWR; 29 at Oak Orchard WMA; the Beattie Point grassland at Braddock Bay WMA) support few, if any, grassland birds. Although most of these fields are small, and the absence of grassland birds could be attributed to area effects, the absence of grassland birds from the 44 ha Beattie Point grassland supports the hypothesis that switchgrass fields do not possess the proper vegetation structure to attract most grassland birds. In other regions switchgrass fields also may support low numbers of grassland birds, especially those species which require open habitats (Volkert 1992; Prescott and Murphy 1995; Evrard and Bacon 1995; R. C. Gatti et al., unpublished manuscript). Thus, the decision as to whether or not to plant and maintain switchgrass monocultures should be based on overall management goals for the land. For example, *Panicum* monocultures may provide suitable habitat for Northern Harrier and Short-eared Owl (*Asio flammeus*) nest sites and Sedge Wren territories, although Kahl's (no date) suggestion that switchgrass fields may be suitable for Henslow's Sparrows is probably incorrect. Henslow's Sparrows in Illinois, Wisconsin and New York may prefer taller, more dense vegetation with a relatively high percentage of dead cover (Wiens 1969, Herkert 1994a, Herkert 1995b, Smith 1997), but these studies were carried out in areas without dense switchgrass monocultures. No Henslow's Sparrows were found in any of the switchgrass fields ($n = 7$) surveyed in the current study, nor did Kerr (no date) find any Henslow's Sparrows in a survey of six switchgrass fields at Iroquois NWR and Tonawanda WMA.

Monotypic switchgrass stands are widely believed to provide high-quality dense nesting cover for waterfowl and other game birds. However, data from Wisconsin indicate that both Mallards (*Anas platyrhynchos*) and Blue-winged Teal (*Anas discors*) preferred cool season grasslands over switchgrass fields (Livezey 1981; Gatti et al., no date). At Iroquois NWR, Mallards but not Blue-winged Teal have higher nest success in switchgrass fields (Estel-Costanzo and Malecki 1994). In addition, 1989 custom rate guides and seed costs indicated that switchgrass was 53 % more expensive to establish than mixtures of cool season grasses and forbs (Gatti et al., no date). Thus land managers should be cautious about establishing dense switchgrass monocultures in the Northeast, and Kahl's (no date) recommendation that 50% of Montezuma NWR's grassland acreage should be devoted to warm season grasslands would only be appropriate if the acreage is planted in a diverse mixture of short warm season grasses with relatively small stem diameters and low height.

Grazing Effects: Although intensive grazing can negatively impact populations of Upland Sandpipers, Savannah Sparrows, Grasshopper Sparrows, and Bobolinks (Kantrud 1981, Bowen and Kruse 1993), moderate or low levels of grazing may actually increase grassland bird species richness (Kantrud and Kologiski 1983), and the abundance of Eastern Meadowlarks and Grasshopper Sparrows (Risser et al. 1981). At Iroquois NWR, the moderate stocking rate in productive pastures that are grazed every other year (0.6-0.83 animals/ha), coupled with the introduction of cattle after 15 July, meant that grazing had little effect on grassland bird populations in the pastures where it occurred. Grazing also had little effect on grassland bird populations at Finger Lakes National Forest in

central New York, where stocking rates were also low (0.12 – 0.24 cattle/ha; Smith and Smith 1990). Thus I recommend continuation of current grazing practices at Iroquois NWR. Expansion of grazing activities to include other fields could also be considered, as long as cattle were not let onto fields until late July, and grazing intensity remained low.

Mowing Effects: Some mowing practices are detrimental to grassland birds. Changing forage crop agricultural practices, most importantly earlier haycropping dates, have negatively affected grassland birds in New York and other parts of the United States (Warner and Etter 1989, Bollinger et al. 1990, Frawley and Best 1991, Bollinger and Gavin 1992). In New York, first cutting dates are about two to three weeks earlier than 30-40 years ago (Bollinger and Gavin 1992), and because most grassland birds in western New York have not fledged young until after 20 June, early mowing, which commonly occurs around 15 June, could drastically reduce nest success for these species. In central New York, fields with earlier haycropping dates the previous year had lower grassland bird densities than fields with later mowing dates (Bollinger 1995).

Although early mowing is clearly detrimental to grassland bird populations, late-season mowing may be beneficial for grassland species such as the Upland Sandpiper, Grasshopper Sparrow, and Western Meadowlark (Westemeier 1989, Byre 1997). In a series of North Dakota grasslands, Savannah Sparrow, Bobolink, and Western Meadowlark (*Sturnella neglecta*) densities were highest in hayfields that had been mowed and raked (Kantrud 1981). However, other grassland species such as Grasshopper Sparrows and Henslow's Sparrows may be adversely affected by mowing, at least for several years following the disturbance (Kantrud 1981, Zimmerman 1988, Herkert

1995b, Mazur 1996). Although Smith (1997) found no evidence that the number of years since last mowing negatively affected Grasshopper Sparrow or Henslow's Sparrow abundance on pastures in the Finger Lakes National Forest, I observed that Henslow's Sparrows were absent from sites that they had occupied the previous year, but that had been mowed during the preceding summers, at Carleton Hills WMA in western New York (Norment, personal observation), and Herkert (1995b) and Mazur (1996) found that Henslow's Sparrows were absent or much reduced in numbers in the year following mowing. In general, it might be expected that grassland species that prefer taller, more dense vegetation may be adversely affected by mowing more than would species that prefer shorter, more open vegetation.

The fields at Iroquois NWR that have been haycropped in late summer or fall in recent years (parts of I annually, C5 in August 1997) supported high numbers of grassland birds the following year. Although mowing without raking may lead to increased litter accumulation (Rudnicky et al. 1997), which negatively affects some grassland birds (e.g. Weins 1969), mowing to control shrubs still may be an important grassland management technique in the Northeast (Dunwiddie et al. 1997). Mowing cool season grasslands may best be done in late July through late August (Dan Carroll, NYSDEC, personal communication). The necessary frequency of mowing will vary from field to field, depending in part upon the amount of woody shrub invasion. Because most shrubs resprout after cutting (Solecki 1997), areas with high shrub cover will have to mowed annually if mowing is not combined with herbicide treatment or some form of mechanical removal. Examples of this are the Central Unit of the Esker Brook field at Montezuma NWR, and field G2 at Iroquois NWR, where high shrub cover was present

within two years of mowing. Although annual mowing may be preferable in some cool season grasslands (Duebbert et al. 1981), mowing every two to three years may adequately deter shrub invasion (Byre 1997) and will probably be less harmful to grassland bird populations. Not mowing a field every year, or delaying mowing until late August, will also allow development of late-blooming wildflower species and will benefit other grassland-dependent taxa such as butterflies (Jones and Vickery, no date a). There are insufficient data to evaluate the effects of mowing frequencies of three times/year on shrub survival and grassland revegetation in the study area. However, the lack of shrub reinvasion in Q15 as of 1998 suggests that this may be an effective management tool; the effects of this practice in the South Unit of Esker Brook at Montezuma NWR should also be evaluated over a period of several years. Early-season mowing in fields with grassland birds should be scheduled so that portions of the field are left undisturbed in any one treatment year.

Warm season grasslands do not need to be mowed as frequently as cool season grasslands to control forbs and shrubs, and a three- or four-year mowing interval may be adequate (Myers and Dickerson 1984). Although Myers and Dickerson (1984) also recommend cutting switchgrass fields between 20 July and 1 September, switchgrass fields at Iroquois NWR and in the surrounding NYSDEC lands are usually cut between 15 May and 15 June (Iroquois NWR 1990; Dan Carroll, personal communication). Because these dates fall within the breeding season for Northern Harriers and Sedge Wrens, both of which utilize switchgrass fields and are species of management concern, any switchgrass field scheduled to be cut early in the year should be surveyed for harriers and Sedge Wrens before cutting. If either of these species is found, cutting should be

postponed until after mid-August, by which time these species should have fledged young (Andrle and Carroll 1988).

In conclusion, mowing may be a valuable management tool for managing grassland bird populations in the study area, although when used alone it may not be effective in reducing or eliminating woody vegetation from shrub-dominated sites. Cool season grasslands can probably be maintained with a two- or three-year mowing interval, although sites with high shrub density will need more frequent treatment. References (Duebbert et al 1981, Myers and Dickerson 1984) should be consulted for details regarding mowing techniques, including cutting height. Whenever possible, mowing should be done after conclusion of the breeding season – *at least* July 15 for most single-brooded species, but after mid-August in habitats supporting Northern Harriers, Sedge Wrens and Henslow's Sparrows. In addition, late-blooming grassland plants may benefit from postponing mowing until after 1 September (Jones and Vickery, no date a). Thus timing and frequency of mowing must be determined after considering the specific habitat requirements, and responses to mowing, of target species and other grassland taxa. Three publications by Vickery and Jones (no date a) provide valuable information on how grassland birds in the Northeast respond to management techniques.

Special care should be exercised when contemplating mowing fields occupied by Henslow's Sparrows. In addition to their suspected sensitivity to mowing, Henslow's Sparrows may lay a second clutch of eggs in late July or August (Pruitt 1996), and in August pairs may be present in fields that were vacant earlier in the season (Mazur 1996). Thus I recommend that only a portion of any field with Henslow's Sparrows be mowed in any year, and that mowing be postponed until after 1 September. Although Smith

(1997) found that mowing during late July and August had no noticeable effect on occupancy of fields the following year in central New York, Mazur (1996) recommended that fields with Henslow's Sparrows at Saratoga National Historical Park be mowed either before 15 April or after 15 September. Mazur (1996) also recommended that fields with Henslow's Sparrows be managed on a 5- or 6-year cycle.

Herbicide Application - Effects and Considerations: Because mowing alone may not control widespread shrubs (Dunwiddie et al. 1997, Solecki 1997), herbicides that target broadleafed plants sometimes have been used, alone or in combination with other management techniques, to maintain or revegetate grasslands at both Iroquois and Montezuma NWRs, as well as elsewhere in the country (Solecki 1997) and in Europe (Tiffney 1997). Although I do not have sufficient data to directly evaluate the efficacy of herbicide use as a grassland management tool, herbicides should be used cautiously, taking into account potential effects on nontarget species and overall ecosystem health and diversity, and should generally not be used to completely eliminate exotic species (Solecki 1997). In general, herbicides are most effectively used to revegetate or maintain grasslands in combination with other control methods, such as prescribed burning, mechanical control, and restored hydrology (Solecki 1997). It should also be remembered that persistent herbicide application may degrade grasslands and reduce or eliminate some grassland bird species (Vickery et al. 1994, Vickery and Dunwiddie 1997a). A final – *and very important* – consideration is that some herbicides act as endocrine disrupters in wildlife species, at concentrations several orders of magnitude less than those at which they exhibit carcinogenic effects (Colborn et al. 1993). Included

among the list of herbicides that have reproductive and endocrine-disrupting effects are 2, 4-D and 2,4,5-T (Amdur et al. 1991, Hays and Laws 1991, Colborn et al. 1993). *Thus I recommend that any herbicides suspected of acting as endocrine disrupters not be used by the United States Fish and Wildlife Service, no matter what their utility in controlling unwanted vegetation.*

Prescribed Burning: As with mowing, prescribed burning is a useful tool for managing grasslands. Fire may remove shrubs, decrease litter, encourage the growth of warm season grasses, and promote nutrient cycling, and is a cost-effective management tool. However, it also may affect different bird species in different ways (Byre 1997, Johnson 1997). For example, species which prefer very open conditions, such as the Horned Lark, Vesper Sparrow, and Lark Sparrow (*Chondestes grammacus*), may settle in, and show a preference for, recently burned areas (Sample and Hoffman 1989, Pylpec 1991), while species such as the Henslow's Sparrow and Eastern Meadowlark may avoid recently burned areas (Knodel 1980, Zimmerman 1988, Sample and Hoffman 1989, Herkert 1995b). In general, studies in the Midwest suggest that most grassland-dependent passerines decrease in the year following a burn, but then increase in the following 2-5 years (Johnson 1997, Zimmerman 1997).

Although I have few data on the effects of prescribed burning on grassland birds in the study area, results from other studies can be used to suggest conditions that *might* favor use of prescribed burning in the study area. In general, warm season grasses respond better to burning than do introduced cool season grasses (Duebbert et al. 1981, Myers and Dickerson 1984, Wark et al. 1995). While burning cool season grasslands

may initially increase their vigor, positive effects may last only a few years, and lead to the removal of legumes (Duebbert et al. 1981). Myers and Dickerson (1984) recommend burning mature switchgrass fields every three to four years, with burns in April to mid-May. The grassland management plan for Iroquois NWR (1990) calls for fall burns in switchgrass fields, when moisture conditions are more favorable, although spring burns have also been conducted (Soch Lor, personal communication). In the Midwest, cool season grasslands are best burned either between late March and mid-May, or between mid-August and mid-September (Duebbert et al. 1981).

Studies at Floyd Bennett Field, Brooklyn, New York, and Nantucket Island, Massachusetts, both in grasslands with a high proportion of cover in the warm season grass little bluestem, suggest that burning (or burning and mowing) is a more effective way to decrease shrub cover and promote conditions favorable to grassland birds than is mowing alone (Dunwiddie et al. 1997, Rudnickey et al. 1997). Both studies also found that August burns were more effective than spring burns in reducing shrub cover (Dunwiddie et al. 1997, Rudnickey et al. 1997). However, caution should be exercised in extrapolating results of prescribed burn studies on effects from one area to another (Dunwiddie et al. 1997). For example, annual and biennial spring burns on grasslands in Connecticut dominated by little bluestem eventually led to an increase in some clonal shrubs (Niering and Dreyer 1989).

Because I have few data on the effects of prescribed burning on grassland bird populations in the study area, my management recommendations concerning this method should be viewed cautiously. However, the balance of available data suggest that in western New York, prescribed burning will be a more effective management tool in

warm season grasslands than in cool season grasslands. Late summer or early fall burns will probably more effective at controlling shrubs than spring burns, and will have less impact on birds in these habitats. Special care should be exercised when burning switchgrass fields with Northern Harriers or Sedge Wrens, or any grassland with Henslow's Sparrows, as this species appears to be particularly sensitive to fire. Jones and Vickery (no date) suggest burning appropriate sites on a 2-6 year rotation; ideally, no more than 40% of the grassland should be burned in any one year, to provide unburned nesting habitat.

Revegetation and Field Enlargement: Most of my comments related to landscape and vegetation characteristics, as they relate to grassland revegetation and enlargement, have already been made in the section on "Management Recommendations Related to Grassland Bird/Habitat Relationships and Breeding Biology," and subsequent sections on management effects. However, I would like to make some general comments concerning what might be termed the "philosophy" of grassland revegetation on public lands in the region. First, grassland revegetation is a relatively expensive process that involves extensive mechanical preparation of the seedbed in order to remove shrubs and other undesirable plants, herbicide application, fertilization, and seed purchase and planting. Given the limited resources available for management of public lands, managers should prioritize areas as to their suitability for grassland bird habitat, and focus revegetation efforts on the most valuable sites.

Second, managers should give careful consideration to the seed mixtures used in revegetation efforts, given specific management objectives for the area being

manipulated. In general, I would encourage the use of native grasses over introduced grasses, *if the management goal is to maximize grassland bird abundance*. This practice may be particularly important because some recent research suggests that grassland birds tend to avoid fields planted with mixtures of exotic cool-season grasses (Titus and Haas 1998) – although my studies suggest that grassland bird abundance and nest success are relatively high in introduced cool season grasslands in western New York. Commercially available native cool season grasses include slender wheatgrass (*Agropyron trachycaulum*), Canada bluejoint (*Calamagrostis canadensis*), Canada wild rye (*Elymus canadensis*), and Virginia wild rye (New York Flora Association 1990). Some warm season grasses may also be valuable when planted in areas to be managed for grassland birds, although switchgrass monocultures should be avoided, unless they are to be used as habitat for Sedge Wrens. Among the native warm season grasses that may be appropriate are big bluestem, side-oats gramma (*Bouteloua curtipendula*), little bluestem, Indian grass, and eastern gramma grass (*Tripsacum dactyloides*) (New York Flora Association 1990, Jones and Vickery no date). Plantings should emphasize species that average less than 0.6 – 0.7 m tall in late May – early June.

Third, planting different mixtures of forbs and grasses in different portions of single fields may not be a good way in which to meet *any* management objective, because this practice may create smaller areas with very disparate cover types. In general, managers should decide on a single planting mixture for a field and perhaps refuge, based upon the most appropriate management objectives for the area. Examples of the current practice of using different planting mixtures in single include fields K9 and the B12/13/5/14 complex at Iroquois NWR. Two mixtures were used during the revegetation of K9 - a

mixture of yellow sweet clover, Indian grass, big bluestem, and tall fescue in the portion of K9 nearest headquarters, and a mixture of eastern gamma grass, yellow sweet clover, and Virginia wild rye in the area nearest the cattails. The former mixture produced very tall vegetation that was avoided by grassland birds, at least in the year (1998) following planting. Three mixtures were used in the B12/13/4/15 complex: yellow sweet clover and big bluestem; little bluestem and Indian grass; and switchgrass. Again, grassland birds avoided the taller vegetation and were found most frequently in the area planted in little bluestem and Indian grass. In conclusion, I cannot overemphasize the importance of making management decisions regarding the manipulation of upland habitats based upon specific, appropriate and stated management goals for the specific field, parcel of public land, and region.

Using Consistent Management Techniques: Past practices on some refuges involved application of a wide variety of management techniques to grassland habitats. Some areas were mowed; other areas were mowed and treated with herbicides; some areas were treated with herbicides but not mowed. Some fields were prescribed burned. Mowing or burning dates may have varied widely. Some fields were planted in monocultures, while various grass/forb mixtures were used, both within and among fields. This plethora of approaches to managing grasslands has made it difficult to evaluate the effects of *any* treatment. Thus I would recommend that, wherever possible, standardized grassland management protocols be developed and implemented on individual refuges, or on refuges in areas that share similar management goals, climate, and vegetation. If managers want to evaluate the effects of various management techniques for promoting

grassland vegetation, then wherever possible they should use experimental design procedures, including replication and controls. If the effects of vegetation manipulation on grassland birds is a goal of the project, then habitat manipulation blocks should be large enough to attract grassland birds (≥ 5 ha), and should occur within the same field, in order to minimize any effects due to field area and the surrounding landscape characteristics. Although budgetary and resource constraints may limit the ability of managers to carry out *statistically* valid "experiments" over large areas, proper attention to study design will provide much more useful information on the effects of habitat manipulations. For example, a study designed to test the effect of mowing regime on grassland vegetation and birds might take place in a 20-ha field, divided into four equal-sized treatment blocks. Two blocks would remain as controls, while two would be subjected to the same mwoing regime.

Specific Management Recommendations for Fields in the Study Area Managed by the United States Fish and Wildlife Service or the New York State Department of Environmental Conservation.-- In the following section I prioritize the fields that I studied, in terms of their value as grassland bird habitat. These areas should receive first consideration in allocation of resources if grassland bird conservation is considered an important management objective.

Iroquois National Wildlife Refuge _

Unit I, Fields 1, 2, 3, 4: This 98 ha complex forms the largest single grassland in the study area, and should receive the highest management priority. Savannah Sparrows and

Bobolinks are very abundant in Unit I; Eastern Meadowlarks and Northern Harriers also use the area. Current management practices (late-summer grazing and autumn mowing) should be continued to control unwanted forbs and shrubs.

Unit Q, Fields 5, 7, 8, 12, 13, 15, 16: This complex of ± 69 ha has been managed to increase grassland area through a combination of hedgerow and shrub removal, disking, and planting with a mixture of grasses and forbs. Savannah Sparrows, Bobolinks, and Eastern Meadowlarks nest in this complex. Future management efforts should involve periodic mowing to control shrubs and unwanted forbs. Field Q 13, which currently is dominated by *Panicum*, could eventually be planted in a mixture native cool- or warm-season grasses.

Unit C, Fields 5 and 7; Unit D, Field 13: This complex of ± 46 ha consists of one field planted in a monoculture of reed canary grass (*Phalaris arundinacea*; C7); a former pasture dominated by introduced cool-season grasses, but showing signs of shrub invasion in some areas (C5); and a fallow field dominated by a mixture of cool-season grasses and forbs (D13). Savannah Sparrows, Bobolinks, and Eastern Meadowlarks nest in this complex; Northern Harriers also hunt over these fields. Although D13 is separated from C5 and C7 by Sour Springs Road and a line of old poplars and willows, Eastern Meadowlarks and Bobolinks fly back and forth between C5 and D13, and appear to treat the complex as a single field. Although Savannah Sparrows, Eastern Meadowlarks, and Bobolinks nest in C7, reed canary grass generally does not attract many grassland birds, and the field eventually should be planted in a diverse mixture of low-growing, native

cool- or warm-season grasses. Fields C5 and D13 should be mowed at intervals of two-three years to control shrub invasion. Eventual removal of the poplars, willows, and shrubs to the west of Sour Springs Road would help to create a larger, more contiguous grassland management unit.

Unit K, Fields 6, 8, 9: Portions of this complex of ± 32 ha have been tilled and planted with mixtures of cool-season and warm-season grasses and legumes, although some areas with high densities of shrubs and forbs still remain on K6 and K9. Savannah Sparrows, Bobolinks, and Eastern Meadowlarks nest in this complex. Future management efforts should concentrate on shrub removal and replanting with grass/forb mixtures that produce lower, less dense growth.

Unit B, Fields 5, 12, 13, and 14: Hedgerow removal, tilling and planting created a single field of ± 8.4 ha that was first occupied by grassland birds in 1998. Although the relatively small area of this field is not ideal for grassland birds, it did support low numbers of Savannah Sparrows and Bobolinks in 1998, along with two territorial male Grasshopper Sparrows – at least one of which mated and nested. The presence of this species, which is listed as a species of management concern by the New York State Department of Environmental Conservation, in this area and in the adjacent Fields 1 and 11 of Unit B, suggests that the western portion of Unit B might be managed to encourage the type of vegetation preferred by this species – low, sparse vegetation with relatively little litter accumulation (Swanson 1996).

Other fields at Iroquois NWR that currently support some grassland birds, and could be managed for them, include H11, E6, and P4. Of the three fields, E6, a 20 ha former pasture, is probably the most valuable to grassland birds. The field supports Savannah Sparrows, Bobolinks, and Eastern Meadowlarks, but is partially subdivided by a hedgerow. Removal of the hedgerow could make the field more attractive to grassland birds. H11, a 5 ha field dominated by introduce cool-season grasses, has supported relatively high numbers of Bobolinks and Savannah Sparrows (maximum of 4.5 individuals/census/point). P4, a fallow field, has supported Bobolinks and Savannah Sparrows in the past, but currently is undergoing succession and the vegetation has become unsuitable for these species.

Montezuma National Wildlife Refuge

Waugh 1 and Waugh 2: These two adjacent fields form the largest grassland on the refuge, and should be managed as a single, ± 35 ha grassland unit. Between 1995 and 1998, grassland bird abundances were higher on the Waugh tract than in other fields we censused at Montezuma NWR. Northern Harriers, Savannah Sparrows, Bobolinks, and Eastern Meadowlarks nested in the unit; Kahl (no date) also observed Vesper Sparrows in the area. Specific management practices – primarily mowing - to discourage shrub invasion and promote the growth of low, less dense grasses and forbs should be continued. Waugh 1 was control burned in April, 1998, but the value of burning as a tool for encouraging the growth of cool-season grasses in the Northeast remains an unresolved issue (Duebbert et al. 1981, Myers and Dickerson 1984, Wark et al. 1995).

Esker Brook Fields South, Central, and North: This management unit of ±11 ha has supported nesting Savannah Sparrows, Eastern Meadowlarks, and Bobolinks during the current study; Kahl (no date) also observed Grasshopper Sparrows in the area. However, densities of grassland birds are generally low, perhaps because the long, narrow shape maximizes edge habitat and means that all points in the field are within 75 m of the nearest field/forest boundary. Given the low numbers of grassland birds in the area, I question the cost effectiveness of intensive management efforts aimed at promoting grassland vegetation in the Esker Brook fields. The same conclusion can be applied to fields such as Subheadquarters North and "Way-Kay" along Savannah – Spring Lake Road in the Northern Montezuma Wetlands Complex: Because these fields appear to support few or no grassland birds even when they are managed to reduce shrub cover, I doubt that such management practices are cost effective.

SUMMARY OF RECOMMENDATIONS FOR PROMOTING GRASSLAND BIRD POPULATIONS

1. Grassland management efforts should focus on relatively large ($\geq \pm$ 8 ha) fields, especially those with minimal edge, less surrounding forest, and more surrounding open habitats (early successional fields, wetlands, and croplands). Hedgerow removal should be considered as a way to increase field size.

2. Wherever possible, create and maintain grasslands that are in close proximity to one another.

3. Develop and maintain grasslands with diverse mixtures of herbaceous species; avoid planting monocultures of any kind. Planting of native warm season grasses should be encouraged, although grassland birds in the region also do well in grasslands dominated by introduced cool season grasses. For most grassland birds, vegetation in late May and early June should not be taller than ± 60 cm. Henslow's Sparrows may prefer taller, more dense vegetation than most other obligate grassland birds in the region.

4. Scattered shrubs and forbs such as goldenrod, milkweed, and wild carrot may provide valuable song perches. Some forb cover (generally < 20%) and shrub cover (always < 3%, and generally < 1%) are acceptable, and may act to increase small-scale habitat diversity.

5. Do not plant dense monocultures of any grass, especially switchgrass.

6. Wherever possible, restrict all management activities (mowing, grazing, burning, etc.) to periods outside the primary pre-nesting and nesting season for grassland birds. These dates will vary within Region 5, but a general rule of thumb might be prior to 15 April or after 15 July (at the earliest). Preferably, any late-season management would occur after 15 August, or later, if the area supported either Sedge Wrens or Henslow's Sparrows.

7. Late-season, light to moderate grazing in productive fields is acceptable, and may be used as a management tool to retard succession.

8. If initial shrub cover is not high, most fields can be maintained by mowing on a 2- to 3-year rotation; the mowing interval may be somewhat longer for warm season grasslands than for cool season grasslands. A single, annual mowing may be insufficient to retard shrub growth for very long in fields with high initial shrub cover, and other control measures will probably be needed. Three mowings within a single season may effectively retard shrub growth, although more research on this technique is needed.

9. Herbicides known to act as endocrine disrupters should not be used to control unwanted forbs and shrubs.

10. More research needs to be done on the efficacy of prescribed burns as a tool for maintaining grasslands in Region 5, especially in cool-season grasslands. Available evidence suggests that prescribed burning will work best in warm season grasslands, and that late summer or fall burns are most effective.

11. Large fields ($> \pm 16$ ha) may best be managed by treating large blocks ($\pm \geq 8$ ha) on rotational basis, in order to provide suitable grassland habitat during all breeding seasons – especially if species of management concern are present. In general, revegetation efforts should focus on creating large patches of suitable habitat, and should avoid using different planting mixtures in a manner that reduces the extend of habitat suitable for grassland birds.

12. Prior to embarking upon any grassland management, biologists and managers need to consider a number of important issues. These include identification of target species, a clear understanding of management assumptions, effects on other important species in the area, overall management goals (at both the refuge and regional level), and problems of spatial and temporal scale.

ON THE NEED TO DEVELOP A COMPREHENSIVE USFWS MANAGEMENT PLAN FOR GRASLAND BIRDS IN THE NORTHEAST REGION

In the introduction of this report I describe population declines of grassland-dependent birds and decreases in grassland area in the Northeast. These trends have stimulated research or grassland bird ecology, educational initiatives, conservation-oriented management activities, and acquisition of grassland habitat. For example, by the early 1990s, birds of grassland and open habitats were the species most frequently listed by states in the Northeast, with 12 species of grassland and open habitats listed by three or more states (Vickery 1992). A Northeast Grassland Bird Working Group within the northeastern section of Partners in Flight has been active since 1995; its activities are described in a biannual newsletter. The Center for Biological Conservation of the Massachusetts Audubon Society publishes a Grassland Conservation Newsletter, as well as three booklets describing management practices to encourage grassland birds (Jones and Vickery no date a, b, c), and recently published the book *Grasslands of Northeastern North America: Ecology and Conservation of Native and Agricultural Landscapes* (Vickery and Dunwiddie 1997). The National Fish and Wildlife Foundation helped fund an extensive Northeast Grassland bird survey in 1997 (Shriver et al. 1997), and grassland

bird populations currently are monitored in all northeastern states and New York. The New York State plan for the Wildlife Habitat Incentives (WHIP) Program has targeted grassland habitat within the state for restoration, enhancement, and establishment through the year 2002 (National Resources Conservation Service 1997). Detailed research projects on grassland bird ecology are underway, or have been completed, in a number of states, including New York, Massachusetts, Rhode Island, and Maine.

The United States Fish and Wildlife Service also has shown an interest in the conservation of grassland birds in the region. It has funded applied research on grassland birds through its Challenge Grant program, and in May, 1998 distributed a Grassland Breeding Bird Survey Inventory/Monitoring Procedure to refuges in Region 5 (Casey, 1998). Managers at National Wildlife Refuges such as Iroquois and Montezuma have implemented grassland management plans that involve active, labor intensive practices to maintain fields in early successional stages attractive to grassland birds.

However, the activities described above have occurred in the absence of any comprehensive regional management plan for conserving grassland birds (Diane Pence, USFWS Region 5, personal communication). I believe that development of such a regional grassland bird management plan by the USFWS, preferably in the context of a larger plan for all native passerines in the region, is crucial for several reasons. First, such a management plan would provide a rationale for conserving grassland birds in the Northeast. Second, the management plan could establish a regional framework for coordinating research and conservation efforts, and implementing management and monitoring activities on refuges. Ideally, the management plan would also inform the actions of state agencies and private organizations interested in the conservation of

grassland birds. This management plan might well be formulated in concert with current efforts by the Partners in Flight program to develop landbird conservation plans for physiographic areas in the region, and should incorporate major planning principles outlined in two recent documents: 1. "Biological Needs Assessment" (U. S. Fish and Wildlife Service 1998); and 2. "Selecting Habitat Management Strategies on Refuges" (Schroeder et al. 1998).

I also believe that a management plan, *with a well-developed rationale*, is necessary because the documented decline of grassland birds in the Northeast is undoubtedly a relatively recent phenomenon, caused mainly by the post-1900 decrease in non-forested habitat in the region (Figure 20, Foster 1995; see also Whitney 1994, Pimm and Atkins 1995). Prior to European settlement there undoubtedly were some scattered and relatively large areas of grassland habitat in the region, such as Montauk Downs and the 24,000 ha Hempsted Plains on Long Island, the coastal plains surrounding Narrangansett Bay, Rhode Island, and the "blueberry barrens" and associated habitat along the coast of Maine (Askins 1997, Winne 1997). However, palynological data and pre-1800 land survey records suggest that in pre-Columbian times most of northeastern North America was forested (Siccama 1971, Russell 1981, Burden et al. 1986, McAndrews 1988, Patterson and Sassaman 1988, Marks and Gardescu 1992, Foster 1995, Dieffenbacher-Krall 1997). Native Americans undoubtedly created open areas through agricultural practices and use of fire (Day 1953, Burden et al. 1986, McAndrews 1988, Askins 1997), particularly in southern New England (Patterson and Sassaman 1988). However, Foster's (1995) analysis of 400 years of land-use history in New England concludes that "Although early historical accounts abound with descriptions of local forest clearance

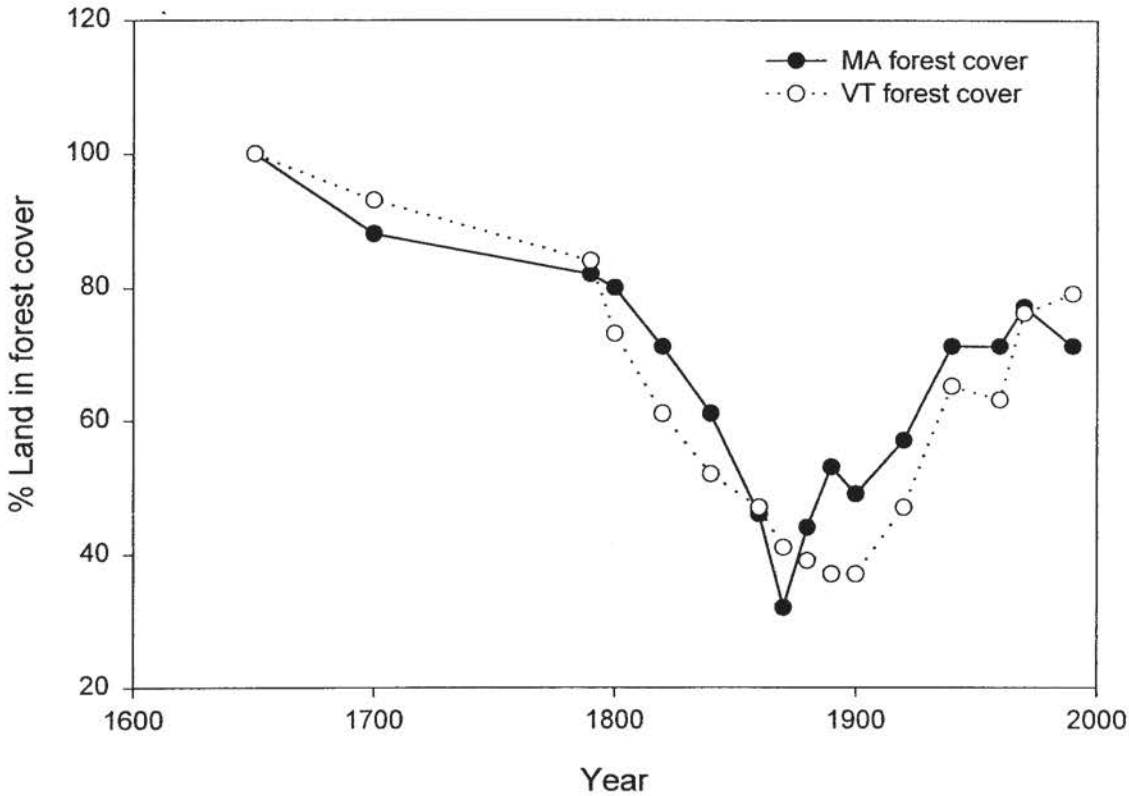


Figure 20. Forest cover in Massachusetts (MS) and Vermont (VT), 1650 - 1990. Data from Foster (1995) and Harvard Forest data archives.

around Indian villages, there is little evidence that aboriginal activity exerted an impact on the broad-scale pattern of vegetation as would have occurred for example through extensive slash-and-burn agriculture."

Askins (1997) has also cited the existence of endemic avian taxa such as the Heath Hen (*Tympanuchus cupido cupido*) and the eastern subspecies of the Henslow's Sparrow (*A. henslowii susurrans*) as evidence that extensive grassland habitat must have existed in the region. However, the inference of extensive grasslands in the region based on the subspecific designation of two taxa is only as strong as are the data on habitat selection or taxonomic status for the taxa. Thus Heath Hens evidently were also common in scrub oak habitats, oak parklands and shrubby habitats, as well as blueberry barrens and fire-created prairie (Schroeder and Robb 1993, Askins 1997), and long-term persistence and differentiation of populations in the Northeast may not have required grassland habitat. The subspecific status of eastern populations of the Henslow's Sparrow has been questioned (Bull 1974, Smith 1998), and "there is evidence of clinal variation in Henslow's Sparrows along an east-west gradient (Smith 1998)." If this scenario is correct, and if Henslow's Sparrows spread into the northeast relatively recently (see below), it would be difficult to use *Ammodramus henslowii susurrans* as an argument supporting the existence of extensive grasslands in the Northeast prior to colonial times.

Whatever the taxonomic status of eastern populations of the Henslow's Sparrow and the habitat preferences of the Heath Hen, it is clear that a number of grassland bird species expanded their range into eastern North America during the late 1800s and early 1900s. These range expansions have been attributed to the clearing of forested land in the Midwest and Northeast (Hurley and Franks 1976, Askins 1997). For example, Horned

Larks spread eastward from Illinois and Wisconsin beginning in the 1870s, and reached New England by 1891 (Hurley and Franks 1976). Other grassland species that have expanded their range eastward include the Western Meadowlark (*Sturnella neglecta*, Lanyon 1956) and Lark Sparrow (*Chondestes grammacus*, Brooks 1938). The Henslow's Sparrow, which currently is listed by five states in the Northeast (Vickery 1992), and whose status was recently assessed by the United States Fish and Wildlife Service (Pruitt 1996), also has expanded its range within the last 100 years. Pruitt (1996) describes the species in New York as "rare" in the early 1900s, and suggests that populations may have increased in the 1920s through 1940s. The species may not have occurred in Pennsylvania prior to 1900 (nesting was first documented in 1913), while the "species zenith in Massachusetts coincided with the period of farm abandonment" (Pruitt 1996). Henslow's Sparrows first appeared in Ontario, Canada in the late 1890s (Knapton 1984). Other grassland birds that are currently common in the Northeast, including the Upland Sandpiper, Grasshopper Sparrow, Savannah Sparrow, Eastern Meadowlark, and Bobolink, evidently did not expand their range eastwards during the late 1800s, and were most likely present in the region prior to the time of large-scale forest clearing (Askins 1997). Even so, it is very unlikely that grassland bird populations in the Northeast would have been very high in pre-Columbian times, relative to populations at any time in the twentieth century, given the preponderance of forest habitat in the region prior to European settlement (Figure 20, Foster 1995).

My brief analysis of prehistoric and historic vegetation and avian distribution patterns in the Northeast is not meant to suggest that current concern for grassland birds in the region is misplaced. Rather, I am emphasizing the need for a *temporally explicit*

management plan for grassland birds – and other groups of breeding birds - in the Northeast. By "temporally explicit" I mean that any viable management plan for grassland birds – or for that matter, for any species or ecosystem – must incorporate a temporal perspective that recognizes that landscapes, and the populations that they support, are dynamic on geological and historical time scales (Litwin and Smith 1992, Foster 1995, Christensen 1997, Crow and Gustafson 1997). Influences on landscape dynamics may be cultural, as in the effects of Native Americans, European colonists, or latter-day farmers, or they may be ecological, as in the effects of climate, soils, and successional regimes. Given that landscapes are dynamic entities, a critical management question becomes one of identifying where the target ecosystem, community, or population lies along the temporal continuum. Thus the seemingly straightforward suggestion that restoration activities should target "the original ecosystem" (Bradshaw 1987) ignores the issue of a temporal reference point for defining the "original ecosystem".

Ecologists have recognized the need for incorporating spatial scale into planning ecological restorations (Allen and Hoekstra 1987, and many others). However, issues of temporal scaling (or dynamics) are equally important, but have received less attention until recently (see Christensen 1997, Crow and Gustafson 1997). For example, regional forest landscape structure in both western Oregon and Georgia have changed dramatically during the twentieth century - although the direction of change in the two states has been in very different directions, due to differences in initial conditions and patterns of human land use (Turner and Ruscher 1988, Spies et al. 1994). In turn, landscape-level changes in habitat composition may have large effects on bird

populations. Litvaitis (1993) documented how early successional migratory bird populations in New Hampshire declined following forest maturation in the mid-1900s. At a more local scale, Litwin and Smith (1992) have described how forest succession and changing land use practices have affected Neotropical migrants in a northeastern forest fragment, and how such changes need to be incorporated into our thinking about bird population changes and management. David Graber, an U. S. National Park Service biologist who has worked with fire management in mixed-coniferous forests of the Sierra Nevada, California, has written an insightful essay dealing with the problem of temporal scaling and management objectives. Graber (1995) writes that, "Given these dynamic forces [cultural influences of Sierran Indians, climate change], what was the objective of administrative burning? The logic of attempting to simulate a fire regime produced by dynamic aboriginal culture operating in a dynamic climatic regime began to fade by the late 1980s." Graber's point is relevant to grassland bird conservation in the Northeast. Thus, we might ask, what should be our temporal target for grassland bird conservation efforts? Presumably, this target, once identified, should lead to management decisions for bird populations based on the relative extent of open or grassland habitat in the region at that time.

Perhaps our target should be approximately 1600 A. D., prior to the arrival of European colonists in the Northeast. There seems to be a widespread view that ecosystems in North America should be managed within their "range of natural variability," with "natural variability" referring to ecosystem variability in structure, composition, and dynamics prior to the influence of European colonists (Kaufmann et al. 1994, Swanson et al. 1994). Thus, pre-Columbian or precolonial landscapes represent a

conservation ideal (Swanson et al. 1994). For example, the primary goal for habitat restoration at Walnut Creek National Wildlife Refuge in Iowa is to return the refuge landscape "to the natural condition that existed prior to Euro-American settlement" (Drobney 1994). In the Northeast, one U. S. Fish and Wildlife Service Biologist suggested that the regional "ideal" might be a landscape with scattered small openings created by native peoples – even though Foster (1995) has written that, "To date there is no conclusive paleoecological record of Indian modification of the New England forest landscape," and aboriginal land use patterns were themselves dynamic in both space and time (Patterson and Sassaman 1988, Doolittle 1992, Foster 1995, Graber 1995). Another target date for grassland bird management might be approximately 1850-1875, when the amount of cleared land in New England reached its historical maximum (Foster 1995). Yet another target might be 1966, when the Breeding Bird Survey began; at this point, we would be able to incorporate hard data on both grassland bird populations and habitat area into our management plans, even though interpretation of Breeding Bird Survey data may be strongly biased by statistical assumptions (Thomas and Martin 1996).

Of course, very different conclusions would follow from selection of 1600, 1850, or 1966 as our regional target date. If we were to choose 1600 – which would embrace the principle of targeting Pre-Columbian landscapes as our restoration ideal - then available evidence suggests that grassland habitats, and the bird species they support, are undoubtedly much more common in 1998 than in 1600 (Whitney 1994, Foster 1995, Pimm and Atkins 1995), while bird species dependent on mature deciduous forest habitat are less common than they were. This would lead to the conclusion that we should probably ignore grassland birds in the Northeast and focus on late-successional forest

species in the region. If we were to choose 1850 or 1875 as our target date, then we probably have fewer numbers of many grassland species – excepting late arrivals such as the Horned Lark and Henslow's Sparrow– and we should emphasize grassland birds at the expense of forest-dependent species. A focus on 1966, with the benefit of a perspective that incorporates Breeding Bird Survey data, would also imply that we should be focusing our attention on grassland birds, due to the region-wide declines in most grassland species between 1966 and 1996 (Sauer et al. 1997). However, it should be pointed out that declines in forest-dependent species, as produced by effects stemming from forest fragmentation were of most concern during the late 1970s and early 1980s (Whitcomb 1977, Robbins et al. 1979, Butcher et al 1981, Leck et al. 1981, Askins and Philbrick 1987) – even though Breeding Bird Survey data suggest that many forest-interior species, such as the Ovenbird (*Seiurus aurocapillus*) are currently increasing across the region and North America (Sauer et al 1997).

The different conclusions stemming from selecting different regional "target dates" illustrates why we cannot ignore the temporal perspective and dynamic nature of landscapes. I believe that those of us concerned with conserving biodiversity must "open up the time series (Magnuson 1990)," as a way of understanding long-term ecological phenomena and developing a context for crafting management plans. To illustrate my point about how "opening up a time series" might affect our view of grassland bird conservation in the Northeast, let me begin with the Breeding Bird Survey data for Savannah Sparrow abundance in USFWS Region 5 (Sauer et al. 1997, Figure 21); I chose the Savannah Sparrow because it is the most widely distributed grassland bird in the region (Shriver et al. 1997). These data show a consistent, region-wide decline in

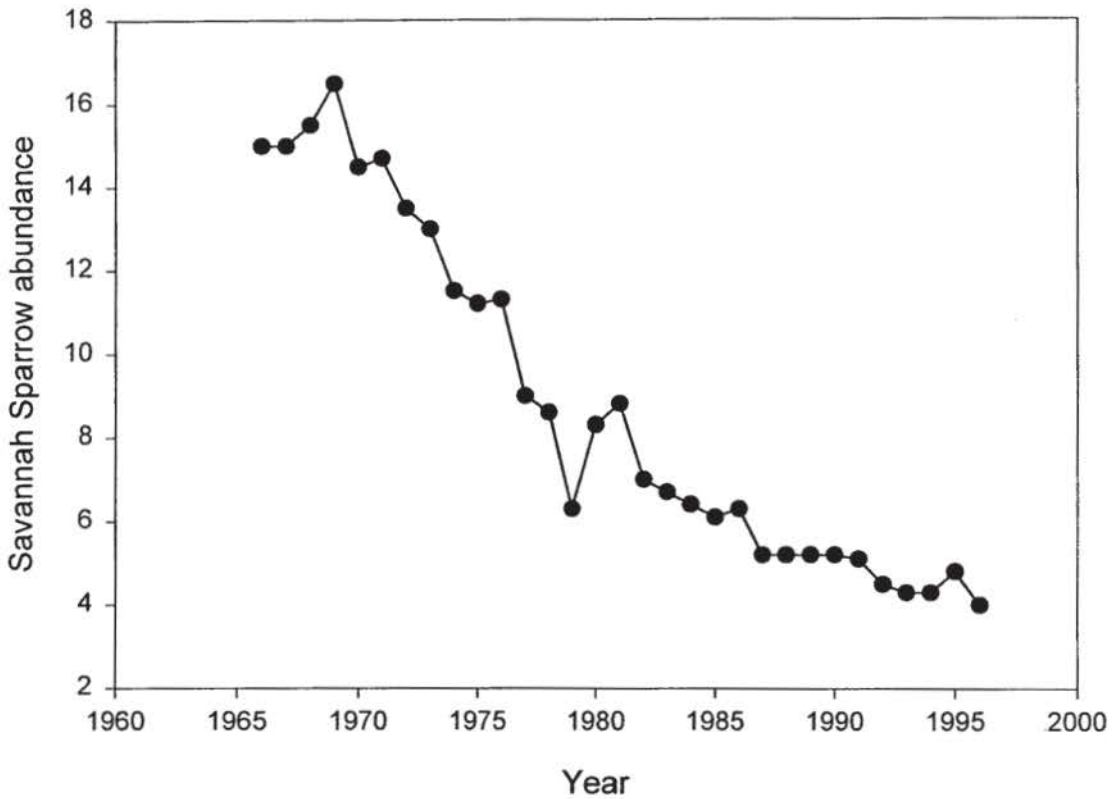


Figure 21. Savannah Sparrow abundance in USFWS Region 5, as estimated from Breeding Bird Survey data (Sauer et al. 1997).

Savannah Sparrows between 1966 and 1996; similar trends for other grassland species in the region, such as Eastern Meadowlarks and Henslows' Sparrows, are the basis for our current concern for grassland birds in the region. However, a much different picture emerges if we "open up the time series," and extend our thinking back to 1650. To do this, however, will require making several assumptions, because there are no reliable, region-wide data on grassland bird abundance prior to 1966. First, let me assume that the amount of grassland habitat in the region is inversely proportional to forest cover in the region. In doing so I am not assuming that *all* cover not in forest will be in grassland, but only that the extent of forest cover should be roughly, and inversely, proportional the amount of grassland habitat available on a region-wide basis. Second, I will assume that the regional abundance of grassland birds is directly proportional to the amount of available grassland habitat. Thus, regional grassland bird abundance should be inversely (even if only roughly) proportional to the amount of forest cover. Using these assumptions, I generated an hypothetical index of Savannah Sparrow abundance based on the extent of regional forest cover, as represented by the data for Massachusetts. In doing so, I assumed that the maximum number of Savannah Sparrows would have occurred around 1870, when forest cover was at a minimum in the state (Figure 20); I assigned a value of 1.0 for Savannah Sparrow abundance at this time. I then assigned a value of 0 to Savannah Sparrow abundance in 1650, when region-wide forest cover approached 100% (Foster 1995, Figure 20). This value of 0 is not meant to imply that there were no grassland birds in the region, only that numbers would have been very low, relative to the situation in 1870. Increases or decreases in forest cover between 1650 and 1990 would then produce proportional increases or decreases in estimated Savannah Sparrow

abundance. If I now plot estimated regional Savannah Sparrow abundance, along with regional forest cover, as exemplified by the data for Massachusetts (Foster 1995), a very different picture from that implied by the data in Figure 21 emerges for Savannah Sparrow numbers in the region (Figure 22). My analysis implies that current Savannah Sparrow abundance in the region is most likely higher than in the 1600s, and that Savannah Sparrow abundance *at the regional level* must have been very low in pre-Colonial times. Similarly, anecdotal evidence in Litvaitis (1993) suggests that early-successional forest passerines, such as the Chestnut-sided Warbler (*Dendroica pensylvanica*), were relatively rare prior to the European colonization of New Hampshire. The question now becomes, how should this sort of analysis influence our thinking about management objectives for grassland birds, or for any other group of organisms?

The problem with ignoring the temporal perspective and the dynamic nature of landscapes when creating management plans is that such ignorance can lead to a perpetual and sometimes misplaced state of anxiety or even paranoia about the dynamics of target populations. The result might then be the urge to promote increases in *all* populations, relative to some recent reference date (such as 1966) - which was selected implicitly rather than explicitly, and only because data on bird species abundance became available at that time. Associated with this attitude would be the view that a regional decline in the numbers of *any* species is dangerous – even for those species clearly at the edge of their distributional ranges, as for some grassland bird species in the Northeast. Given the link between the dynamic nature of landscapes and the relative abundance of various habitats within these landscapes, a decline in the amount of breeding habitat for one group of species, such as grassland birds, will almost inevitably lead to an increase in

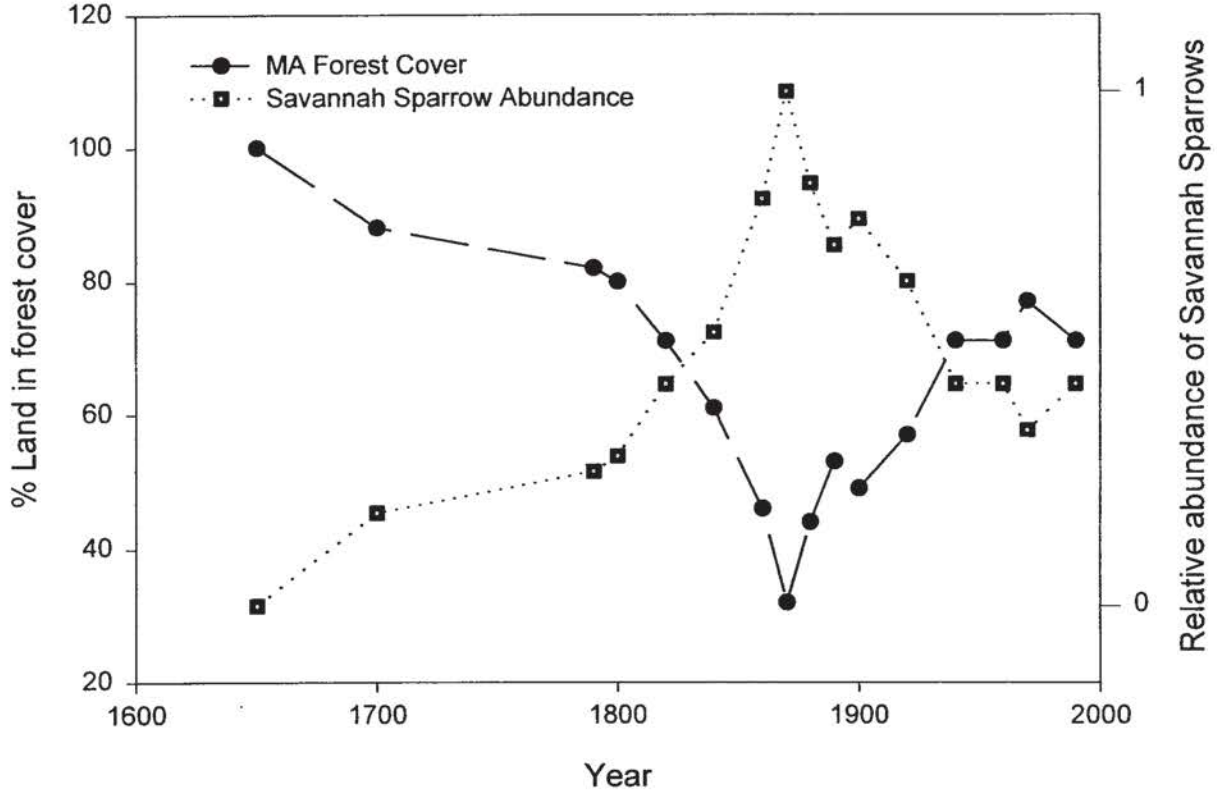


Figure 22. Hypothetical Savannah Sparrow abundance in New England, plotted as the inverse of Massachusetts forest cover, 1650 to 1990 (dashed line; data from Foster 1995 and Harvard Forest data archives). See text for details.

the amount of breeding habitat for another group of species, such as late-successional forest birds. In turn, the obvious relationship between habitat characteristics and bird abundance (Cody 1985, Wiens 1989) means that a regional decline in one type of breeding habitat could have contrasting effects on the abundances of different species groups. This is the scenario that we are currently witnessing in the northeastern United States, where there is an overall decline in grassland birds, while at the same time many forest-dependent species are increasing (C. R. Smith, Cornell University, personal communication; Sauer et al. 1997). Clearly, the dynamic nature of landscapes means that we cannot create a Panglossian situation in which all species groups dependent on different habitat types will be either stable or increasing.

The above considerations mean that establishing a coherent set of management objectives may be difficult; I liken it to the process of trying to "hit a stationary target from a moving vehicle." In this case the stationary target is our static management objective for the population, community, or ecosystem. The moving vehicle is composed of two components. The first is our management perspective, which is influenced by our own (narrow!) temporal perspective, which in turn is influenced by cultural, political, and economic factors. The second is the landscape itself, which is being propelled through time by dynamic ecological and cultural forces (see Litwin and Smith 1992, Litvaitis 1993, Graber 1995, Christensen 1997, Crow and Gustafson 1997).

Is there any way out of the dilemma imposed by the dynamic nature of landscapes? Is there any way to create a rational, regional management plan for grassland birds? I believe that there is, as long as biologists and managers recognize that, to some extent, all management decisions are based on values. We must identify the reasons *why* the

conservation of any group of organisms is important, much as Rosenberg and Wells (1995) have attempted to do for grassland birds. Once this has been accomplished, conservation priorities can be established, as the Partners in Flight and the Colorado Bird Observatory are doing for all North American breeding species, and these priorities then incorporated into management plans. However, these reasons may be useful only if they are framed within the context of temporal change in landscapes. There are two possible approaches to addressing the problem of temporal change. The first is to simply identify some target date as the reference point for research and conservation efforts directed at birds – not for one species or group of species, such as grassland birds, but for *all* species in some more inclusive group, such as terrestrial birds. It is important to remember that management activities targeted for one group of organisms, such as grassland birds, will have effects on all taxa in the management unit – both those groups that will increase under the proposed management regime, but also those that will decrease (see Hendricks 1997). Management plans that incorporate principles of ecosystem management (Kaufman et al. 1994, Christensen et al. 1996) could then be produced, in the manner of the Partners in Flight Landbird Conservation Plans for physiographic regions of North America. A number of these Landbird Conservation Plans are currently being developed, such as the one for The Saint Lawrence Plain (Physiographic Area 18; Rosenberg 1998). Once a target date has been selected, however, the implication is that we will have to fight the dynamic nature of landscapes in order to realize our management goals. Thus, if our selected target date for northeastern birds is 1966, we will have to actively work to retard forest succession in the region. Such an effort is difficult or impossible at the regional scale, and could only be successful on a limited, site-by-site basis.

A second approach, and the one that I feel is best, would be to accept the fact that landscapes are dynamic, and would attempt to conserve species within very broad limits established by reference to both landscape dynamics (which would include consideration of both cultural and ecological effects) and values. For example, values that *might* be important in framing a specific regional conservation management plan would be the importance of maximizing the biodiversity of native bird species in the region, and the degree to which the global or national abundances of particular species are tied to the region (Rosenberg and Wells 1995). The draft Landbird Conservation Plan for the Saint Lawrence Plain (Physiographic Area 18; Rosenberg 1998) is extremely valuable because it does acknowledge the issue of temporal dynamics in the Northeast region, even though it does not fully address the problem. For example, the plan (Rosenberg 1998) makes the following statements:

> "The dynamic between agricultural intensification, agricultural abandonment, and urban development constitutes the most important bird-conservation issue in the region…"
>
> "This issue [early vs. late-successional habitats and species – historical baselines] which permeates bird-conservation planning throughout the Northeast, must be resolved before priority species and habitats are determined."
>
> "Although originally forested, this region has been dominated by agricultural production for over 200 years."

The next step would be to develop an approach that explicitly incorporates a temporal perspective and the dynamic nature of landscapes, and recognizes that wise management cannot be all things to all species. This approach seems like the most rational and

potentially effective, and least frustrating, way in which to approach the study and practice of conservation biology. To quote Christensen (1997), whose perceptive essay should be required reading for all land managers: 'Management determined to "freeze" ecosystems in a particular state has generally proven to be futile and unsustainable.' A guiding philosophy of land management should incorporate the ideas that change is constant and complex, human impacts are historically important and ubiquitous, and patterns of disturbance and recovery are uncertain (Christensen 1997).

One recent attempt by the USFWS to incorporate a temporal perspective is the Landscape Plan developed by Minnesota Valley NWR (Schroeder et al. 1998). This plan identifies a specific time period as the reference point for establishing management objectives for the refuge. This time was taken to be the point at which "the system was least affected by human [European] disturbance (Schroeder et al. 1998)." As such, the plan appears to adopts a "static" approach to the problem of temporal scaling, and embraces the value that Pre-Columbian landscapes represent a conservation ideal (Swanson et al. 1994) – even though the plan defines "natural diversity as an organism consisting of continually shifting communities (U. S. Fish and Wildlife Service 1996)." Based upon this goal, the planners then established specific objectives for the proportions and types of habitat that should be present on the refuge. Note that adopting a similar ideal (a Pre-Columbian landscape) in the Northeast would probably mean de-emphasizing grassland bird conservation at the regional level, although grasslands and their associated avifauna might still be deemed important on certain refuges. A second point is that a focus on landscapes "makes it less practical to set wildlife population objectives, especially for the traditional single-species approach (Schroeder et al. 1998)."

Finally, I echo the advice of Ludwig et al. (1993), who proposed a number of principles for effective management of exploited resources. Several of their suggestions are applicable to the issue of grassland bird conservation and management, and to the development of an effective philosophy for managing populations, ecosystems, and landscapes:

1. Include human motivation [values] and responses as part of the system to be managed and studied, as shortsightedness underlies many management difficulties.
2. Effective management policies are possible only when biological uncertainty is taken into account.
3. The complexity of biological and physical systems precludes a reductionist approach to management.

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Appendix 1. Description of habitat types of fields censused for grassland birds, 1994-1998.

Habitat type	Description
Warm season grassland	A grassland dominated by switchgrass (*Panicum* spp.), which produces most or all of its growth during the late spring or summer.
Cool season grassland	An ungrazed grassland dominated by plants that produce the major portion of their growth during the spring. Common grasses include timothy (*Phleum pratense*), brome-grass, (*Bromus inermis*), orchard grass (*Dactylis glomerata*), and redtop (*Agrostis gigantea*). spp.), and birds-foot trefoil (*Lotus corniculatus*).
Pasture	Grazed grasslands; common species similar to those found in cool season grasslands.
Fallow field	Agricultural land no longer being cultivated; dominated by early-successional grasses and forbs.
Forb-dominated fields	May contain species found in cool-season grasslands, but forbs such as goldenrod (*Solidago* spp.), wild carrot (*Daucus carota*), and milkweed (*Asclepias* spp.) common. Shrubs (cover < 5%) may also be present.
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.), dogwood (*Cornus stolonifera*), choke cherry (*Prunus virginiana*), Russian olive (*Elaeagnus angustifolia*), meadowsweet (*Spirea alba*), and arrowwood (*Viburnum* spp.).

Appendix 2. Number of fields and points surveyed for grassland birds, 1994-1998.

Year	Number of fields	Number of census points
1994	34	59
1995	43	82
1996	41	65
1997	27	53
1998	24	41

Appendix 3. Species observed in fixed-radius census plots located within different upland habitat types, Iroquois NWR, 1994-1998. B = nests in habitat; P = present, but no evidence of nesting; * = observed flying over only.

Species	Habitat type				
	Pasture	Cool season grassland	Warm season grassland	Old field (w/ shrubs)	Fallow field
Canada Goose	P	*	*	*	P
Mallard	B	P	*	*	
Blue-winged Teal	B	B	*	*	*
Wood Duck	*	*		*	*
Turkey Vulture	*	*	*	*	*
Cooper's Hawk		*			
Northern Harrier	*	*	B[4]	*	
Red-tailed Hawk	*	*	*	*	*
American Kestrel	*	*			*
Wild Turkey		P			
American Bittern		B			
Great Blue Heron	P	*	*	*	*
Green Heron		*		P	
Killdeer	*	P			P
Upland Sandpiper					B(?)
Spotted Sandpiper		P			
Woodcock		P		B	P
Common Snipe	P				
Herring Gull		*			
Black Tern	*	*	*		
Mourning Dove	B	*	*	*	*
Ruby-throated Hummingbird	P	*		P	
Northern Flicker	*	*		*	
Eastern Kingbird	P	B	*	P	P
Eastern Phoebe		P		P	P
Willow Flycatcher		P		P	P
Barn Swallow	*	*	*	*	*
Tree Swallow	B[1]	*	*	*	*
Bank Swallow				*	
Purple Martin				*	
Blue Jay	*	*		*	P
American Crow			*	*	P
Sedge Wren			B(?)		
Gray Catbird				P	
American Robin	P	P	P	*	P

Appendix 3 (continued)

Species	Habitat type				
	Pasture	Cool season grassland	Warm season grassland	Old field (w/ shrubs)	Fallow field
Eastern Bluebird				P	
European Starling	*	P	*	*	P
Blue-winged Warbler				P	
Yellow Warbler		P	P	B	P
Common Yellowthroat	P	P	B	B	P
House Sparrow	B[1]				
Eastern Meadowlark	B	B			B
Bobolink	B	B		P	B
Red-winged Blackbird	B	B	P	P	B
Common Grackle	*	*	*		P
Brown-headed Cowbird		*			P
Northern Oriole	*	*		P	
Northern Cardinal		*			
Indigo Bunting				P	
American Goldfinch	P	P	P	P	P
Grasshopper Sparrow		B			
Savannah Sparrow	B	B	P	P	B
Chipping Sparrow	P		P	P	
Field Sparrow		P	P	B	P
Swamp Sparrow	P	B	B	B	P
Song Sparrow	B	B	B	B	B
Species observed (n)[2]	20	23	12	21	23
Species breeding (n)[3]	10	10	5	6	6

[1]Nested in nest boxes along fencelines.
[2]Does not include species seen flying over the plots (*).
[3]Includes probable breeders.
[4]Nests in warm season grasslands on Tonawanda Wildlife management Area (Dan Carroll, NYSDEC, personal communication).

Appendix 4. Species observed in fixed-radius census plots located within different upland habitat types , MNWR, and surrounding areas, 1995-1998. B = nests in habitat; P = present, but no evidence of nesting; * = observed flying over only.

Species	Habitat			
	Old field (w/shrubs)	Former agricultural field	Cool season grassland w/ forbs	Purple loosestrife-dominated wetlands (Martens Tract)
Canada Goose	*		P	
Mallard	P		*	*
Blue-winged Teal	*			*
Turkey Vulture	*			*
Bald Eagle				*
Northern Harrier	*	B		*
Red-tailed Hawk	*			
Wild Turkey	P			
Ring-necked Pheasant		P		
Great Egret				*
Green Heron	*			
Great Blue Heron	*	*	*	P
Killdeer	*	*	*	*
Woodcock				*
Herring Gull	*			
Ring-billed Gull	*			
Mourning Dove	P	*	*	
Chimney Swift				*
Ruby-throated Hummingbird	*			
Pileated Woodpecker	*			
Red-bellied Woodpecker	*			
Eastern Kingbird	P		P	
Willow Flycatcher	P		P	P
Great Crested Flycatcher	*			
Barn Swallow	*			
Tree Swallow	*	*	B[2]	*
Blue Jay	*	*		
American Crow	P	*	*	P
Gray Catbird	P			
American Robin	P		P	P
Eastern Bluebird			P	
Cedar Waxwing	P			

Appendix 4 (continued)

Species	Habitat			
	Old field (w/shrubs)	Former agricultural field	Cool season grassland w/ forbs	Purple loosestrife-dominated wetlands (Martens Tract)
European Starling	P	*	P	
Blue-winged Warbler	P			
Yellow Warbler	P		P	P
Common Yellowthroat	P	P	P	P
House Sparrow			B[2]	
Eastern Meadowlark			P	*
Bobolink	P	B	B	
Red-winged Blackbird	P	B	B	P
Common Grackle	*			
Brown-headed Cowbird	P			
Northern Oriole	*			
Rose-breasted Grosbeak	*			
Indigo Bunting	*	P		
American Goldfinch	P	P		P
Savannah Sparrow	P	B	B	P
Field Sparrow	P			
Swamp Sparrow	P	P	P	P
Song Sparrow	P		P	P
Species observed (n)[1]	21	9	16	11

1. Does not include species only seen flying over.
2. Nested in nest boxes in habitat.