Avian response to harvesting switchgrass for biomass in southern Iowa

by

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TABLE OF CONTENTS

CHAPTER 1. GENERAL INTRODUCTION

The Midwest region of the United States is highly dependent on fossil fuels from other areas of the country for electric generation; 70% of the electricity in the Midwest is generated by coal-fired power plants (Brower et al. 1993). The use of biomass fuels (fuels derived from organic materials) could reduce coal use by 5% in areas where biomass fuels are used (Teel 1998) and provide a local, renewable energy source for the region. The burning of biomass fuels in combination with coal also would reduce carbon dioxide production compared with 100% coal generated electricity (Boman and Turnbull 1997).

Brower et al. (1993) found that switchgrass (*Panicum virgatum*) yielded more biomass per unit area than other herbaceous energy crops, and thus has been chosen for use in pilot studies of biomass production in the Midwest. Standard farm equipment can be used for harvesting and bailing of switchgrass biomass, and once switchgrass is established in a field it may not need to be replanted for up to 10 years.

Switchgrass also provides environmental benefits similar to the Conservation Reserve Program (CRP). The CRP reimburses farmers for removing highly erodible land from rowcrop production and planting it to perennial cover, commonly grasses in the Midwest (Heard et al. 2000). The extensive root system of switchgrass would help control soil erosion and increase water quality compared with rowcrop fields (McLaughlin and Walsh 1998). Biomass switchgrass fields would also provide habitat for grassland birds.

Grassland birds are declining across North America at a faster rate than any other group of species (Askins 1993, Peterjohn and Sauer 1999). Habitat loss and fragmentation through increased rowcrop production and urbanization are considered a major reason for the decline of grassland birds (Herkert et al. 1996). Most of the grassland habitat in the Midwest is agricultural land (e.g., pastures, hayfields). Nesting success in these agricultural lands, however, is lowered because of grazing and mowing (Bollinger et al. 1990, Frawley and Best 1991, Paine et al. 1996). The harvest of biomass fields would not directly affect nest success because fields are harvested in fall and winter. Bird abundances in switchgrass fields, however, would be affected by the harvest because of changes in vegetation structure.

Evaluating the effects of biomass harvest on bird communities in switchgrass fields would help land managers to minimize potential negative effects to birds as biomass production continues. This study compares bird abundance and nest success among harvested and non-harvested switchgrass fields in southern Iowa.

Thesis organization

This thesis is composed of three papers written for publication in scientific journals. Chapter two examines field level effects of harvesting biomass on bird abundance and nest success in switchgrass fields in southern Iowa. Chapter three uses a Geographic Information System (GIS) and bird abundance data to model the regional effects of converting rowcrop fields to biomass switchgrass fields in the Rathbun Lake Watershed in southern Iowa. Chapter four compares bird abundance in harvested switchgrass fields to that in non-harvested fields during winter. Data acquisition, statistical analysis, and the preparation of the text were the responsibility of the candidate; guidance and editorial advice were given by Dr. Louis B. Best.

CHAPTER 2. BIRD ABUNDANCE AND NESTING SUCCESS IN CRP SWITCHGRASS FIELDS HARVESTED FOR BIOMASS IN SOUTHERN IOWA

A paper to be submitted to the Journal of Wildlife Management

Les D. Murray and Louis B. Best

Abstract: The Conservation Reserve Program (CRP) provides habitat for grassland birds, but as many contracts expire some CRP fields may be returned to rowcrop production. One proposed alternative to returning CRP fields to rowcrop is to grow and harvest switchgrass (*Panicum virgatum*) for use as a biomass fuel. Biomass switchgrass fields would provide erosion control, water quality benefits, and habitat for grassland birds. Because the biomass is harvested during the fall and winter, birds would not experience the low nest success rates associated with summer mowing of hayfields. Bird abundances in fields, however, would change in response to differences in vegetation structure because of the harvest. The objective of this study was to evaluate bird abundance and nest success in totally harvested, partially harvested, and non-harvested CRP switchgrass fields. Total bird abundance and species richness did not differ among harvest treatments. Abundances of grasshopper sparrows (*Ammodramus savannarum*) and sedge wrens (*Cistothorus platensis*) were different among treatments. Grasshopper sparrows preferred the shorter, sparser vegetation of harvested portions of fields, and sedge wrens preferred the taller, denser residual vegetation in non-harvested areas. The residual vegetation in non-harvested areas also provided nest cover for species that begin nesting early in the season (ring-necked pheasant [*Phasianus colchicus*], northern harrier [*Circus cyaneus*]). Nest success rates of grasshopper sparrows and common yellowthroats (*Geothlyps trichas*) were similar to those reported by other

studies in switchgrass fields and should be sufficient to maintain stable populations. Species responses to differences in vegetation structure in switchgrass fields will provide land managers with guidance to minimize negative effects of management practices (harvesting, fertilization, herbicide use) on bird communities in biomass switchgrass fields.

Key words: biomass, birds, energy crops, grassland, Iowa, *Panicum virgatum*, switchgrass

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INTRODUCTION

Grassland birds have experienced population declines across North America (Askins 1993), and in the Midwest 10 grassland species have shown significant negative trends in abundance (Herkert et al. 1996). Three factors could limit grassland bird populations: loss of breeding habitat, reproductive failure, and limited winter habitat and resources (Temple 1988). Although some studies have reported limiting factors associated with winter habitats (Fretwell 1986, Lymn and Temple 1991, Basili and Temple 1995), we will focus on breeding habitat.

Historically, tallgrass prairie was breeding habitat for grassland birds in the Midwest, but > 99% of the native prairie in Iowa has been lost to agricultural and urban development (Smith 1998). Most of the remaining prairies in Iowa are small fragments and are not large enough to support area-sensitive species (e.g., Herkert 1994). In addition, the increased amount of edges created by fragmentation can decrease reproductive success of grassland birds. Higher rates of nest predation and brood parasitism have been recorded near edges of grassland fragments than away from edges (Gates and Gysel 1978, Johnson and Temple 1990, Winter et al. 2000).

Although most of the prairie in Iowa has been destroyed or fragmented, other types of grassland habitat are available to nesting birds. Before 1985, most of the grassland habitat available in southern Iowa was pasture or hayfields. Grazing and mowing, however, lower nest success (Warner and Etter 1989, Bollinger et al. 1990, Bollinger 1995, Temple et al. 1999) and affect bird abundance in these habitats. Frawley and Best (1991) found that after mowing, dickcissels (most scientific names are given in Table 3) left fields and re-colonized the fields only after vegetation grew to a height of 20 cm. Red-winged blackbirds, common yellowthroats, sedge wrens, and mourning doves abandoned fields after mowing and did not return. Interruption of the nesting cycle and low nest success in disturbed grasslands, such as hayfields, may create ecological traps for some species (Gates and Gysel 1978).

The Conservation Reserve Program (CRP), established in 1985, created undisturbed grasslands in agricultural areas by reimbursing farmers for removing highly erodible cropland from production for 10 years and planting it to perennial cover, commonly warm- (e.g., switchgrass) and cool-season (e.g., smooth brome [*Bromus inermis*]) grasses (Heard et al. 2000). The main objectives of the CRP initially were to reduce soil erosion and improve water quality, but CRP fields also provide habitat for grassland birds. Many bird species are more abundant and nest more often in CRP fields than in rowcrop fields (Johnson and Schwartz 1993, King and Savidge 1995, Best et al. 1997).

In the near future, many CRP contracts will expire and some CRP fields may be returned to rowcrop production (Kurzejeski et al. 1992), which would be detrimental to grassland bird populations (Johnson and Igl 1995). One proposed alternative to returning CRP lands to rowcrops is to use them to grow and harvest switchgrass for use as a biomass fuel. The use of switchgrass as a biomass fuel would provide a homegrown energy source, maintain the environmental benefits of the CRP (i.e., reduced soil erosion, increased water quality), and create habitat for grassland birds (Paine et al. 1996). In addition, the use of biomass fuels would reduce air pollution compared to fossil fuels (Boman and Turnbull 1997). Switchgrass has been chosen for use as a biomass fuel because it produces more biomass per area than other native grasses (Brower et al. 1993).

To evaluate the use of switchgrass as a biomass fuel, the Chariton Valley Resource Conservation and Development, Inc. received permission from the U.S. Department of Agriculture to harvest 1,600 ha of CRP switchgrass fields in southern Iowa. The harvest of switchgrass fields for biomass does not have the same effects on breeding birds as harvest of hayfields because biomass fields are harvested during fall and winter. Changes in vegetation structure resulting from the harvest, however, may affect species composition, abundances, and nest success of breeding birds (e.g., Dwernychuk and Boag 1972, Frawley and Best 1991, Horn and Koford 2000). The removal of residual vegetation also may allow easier predator movement through switchgrass fields.

We compared avian abundance, species composition, and nest success among total-, strip- (alternating cut and uncut strips), and non-harvest switchgrass fields. We speculated that the strip-harvest treatment might attract a more diverse bird community because of the presence of cut and uncut areas within a field. But the widths of strips also could affect which birds use the strip-harvest fields because of differences among species in minimum area (e.g., grasshopper sparrows) or territory size requirements. Thus, we compared strips of different widths. In addition, artificial nests were used to examine predator activity in relation to the edges of strips (the interfaces of cut and uncut vegetation) because of the potential that predator activity along strip edges might be greater than away from edges (Winter et al. 2000).

STUDY AREA AND METHODS

Our study sites were located in Appanoose, Lucas, Monroe, and Wayne counties in the rolling hills of the Southern Iowa Drift Plain in south-central Iowa (Prior 1991). The primary land cover is grasslands (pasture, hay, CRP fields) mixed with rowcrops (corn, soybeans) and riparian woodlands. The average temperature for May, June, and July is 16, 21, and 24°C, respectively, and the average rainfall for each month is 11 cm (National Oceanic and Atmospheric Administration 1999, 2000). May 2000 was warmer and drier than May 1999 with an average temperature of 17°C and 5 cm of rainfall in 2000 compared with 15°C and 14 cm of rainfall in 1999. The average temperatures in June 1999 and 2000 were the same (20°C), but 12 cm of rain fell in 1999 compared with 21 cm in 2000. July 1999 (25°C) was 3 degrees warmer than July 2000 (22°C) with 7 and 10 cm of rainfall, respectively.

We used 21 CRP fields in Appanoose, Lucas, Monroe, and Wayne counties that had been planted to switchgrass ≥ 5 years prior to our study. Fields ranged from 3.8 to 13.0 ha ($\bar{x}$ = 6.6) and were > 0.5 km apart. In our study we evaluated 3 treatments. Total-harvest fields were completely harvested. Strip-harvest fields consisted of alternating cut and uncut strips of different widths (4 fields: 60 m cut, 40 m uncut; 3 fields: 30 m cut, 20 m uncut), with 60% of the field being harvested. Non-harvest fields served as controls. In selecting fields, we used a randomized complete block design with 7 replicates. Fields within each block were of similar size and were adjacent to similar amounts of each of 3 habitat types (rowcrop, grassland, woodland). The blocking helped to reduce variation in bird abundance caused by differences in field size and surrounding habitat. Each treatment was then randomly assigned to one field in each block. During November through March in 1999 and 2000, the switchgrass was cut at about 9 cm in height with a disc mower, baled, and removed from the fields. Fertilizer and herbicides (atrazine and 2,4d) were also applied to most harvested fields in June or July both years.

We surveyed birds on each field between sunrise and 3 hours after sunrise once per week from 15 May to 15 July in 1999 and 2000 by using fixed-width (50 m), non-overlapping transects that covered the entire field. Transects were perpendicular to the strips in strip-harvest fields. We did not survey birds during high winds (>16 km/hr), rain, or fog, and care was taken to not count birds more than once. Observers rotated survey duties among fields to minimize observer bias. Birds flying overhead in search of food were considered to be using the field. In strip-harvest fields, we also recorded the strip type (cut or uncut) in which the bird was first seen.

We systematically and completely searched 5 fields of each treatment for nests 3 times between 15 May and 15 July in both years. Searches were conducted by 4-6 observers walking abreast (3 m apart), sweeping the vegetation with poles and scanning for nests and flushed birds. When a bird was flushed the area near where the bird was first seen was visually searched for nests. For fields > 8 ha, we searched 8-ha sub-plots. The area searched for each treatment was about 36 ha. Nests found opportunistically during other activities also were recorded for all 21 fields. Nests were marked with a flag 5 m north of the nest and checked every 2 to 4 days until the nest fledged young or failed. We recorded the number of eggs or nestlings, approximate age of nestlings, and presence or absence of attending adults during each visit. We minimized time spent at nests and damage to nest-site vegetation to reduce predator attraction to the nests.

To examine nest predator movement through strip-harvest fields we used artificial nest predation as an indirect measure of predator activity. Artificial nests were placed in 5 strip-harvest fields in mid-June and in mid-July in 1999 and 2000. One field had 30-m wide cut strips and 4 had 60-m wide cut strips. We placed nests at 20-m intervals along the strip edge and at different distances from the edge in a repeated pattern: at the strip edge (0), 10 m into the uncut strip (10U), 5 m into the cut strip (5C), 5 m into the uncut strip (5U), and 10 m into the cut strip (10C). The pattern maximized the distance between nests and therefore the likelihood of independence of nest fates. The first nest along a strip edge was placed 10 m from the field edge. The initial position relative to the strip edge (0, 10U, 5C, 5U, 10C) was chosen randomly, and then the pattern was continued and repeated. We used strip edges >50 m from a parallel field edge and >100 m from other strip edges with nests placed along them.

Artificial nests were constructed by forming a nest bowl from nearby herbaceous plant material (Bergin et al. 1997), and 2 Coturnix quail (*Coturnix coturnix*) eggs were placed in each nest. A nail was used to secure a piece of flagging tape under the nest to validate the nest location if the nest was destroyed. We wore rubber gloves and boots when constructing nests and handling eggs to reduce human scent near the nest. Nests were checked 7 and 14 days after placement and considered depredated if at least one egg was missing or damaged.

Visual obstruction and vegetation height were measured at a different random point in each 0.5 ha of each of the 21 survey fields once every 2 weeks from mid-May to late July. In strip-harvest fields, an equal number of points were measured in both strip types. Percent coverage, species composition, and litter depth were measured in mid-June and in mid-July at the same points as above. Visual obstruction was measured from the 4 cardinal directions, 4 m from a Robel pole at a height of 1 m (Robel et al. 1970). Vegetation height was recorded as the tallest piece of live vegetation within 1 cm of the Robel pole. Percent coverage and species composition were measured by using a 0.1-m^2 sampling frame (Daubenmire 1959) placed 1 m from the Robel pole in a random direction. Coverage of the following was estimated as percentages (non-overlapping) to the nearest 5%: switchgrass, other grasses, forbs, woody plants, standing dead vegetation, litter, and bare ground. Litter was defined as plant material no longer supported by a plant stem; all other dead plant material was classified as standing dead vegetation. Litter depth was measured to the nearest cm at the edge of the Daubenmire frame closest to the Robel pole. To estimate species composition we identified and recorded all live plant species that had ≥ 5% coverage within the sampling frame.

The area and amount of the field perimeter adjacent to different habitats were measured for each field surveyed for birds by using aerial photographs and a planimeter. The amount of the perimeter adjacent to each habitat was then divided by the area of the field to standardize across fields.

Vegetation height and density, and litter depth were measured one week after artificial nests were placed in fields by using the protocol described previously. Measurements were made at 60 m intervals along each strip edge used at a point equivalent to one of the five nest positions (0, 10U, 5C, 5U, 10C). The position of the point relative to the strip edge was determined by using a pattern that ensured that the vegetation point was not near an artificial nest to avoid disturbing the vegetation around nests.

Statistical analyses

A repeated measures 2-way Analysis of Variance (ANOVA) was used to test for treatment effects, year effects, and treatment-year interactions for bird abundances, vegetation height and density, and litter depth; all variables were log-transformed to meet the assumption of equal variances (SAS Institute 1999). Fisher's least significant difference (LSD) tests were used to test for pairwise differences between treatments for variables with significant differences among treatments. Percent coverages could not be transformed to meet the assumptions of an ANOVA, thus Wilcoxon rank-sum and Kruskal-Wallis *k*-sample tests were used to test for treatment differences, and paired t-tests were used to test for between year differences (SAS Institute 1999). Paired t-tests also were used to test for differences in vegetation height and density, litter depth, and percent coverage between cut and uncut strips. In fields used for the artificial nest study, an ANOVA was used to test for differences in vegetation height, vegetation density, and litter depth among nest positions, and LSD tests were used to test for differences in vegetation structure between cut and uncut strips and among the distances of nests from the strip edge.

A log-odds ratio (SAS Institute 1999) was calculated for each field to compare bird use of cut and uncut strips in strip-harvest fields for all species with ≥ 25 observations in strip-harvest fields in a year. The log-odds ratio was calculated for each field as:

$$\ln\left(\frac{\text{number of birds in uncut strips}}{\text{number of birds in cut strips}} * \frac{\text{area of field cut}}{\text{area of field uncut}}\right)$$

One sample t-tests were then used to test if the log-odds ratios were different from zero. If the ratio equaled zero, then use of cut and uncut strips was proportional to the availability of the 2 habitats. A positive ratio suggested greater use of the uncut strips, and a negative ratio suggested greater use of the cut strips.

Forward stepwise-multiple regressions with $P = 0.05$ for variable entry were used to test for the relative influence of vegetation variables within the fields and the amount of different habitats adjacent to fields on bird abundances. Pearson product-moment correlations (SAS Institute 1999) were used to help reduce the number of vegetation variables used in the model by removing one variable from pairs of highly correlated ($r > 0.50$) variables. Five vegetation variables (density, litter depth, and percent coverage of forbs, grasses [other than switchgrass], and standing dead vegetation) and perimeter-area quotients for four habitats (grassland [pastures, hayfields, cool-season CRP fields], rowcrop, switchgrass, and woodland) were included in the model.

Estimates of daily nest survival rates and their associated standard error were calculated for bird species with an adequate sample size ($n \geq 12$ nests, Mayfield 1975, Johnson 1979). Chi-square tests were then used to test for differences in daily nest survival rate between incubation and nestling stages, between years, and among treatments (Sauer and Williams 1989) by using the program Contrast. Nest survival estimates for the entire nesting period were calculated by exponentially expanding daily survival rates by the number of days in the nesting period.

A 2 x 5 Chi-square contingency table for artificial nests combined across year and month (598 nests) was used to determine if the pattern of nest predation relative to the 5 nest positions differed from random. Logistic regression analysis (SAS Institute 1999) was used to evaluate the effects of vegetation density and litter depth at artificial nest positions on the probability of nest depredation. Vegetation height was not included in the logistic model because density and height were highly correlated ($r = 0.84$, $P < 0.001$).

RESULTS

Vegetation composition and structure

Switchgrass composed on average 57% of the live vegetation in fields of all 3 harvest treatments; goldenrod (*Solidago* spp.) ranked second (21%) and was the most abundant forb. No other plant species composed greater than 3% percent on average of the live vegetation in fields.

Vegetation height and density were not significantly different among treatments (Table 1). The litter layer was deepest in non-harvest fields and least in total-harvest fields. More standing dead vegetation was present in non-harvest and strip-harvest fields than in total-harvest fields, but the amount of standing dead vegetation did not differ between non-harvest and strip-harvest fields. Switchgrass composed a greater percent coverage in total-harvest and strip-harvest fields than in non-harvest fields in both years. Bare ground coverage was greatest in total-harvest fields and least in non-harvest fields in 1999 but not 2000.

Cut and uncut strips of strip-harvest fields were similar in vegetation structure to total-harvest and non-harvest fields, respectively. Vegetation height, vegetation density, and litter depth were significantly greater in uncut than cut strips for both years combined (Table 2). Height, however, was not significantly different between strip types in 2000 (uncut = 95.5 cm ± 6.1 [$\bar{x} \pm$ SE], cut = 93.1 cm ± 6.9; $t = 0.64$, 13 df, $P = 0.543$). All other differences in vegetation structure between cut and uncut strips were significant both years. Bare ground coverage was significantly greater in cut than uncut strips, and the percent coverage of standing dead vegetation was greater in uncut strips. The percent coverage of other vegetation types did not differ between strip types.

Vegetation structure was significantly different between years (Table 1). The vegetation in all treatments was taller and denser and the percent coverage of switchgrass was greater in 2000 than in 1999. Percent coverage of litter and bare ground were greater and the litter layer was deeper in 1999 than in 2000 across all treatments.

The phenology of vegetation growth also differed between years (Fig. 1). Early in the growing season in both years, mean vegetation density was greatest in non-harvest fields, least in total-harvest fields, and intermediate in strip-harvest fields. By late May in 1999 vegetation density was similar in total-harvest and strip-harvest fields; by mid-July vegetation density of all 3 treatments had converged. In 2000, however, vegetation density in all 3 treatments was similar by late May, and vegetation density of total-harvest and strip-harvest fields then surpassed that of non-harvest fields by mid-June.

In fields used for the artificial nest study, vegetation height (F =0.48; 4, 16 df; P = 0.750) and vegetation density (F = 1.46, P = 0.262) did not differ among the 5 artificial nest positions, but litter depth did differ (F = 12.5, P < 0.001). The litter layer was deeper in the uncut than cut strips (uncut = 5.8 cm ± 0.7, cut = 1.9 cm ± 0.2; t = 6.93, 16 df, P < 0.001), but did not differ between 5 and 10 m from the strip edge for the strip types combined (t = 0.66, 16 df, P = 0.520).

Bird abundance

A total of 45 bird species was recorded in fields of all 3 harvest treatments. The mean number of species observed per field was not significantly different among treatments (Table 3). Bird abundances did not differ significantly in fields with different strip-widths (P >

0.05), thus abundances in strip-harvest fields were pooled across strip-widths for further analyses. Total bird abundance also did not differ significantly among treatments, and abundances of only 2 of the 18 species observed > 10 times in both years were significantly different among treatments (grasshopper sparrow, sedge wren, Table 3). Grasshopper sparrow abundance was significantly different among all treatments and was greatest in total-harvest fields and lowest in non-harvest fields. Sedge wrens were more abundant in non-harvest than total-harvest fields, but abundance in strip-harvest fields did not differ from either total-harvest or non-harvest fields. Differences in upland sandpiper, ring-necked pheasant, and bobolink abundances among treatments approached statistical significance ($0.05 < p \leq 0.10$). Pheasant abundance was greatest in non-harvest fields, and estimates of upland sandpiper and bobolink abundances were greatest in strip-harvest fields.

Within strip-harvest fields, 4 species (red-winged blackbird, song sparrow, common yellowthroat, sedge wren) were observed more frequently in uncut than cut strips in at least one year (Table 4). The grasshopper sparrow was the only species that preferred cut strips to uncut strips.

Abundances of some bird species differed between years. The mean number of birds per 100 ha was greater in 1999 than 2000 for barn swallows (1999 = 14.4 ± 2.0; 2000 = 8.4 ± 2.0; $F = 5.72$; 1, 18 df; $P = 0.028$) and grasshopper sparrows (1999 = 22.8 ± 6.5; 2000 = 5.9 ± 2.1; $F = 17.14$, $P < 0.001$). In contrast, bird abundance was greater in 2000 than 1999 for red-winged blackbirds (1999 = 70.0 ± 17.7; 2000 = 159.4 ± 37.0; $F = 10.86$; 1, 18 df; $P = 0.004$), common yellowthroats (1999 = 86.9 ± 11.8; 2000 = 108.9 ± 9.7; $F = 6.11$, $P = 0.024$), and dickcissels (1999 = 1.4 ± 0.6; 2000 = 7.3 ± 2.3; $F = 15.15$, $P = 0.001$). The interaction between year effects and treatment effects was significant for grasshopper sparrows ($F = 7.45$; 2, 18 df; $P = 0.004$), dickcissels ($F = 4.57$, $P = 0.025$), and sedge wrens ($F = 7.36$, $P = 0.005$) because of disproportional changes in abundance among the 3 treatments between 1999 and 2000 (Fig. 2). Sedge wrens in total-harvest and strip-harvest fields were more abundant in 2000 than 1999, but in non-harvest fields abundance was greater in 1999. Between 1999 and 2000 grasshopper sparrow abundance decreased by 75% in total-harvest fields and 81% in strip-harvest fields, but increased in non-harvest fields. Although dickcissels were more abundant in 2000 than 1999 in all 3 treatments, the percent increase in dickcissel abundance between 1999 and 2000 in total-harvest fields was twice that in strip-harvest fields.

Bird abundances were affected by vegetation structure within fields and the habitats surrounding fields (Table 5). Common yellowthroats, red-winged blackbirds, and sedge wrens were more abundant in fields with denser vegetation and a greater percent coverage of grasses other than switchgrass, but barn swallows, grasshopper sparrows, meadowlarks, and song sparrows were more abundant in fields with sparser vegetation. Northern harrier, sedge wren, and bobolink abundances were positively correlated with the amount of standing dead vegetation in a field. The type of habitat surrounding the fields affected abundance of every species, except common grackles, grasshopper sparrows and barn swallows. Abundances of 10 species were negatively associated with the amount of switchgrass adjacent to the fields, and counts of 7 species were positively related to the amount of woodland. The amount of grassland adjacent to fields was positively related to the abundance of 5 species, and only numbers of common yellowthroats were inversely related to the amount of grassland surrounding fields.

Nest placement

Nests belonging to 20 species (3 sparrow nests could not be identified to species) were found in switchgrass fields in 1999 (184 nests) and 2000 (307 nests, Table 3). Red-winged blackbirds and common yellowthroats accounted for 56 and 28% of the nests found, respectively. In 1999, more red-winged blackbird nests were found in non-harvest than in strip-harvest or total-harvest fields, but in 2000 the greatest proportion of nests was found in total-harvest fields. Common yellowthroat nests were more abundant in non-harvest fields than in strip-harvest or total-harvest fields. In strip-harvest fields, 91% of red-winged blackbird and 86% of common yellowthroat nests were found in uncut strips, and fewer nests of both species were found 0 to 5 m from the edge in uncut strips than in other locations in the strips (Fig. 3).

Nest success

Forty-four percent of all nests were successful (Table 6). Predation accounted for 78% and cowbird parasitism 9% of failures of nests with known fates. Other causes of nest failure included adverse weather conditions (e.g., heavy rain), abandonment by the adults, and disturbance by farm machinery during fertilizer and herbicide application. In both years, the proportion of nests that were successful was greatest in non-harvest fields. Some of the greater success in non-harvest fields can be attributed to the lower proportion of nests that failed because of disturbance by machinery, adverse weather, or unknown causes. The low predation rate (26%) in non-harvest fields in 2000 also explains the high success rate in these fields.

Daily nest survival rates (DSR) could only be calculated for red-winged blackbirds, common yellowthroats, and grasshopper sparrows (total-harvest fields only). DSRs were not significantly different between the incubation and nestling stages for either red-winged blackbirds (χ^2 = 2.21, 1 df, P = 0.138) or common yellowthroats (χ^2 = 0.979, 1 df, P = 0.322), thus the stages were pooled for further analyses. Red-winged blackbird DSR estimates were not significantly different between years (χ^2 = 0.38, 1 df, P = 0.537) and were pooled across years to test for treatment differences. Common yellowthroat DSRs were significantly greater in 2000 (0.9683 ± 0.0077) than in 1999 (0.9388 ± 0.0110; χ^2 = 4.90, 1 df, P = 0.027), thus tests to detect treatment effects were computed for each year separately. Red-winged blackbird DSRs were significantly different among treatments (non-harvest = 0.9691 ± 0.0055, total-harvest = 0.9458 ± 0.0114, strip-harvest = 0.9391 ± 0.0110; χ^2 = 8.028, 2 df, P = 0.018). Pairwise comparisons of treatments were significantly different between non-harvest and strip-harvest fields (χ^2 = 5.97, 1 df, P = 0.015), and approached significance between non-harvest and total-harvest fields (χ^2 = 3.47, 1 df, P = 0.063). Common yellowthroat DSRs were not significantly different among treatments in 1999 or in 2000 (χ^2 < 1.8, 2 df, P > 0.40). The DSR for grasshopper sparrows in total-harvest fields was 0.9654 ± 0.0152. Statistical tests for differences between the incubation and nestling stages, between years, or among treatments were not conducted for the grasshopper sparrow because of the small number of nests found. Average nest survival estimates for the incubation and nestling periods for red-winged blackbirds (24 days), grasshopper sparrows (21 days), and common yellowthroats (19 days) were 30, 48, and 41%, respectively.

Artificial nest predation

The overall depredation rate of artificial nests was 24%. The pattern of nest depredation was not significantly different relative to the 5 nest positions (χ^2 = 7.04, 4 df, P

= 0.134), and neither vegetation density nor litter depth explained a significant portion of the variation in depredation events in the logistic regression analysis. Although vegetation variables were not significant in logistic regression analysis, predation rates at different nest positions appear to be inversely related to the litter depth at the same position relative to the strip edge (Figure 4).

DISCUSSION

Grassland bird use of habitats is affected by the vegetation structure (Wiens 1974). Differences in vegetation structure caused by the harvest of switchgrass fields for biomass affected bird use of the fields. No major shifts in total abundance or species richness due to the harvest were detected for 2 reasons. First, the 2 most abundant bird species in switchgrass fields (red-winged blackbird, common yellowthroat) are habitat generalists (Best et al. 1996), and their abundances did not differ among harvest treatments. Second, decreases in abundance of species that preferred tall, dense vegetation in harvested areas were compensated by increases in species that prefer shorter, sparser vegetation.

Grasshopper sparrows prefer to nest in grasslands with shorter, sparser vegetation and a shallower litter layer (Madden et al. 2000) and were more abundant in total-harvest fields and cut strips of strip-harvest fields than in non-harvest fields and uncut strips. Paine et al. (Department of Agronomy, University of Wisconsin-Madison, unpublished data) found a similar pattern of habitat preference by grasshopper sparrows in switchgrass fields in Wisconsin harvested the previous year. The residual vegetation in non-harvest fields and uncut strips, however, was beneficial to other species. Northern harriers and ring-necked pheasants are ground nesting species that often begin nesting in April (MacWhirter and Bildstein 1996, Clark and Bogenschutz 1999) before switchgrass begins to grow, and the residual vegetation in non-harvested areas provided nest cover for these species early in the growing season. The large amounts of residual vegetation in non-harvested portions of fields also could support higher prey abundance (i.e., small mammals) for harriers than areas with less dead vegetation (Hayslett and Danielson 1994). Thus, non-harvested areas of switchgrass may be important breeding habitat for populations of harriers, an endangered species in Iowa (State of Iowa 1994).

The residual vegetation in non-harvested areas also provided better nest support for species that nested above ground. For example, some red-winged blackbird nests in harvested areas were tilted because live vegetation was often flattened during heavy rains. The residual vegetation in non-harvested areas, however, was stiffer than live vegetation and prevented nests from being tilted (personal observation). This may explain why 4 species that nest above ground (red-winged blackbird, song sparrow, common yellowthroat, sedge wren) were observed more often and nested more frequently in uncut than in cut strips in strip-harvest fields.

The vegetation structure in fields differed between years because of variation in weather and management practices. Total rainfall between April and September had the greatest effect on switchgrass growth in Texas (Sanderson et al. 1999) and the large differences between years in June rainfall in our study may have affected vegetation growth the most. In addition, annual differences in vegetation height were affected by fertilizer application to harvested fields (Muir et al. 2001). In 2000, vegetation in harvested fields was taller than in non-harvest fields because fertilizer was applied to harvested fields only. The fields were fertilized for the first time in June or July 1999 and the taller vegetation earlier in the growing season in 2000 may be attributed to residual effects of fertilizer application in the previous year.

Bird abundance in the fields may have been affected by the differences in vegetation height between years. Grasshopper sparrows were more abundant in 1999 when the vegetation was shorter, but red-winged blackbirds, dickcissels, and common yellowthroats, which prefer tall, dense vegetation (Herkert et al. 1993), were more abundant in 2000. Sedge wrens also prefer tall, dense vegetation (Herkert et al. 1993) and were more abundant in total-harvest and strip-harvest fields in 2000 than in 1999 but the reverse was true for non-harvest fields. Therefore, although overall sedge wren abundance did not differ between years, we speculate that in 2000 some wrens may have shifted use from non-harvested to harvested fields in response to taller vegetation in harvested fields (Fig. 1).

Vegetation characteristics explained a significant portion of the variation in abundances of bird species that commonly nested in switchgrass fields (red-winged blackbirds, common yellowthroats, grasshopper sparrows, northern harriers) but were less important for most other species. The relationships between bird abundances and vegetation structure in our study were similar to those summarized by Herkert et al. (1993). Red-winged blackbirds and common yellowthroats were more abundant in fields with taller, denser vegetation, and grasshopper sparrows were negatively associated with vegetation density. As discussed earlier, northern harriers prefer to nest in areas with large amounts of dead grass (Kantrud and Higgins 1992, Evrard and Bacon 1998), and in our study harrier abundance was related to the amount of standing dead vegetation in fields.

Species that did not breed in switchgrass fields were influenced more by the composition of habitats surrounding fields than by vegetation structure within the fields.

Field sparrows are associated with woodland edges and openings (Carey et al. 1994) and were more abundant in fields adjacent to woodlands. Abundances of species that nest in hayfields, pastures, or CRP fields (e.g., meadowlarks, dickcissels; Frawley and Best 1991, Temple et al. 1999, McCoy et al. 2001) were positively associated with the amount of grassland surrounding fields. The 10 species whose abundances were negatively related to the amount of switchgrass adjacent to fields did not commonly nest in switchgrass fields and may use the fields as a secondary habitat. Thus, the juxtaposition of switchgrass fields could be important in determining bird use. The number of species that use switchgrass fields may be low if fields are planted adjacent to each other, in effect creating a single large switchgrass field.

Our grasshopper sparrow and common yellowthroat nest success rates were similar to Mayfield estimates of nest success reported by others for idle switchgrass fields. Grasshopper sparrow nest success in our study (48%) was similar to that in switchgrass fields in Missouri (49%), but common yellowthroat nest success was greater in Iowa (41%) than in Missouri (32%, McCoy et al. 2001). For common yellowthroat the nest success rates were 41 and 32%, respectively. Nest success rates reported for CRP fields planted to cool-season grasses (e.g., smooth brome, orchard grass [*Dactylis glomerata*]), however, are lower than those in switchgrass fields. In cool-season CRP fields grasshopper nest success was 30% in Iowa (Patterson and Best 1996) and 42% in Missouri, and common yellowthroat nest success was 21% in Missouri (McCoy et al. 2001).

The higher nest success rates observed in switchgrass fields could be attributed to the denser vegetation and deeper litter in switchgrass fields compared with other habitats (McCoy et al. 2001). Denser vegetation and deeper litter may hinder predator movement and/or reduce the searching efficiency of predators. Crabtree et al. (1989) suggested that striped-skunk (*Mephitis mephitis*) movement through fields was more difficult and foraging costs were increased in dense vegetation. The rate of predation of artificial nests was inversely related to litter depth in our strip-harvest fields and much lower than that found for artificial nests in rowcrop fields (Schiavone and Best, Iowa State University, unpublished data), which have sparser vegetation and a much shallower litter layer. The higher red-winged blackbird nest success rates in our non-harvested versus harvested fields also suggests that the deeper litter in the former reduced the risk of predation.

The management of switchgrass fields for biomass production also may have contributed to lower red-winged blackbird nest success in harvested fields than in non-harvest fields. The farm machinery used to apply fertilizer and herbicides destroyed some nests and caused abandonment of others. Common yellowthroat nests, however, were less affected by these management practices because this species nests closer to the ground.

Future research should examine the effects of long-term management on bird use of biomass fields, particularly if biomass switchgrass production is continued or increased. Time lag effects similar to those seen after burning of habitats (Peterson and Best 1999) may occur in switchgrass fields. In particular, grasshopper sparrow response to fertilization should be studied because the effects of annual fertilization may negate the benefits of biomass fields for these birds. Landscape-level effects on bird abundance also should be studied because abundances of some species are related to the amount of different habitats in the surrounding landscape (O'Connor et al. 1999, Ribic and Sample 2001). Planting switchgrass fields adjacent to other grassland habitats may increase abundance of species that require large areas of grassland habitat (e.g., grasshopper sparrows). Northern harriers have a larger home range than most species that use switchgrass fields (MacWhirter and Bildstein 1996), and thus a better understanding of how harriers use agricultural landscapes would guide land managers in determining where non-harvest switchgrass patches should be located to maximize benefits to harrier populations.

MANAGEMENT IMPLICATIONS

Biomass switchgrass production could provide benefits parallel to the objectives of the CRP in that it removes land from rowcrop production, reduces soil erosion compared to rowcrop, and provides habitat for wildlife. In particular, grassland birds would benefit from switchgrass production (Chapter 3) because grassland habitat would be added to the landscape and the harvest does not cause the high rates of nest loss associated with summer mowing because biomass fields are harvested during fall and winter.

McCoy et al. (1999) estimated fecundities needed to support stable populations of grasshopper sparrows and common yellowthroats in Missouri CRP fields, and comparisons of nest success in Iowa switchgrass fields with that in CRP fields in their study suggest that nest survival rates in biomass fields would be sufficient to maintain populations. Thus, switchgrass fields would likely be productive habitats for populations of species that nest in the fields if fields are managed appropriately.

Management of biomass fields for birds should focus on minimizing potential negative effects on the bird community in fields associated with the production of biomass. The taller, denser grass growth resulting from fertilizer use may severely limit the benefits of switchgrass fields to grasshopper sparrows, and reduction of forb abundance through repeated herbicide use would create less attractive habitat for species that nest in forbs (red-winged blackbirds, dickcissels). The number of species using fields also may be reduced because of less variation in vegetation structure created by the use of herbicides and fertilizer.

Grasshopper sparrows, sedge wrens, and northern harriers should be the focus for management of biomass fields because they are of management concern (Fitzgerald and Pashley 2000) and are abundant breeders in switchgrass fields. Strip-harvest biomass fields provided nesting habitat for all 3 focal species because of the presence of both tall, dense vegetation and short, sparse vegetation. But the probability of occurrence and/or density of grasshopper sparrows are lower in small habitat patches than in large ones (Herkert 1994), and these birds were more abundant in total-harvest fields than in strip-harvest fields because the former provided larger areas of suitable habitat.

If 60% of the switchgrass were to be harvested in biomass fields, it could be accomplished by only harvesting 60% of the fields or by strip harvesting 60% of all fields. Both strategies would provide habitat for the 3 species of management concern, but harvesting complete fields rather than strips within fields probably would result in greater grasshopper sparrow abundance. Selecting some fields to remain non-harvested for extended periods of time would allow greater build up of residual vegetation and may provide more nest cover for pheasants and northern harriers. Rotational harvest of biomass fields, however, may maintain healthier stands of switchgrass and increase biomass production. If a rotational harvest system is used the time period between harvests should be long enough to allow the build-up of residual vegetation in non-harvested fields so that the fields provide good cover for early nesting species.

In conclusion, switchgrass fields grown for biomass provide habitat for grassland birds, and nest success rates in the fields should support stable bird populations. The residual vegetation in non-harvested areas of switchgrass is important protective cover for birds during winter (Chapter 4) and nesting cover and/or support for other species during the breeding season. Thus it is important to leave non-harvested areas of switchgrass, as either non-harvested fields or uncut sections of fields, to provide habitat for these species.

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Table 1. Vegetation height and density, litter depth, and percent coverages in total-, strip-, and non-harvest switchgrass fields in southern Iowa in May through July 1999 and 2000.

	1999									2000									Treatment effects[a]		Year differences[b]	
	Total-harvest			Strip-harvest			Non-harvest			Total-harvest			Strip-harvest			Non-harvest						
	$\bar{x}$		SE	$\bar{x}$		SE	$\bar{x}$		SE	$\bar{x}$		SE	$\bar{x}$		SE	$\bar{x}$		SE	*F*	*P*	*F/t*	*P*
Vegetation structure																						
Height (cm)	67.7	A[c]	6.4	69.3	A	6.0	76.6	A	4.7	94.1	A	7.4	94.0	A	6.4	79.5	A	6.1	0.01	0.994	11.53	0.008
Density (dm)	5.5	A	0.6	5.7	A	0.5	6.4	A	0.5	8.7	A	0.7	9.3	A	0.7	7.7	A	0.6	0.82	0.462	27.29	<0.001
Litter depth (cm)	2.2	A	0.2	4.8	B	0.5	6.9	B	1.3	1.5	A	0.2	2.2	B	0.2	4.1	C	0.9	14.54	<0.001	29.67	<0.001
Percent coverage																						
Switchgrass	32.1	A	3.9	35.3	A	5.4	20.0	B	3.7	65.2	A	5.9	66.7	A	5.2	31.8	B	4.4	20.28	<0.001	8.82	<0.001
Forb	22.0	A	2.6	19.5	A	4.1	23.6	A	4.2	17.2	A	4.2	15.4	A	2.9	27.1	A	5.9	0.25	0.777	0.91	0.367
Other grasses	4.0	A	1.4	2.1	A	0.9	10.4	A	4.3	1.8	A	0.7	2.5	AB	1.5	3.5	B	1.4	2.79	0.074	1.92	0.059
Woody	0.3	A	0.2	0.1	A	0.1	3.2	A	2.1	0.4	A	0.2	0.0	A	0.0	0.9	A	0.5	1.50	0.236	1.15	0.256
Standing dead	0.1	A	0.1	5.6	B	2.2	4.9	B	1.0	0.1	A	0.1	3.3	B	0.9	9.7	B	2.8	13.50	<0.001	0.76	0.448
Litter	33.4	A	3.3	34.8	A	3.7	34.5	A	4.2	12.9	AB	2.9	24.4	A	2.1	11.3	B	4.2	1.50	0.236	6.99	<0.001
Bare ground	8.1	A	1.5	4.6	B	0.9	3.4	C	1.0	1.9	A	0.8	1.0	A	0.4	2.4	A	1.5	8.18	0.001	3.93	<0.001

Table 1. Continued.

[a] A repeated measures ANOVA was used to test for differences among treatment means for vegetation height, vegetation density, and litter depth (2, 12 df). For percent coverage, a Kruskal-Wallis *k*-sample test was used to test for differences among treatments (2, 39 df).

[b] A repeated measures ANOVA was used to test for differences in height (1, 225 df), density (1, 228 df), and litter depth (1, 60 df) between years and *F*-statistics are given. For percent coverage, a paired *t*-test was used to test for differences between years and *t*-statistics are given (20 df).

[c] Means within rows and years with the same letter are not significantly different ($P > 0.05$, Fisher's least significant differences test, 12 df). For percent coverage, pairwise *t*-tests were conducted using Wilcoxon rank values (18 df).

Table 2. Vegetation height and density, litter depth, percent coverages, and results from paired *t*-tests (13 df) to test for differences between uncut and cut strips in strip-harvest switchgrass fields in southern Iowa in 1999 and 2000.

	Uncut		Cut		Paired *t*-test	
	$\bar{x}$	SE	$\bar{x}$	SE	*t*	*P*
Vegetation structure						
Height (cm)	83.9	4.5	79.7	4.8	4.65	<0.001
Density (dm)	8.0	0.5	7.0	0.5	2.16	0.050
Litter depth (cm)	5.0	0.6	2.0	0.3	4.49	<0.001
Percent coverage						
Switchgrass	48.5	5.0	53.8	5.0	1.70	0.112
Forbs	16.3	3.0	18.5	2.6	0.89	0.388
Other grasses	1.6	1.0	3.2	1.3	1.39	0.188
Woody	0.0	0.0	0.1	0.1	1.00	0.336
Standing dead	7.6	1.4	1.2	1.2	5.83	<0.001
Litter	25.7	3.4	20.3	3.4	1.63	0.128
Bare ground	1.4	0.6	4.0	0.9	3.07	0.009

Table 3. Number of birds per survey per 100 ha and number of nests found (in parentheses) in total-, strip-, and non-harvest switchgrass fields in southern Iowa in 1999 and 2000.

	Total-harvest			Strip-harvest			Non-harvest			ANOVA[a]	
Species[b]	$\bar{x}$		SE	$\bar{x}$		SE	$\bar{x}$		SE	*F*	*P*
Upland sandpiper (*Bartramia longicauda*)	0.7	A[c]	0.5	2.1(1)[d]	A	1.2	0.2	A	0.2	3.53	0.062
Ring-necked pheasant (*Phasianus colchicus*)	3.1(1)	A	0.9	3.3(1)	A	1.0	5.6(3)	A	1.5	2.80	0.100
Northern harrier (*Circus cyaneus*)	0.1	A	0.1	0.9(2)	A	0.5	3.4(5)	A	1.8	2.04	0.173
Eastern kingbird (*Tyrannus tyrannus*)	2.0	A	0.6	2.2	A	0.7	1.4	A	0.5	0.69	0.522
Bobolink (*Dolichonyx oryzivorus*)	2.4(1)	A	1.4	6.4	A	1.4	2.0	A	3.9	3.15	0.080
Brown-headed cowbird (*Molothrus ater*)	4.1	A	0.8	3.9	A	3.0	5.1	A	1.1	0.19	0.830
Red-winged blackbird (*Agelaius phoeniceus*)	102.6(100)	A	21.5	116.6(89)	A	35.9	124.9(88)	A	50.7	0.03	0.966
Meadowlarks (*Sturnella* spp.)	5.0(4)	A	1.5	3.5(1)	A	1.9	1.1	A	0.5	1.14	0.351
Common grackle (*Quiscalus quiscula*)	0.1	A	0.1	0.5	A	0.5	3.2	A	1.6	2.05	0.171
American goldfinch (*Carduelis tristis*)	2.4	A	0.9	4.1	A	1.4	3.1(1)	A	1.2	1.13	0.355
Grasshopper sparrow (*Ammodramus savannarum*)	35.1(14)	A	8.2	7.2(1)	B	2.6	0.7	C	0.3	24.74	<0.001
Field sparrow (*Spizella pusilla*)	0.9(1)	A	0.4	3.1(1)	A	2.1	3.8(5)	A	2.2	1.30	0.307
Song sparrow (*Melospiza melodia*)	8.8(2)	A	2.0	10.2(1)	A	2.9	11.4(6)	A	4.7	0.29	0.751
Dickcissel (*Spiza americana*)	7.5(5)	A	3.0	5.1	A	1.8	0.4	A	0.2	2.65	0.111

Table 3. Continued.

Species[b]	Total-harvest $\bar{x}$		SE	Strip-harvest $\bar{x}$		SE	Non-harvest $\bar{x}$		SE	ANOVA[a] F	P
Barn swallow (*Hirundo rustica*)	13.6	A	3.0	11.0	A	2.0	9.6	A	2.6	0.37	0.698
Tree swallow (*Tachycineta bicolor*)	1.2	A	0.4	2.4	A	1.4	0.1	A	0.1	2.45	0.128
Common yellowthroat (*Geothlypis trichas*)	71.0(24)	A	10.1	106.5(44)	A	13.5	114.6(69)	A	14.1	2.04	0.173
Sedge wren (*Cistothorus platensis*)	7.4	A	2.7	10.8(1)	AB	2.5	30.0(5)	B	9.4	5.12	0.025
Total abundance[e]	274.9(159)	A	22.3	309.6(147)	A	37.6	342.7(185)	A	70.8	0.14	0.874
Species richness[f]	14.4	A	1.0	12.4	A	0.8	11.5	A	0.7	2.76	0.103

[a] Results of a test for treatment effects from a 2-way repeated measure Analysis of Variance test (2,12 df).

[b] Species with at least 10 observations in both years. Twenty seven other species were observed fewer than 10 times in a year (Appendix 1).

[c] Means within rows with the same letters are not significantly different ($P > 0.05$, Fisher's least significant differences tests, 12 df).

[d] Nests were found during systematic nest searches and incidentally during other activities in 46 ha of each treatment.

[e] Includes all species observed.

[f] Number of species observed during all surveys per field per year.

Table 4. Number of observations, log-odds ratio, and results from a *t*-test to determine if the log-odds ratio was significantly different from zero. A log-odds ratio not different from zero indicates use of strips is proportional to availability, a positive ratio indicates a preference for uncut strips, and a negative ratio indicates a preference for cut strips.

		Number of observations			*t*-test		
Species	Year	Uncut	Cut	Log-odds ratio ($\overline{x}$)	*t*	*P*	*n*[a]
Red-winged blackbird	1999	74	37	1.08	7.28	0.002	5
	2000	218	110	1.13	5.84	0.001	7
Grasshopper sparrow	1999	10	41	-1.23	4.91	0.008	5
	2000	3	5	NA[b]	—	—	3
Song sparrow	1999	30	12	1.08	2.68	0.044	6
	2000	20	8	1.21	2.30	0.070	6
Dickcissel	1999	7	3	NA	—	—	2
	2000	12	14	0.27	0.66	0.550	5
Common yellowthroat	1999	297	43	2.23	13.77	<0.001	7
	2000	263	156	1.22	5.57	0.001	7
Sedge wren	1999	31	2	2.40	18.21	<0.001	6
	2000	51	11	1.27	2.70	0.043	6

[a] *n* = number of strip-harvest fields in which the species was observed.

[b] NA = log-odds ratios were not calculated for species observed fewer than 25 times in strip-harvest fields in a year.

Table 5. Significant ($P \leq 0.05$) vegetation structure (density, and litter depth) and composition (percent coverage of forbs, grasses other than switchgrass [grass], and standing dead vegetation), and perimeter habitat (grassland, rowcrop, switchgrass, and woodland) variables in forward stepwise multiple-regressions of bird abundance in switchgrass fields in southern Iowa for May through July in 1999 and 2000.

Species	Significant variables
Upland sandpiper	switchgrass (-[a], 0.49[b])
Ring-necked pheasant	woodland (+, 0.25), rowcrop (+, 0.11), grassland (+, 0.07)
Northern harrier	standing dead (+, 0.18), woodland (+, 0.08), forbs (-, 0.05)
Eastern kingbird	switchgrass (-, 0.40), woodland (+, 0.11), grassland (+, 0.10)
Bobolink	switchgrass (-, 0.46), standing dead (+, 0.06)
Brown-headed cowbird	switchgrass (-, 0.19)
Red-winged blackbird	density (+, 0.18), grass (+, 0.15), grassland (+, 0.10)
Meadowlarks	switchgrass (-, 0.43), density (-, 0.08), grassland (+, 0.05), woodland (+, 0.05)
Common grackle	no significant variables
American goldfinch	woodland (+, 0.18), SG (-, 0.11)
Grasshopper sparrow	density (-, 0.23), litter depth (-, 0.15)
Field sparrow	woodland (+, 0.45), SG (-, 0.17)
Song sparrow	density (-, 0.25), SG (-, 0.13)
Dickcissel	switchgrass (-, 0.40), grassland (+, 0.06), woodland (+, 0.05)
Barn swallow	density (-, 0.14)
Tree swallow	switchgrass (-, 0.45)
Common yellowthroat	grassland (-, 0.26), density (+, 0.17), forbs (+, 0.06), grass (+, 0.06)
Sedge wren	standing dead (+, 0.22), density (+, 0.14), grass (+, 0.12)

[a] Direction of the relationship between the variable and bird abundance.

[b] Proportion of the variation in bird abundance explained by the variable.

Table 6. Nest outcomes (number of nests) of all species found in total-, strip-, and non-harvest switchgrass fields in southern Iowa in 1999 and 2000.

		Failure due to			
Year	Successful	Predation	Parasitism	Other[a]	Unknown fate
1999					
Total-harvest	15	16	2	4	1
Strip-harvest	19	20	7	6	0
Non-harvest	37	29	5	1	1
2000					
Total-harvest	38	47	2	7	4
Strip-harvest	24	40	3	10	0
Non-harvest	37	15	0	1	4

[a] Includes abandonment from unknown causes, disturbance by farm machinery, and losses attributable to adverse weather.

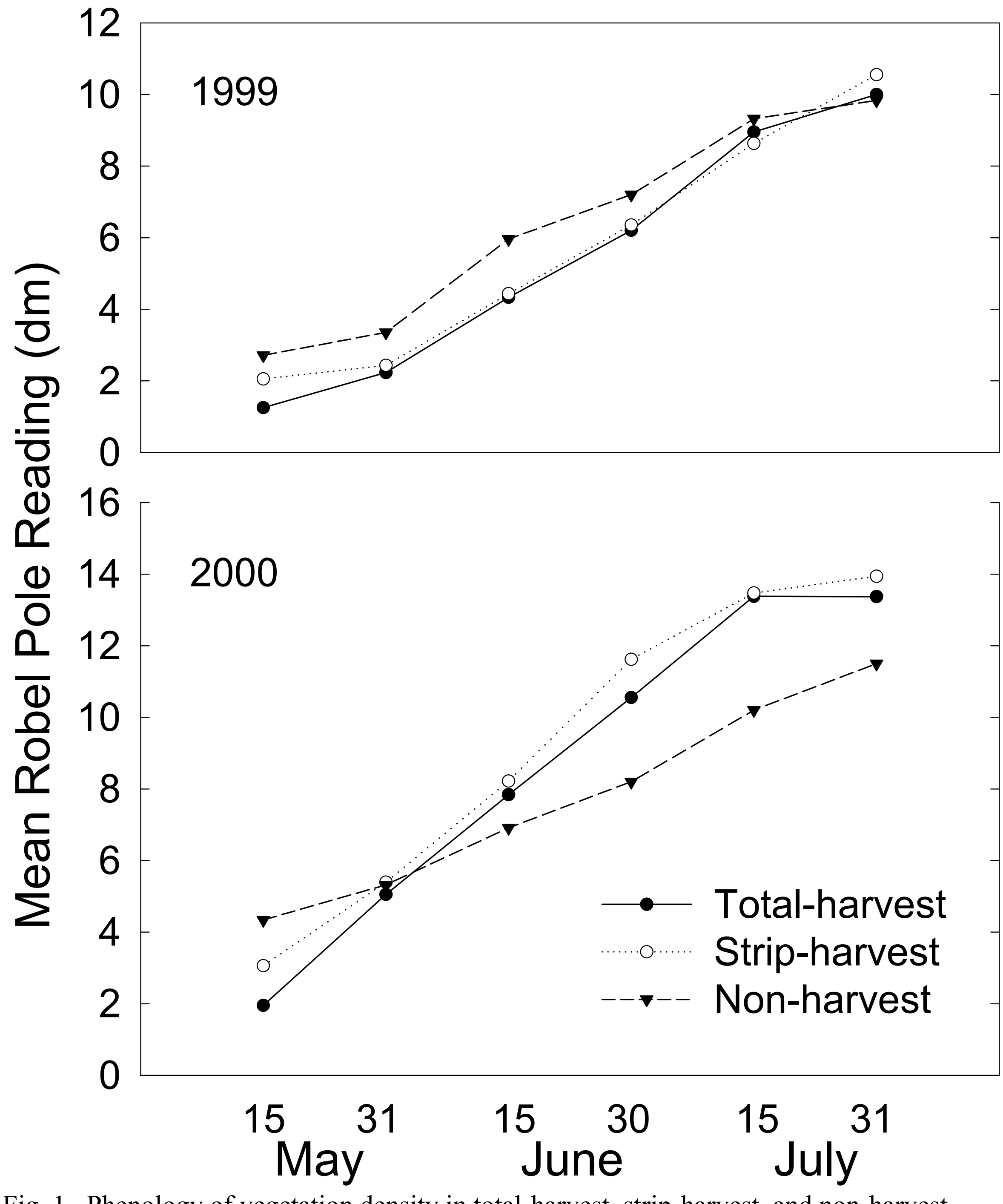
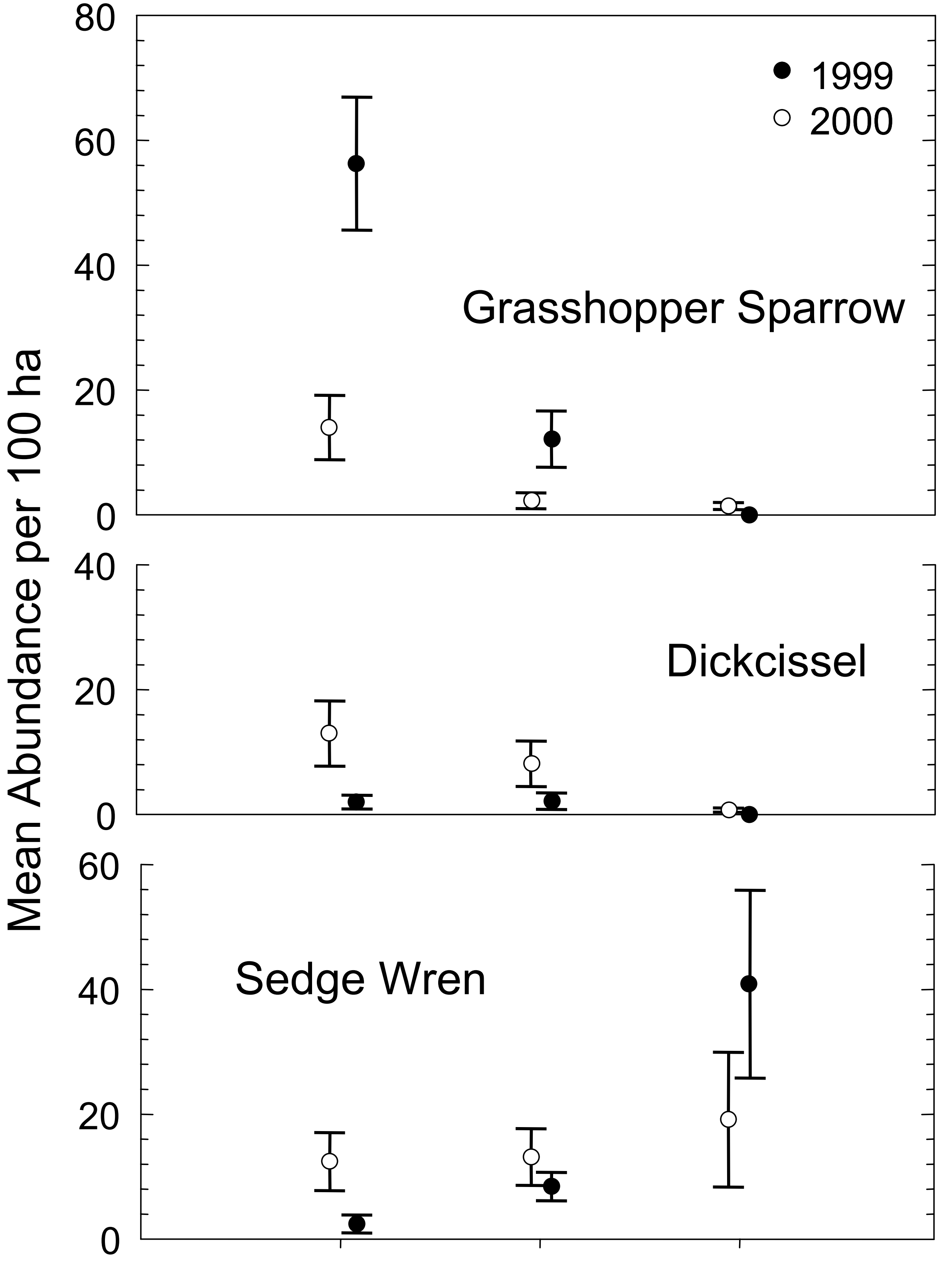


Fig. 1. Phenology of vegetation density in total-harvest, strip-harvest, and non-harvest switchgrass fields in southern Iowa in 1999 and 2000.

Fig. 2. Mean abundance and standard error for bird species with significant interactions between year and treatment effects in switchgrass fields in southern Iowa for May through July 1999 and 2000.


80
60
40
20
0
1999
2000
Grasshopper Sparrow
40
20
0
Dickcissel
60
40
20
0
Sedge Wren
Mean Abundance per 100 ha
Total-harvest
Strip-harvest
Non-harvest

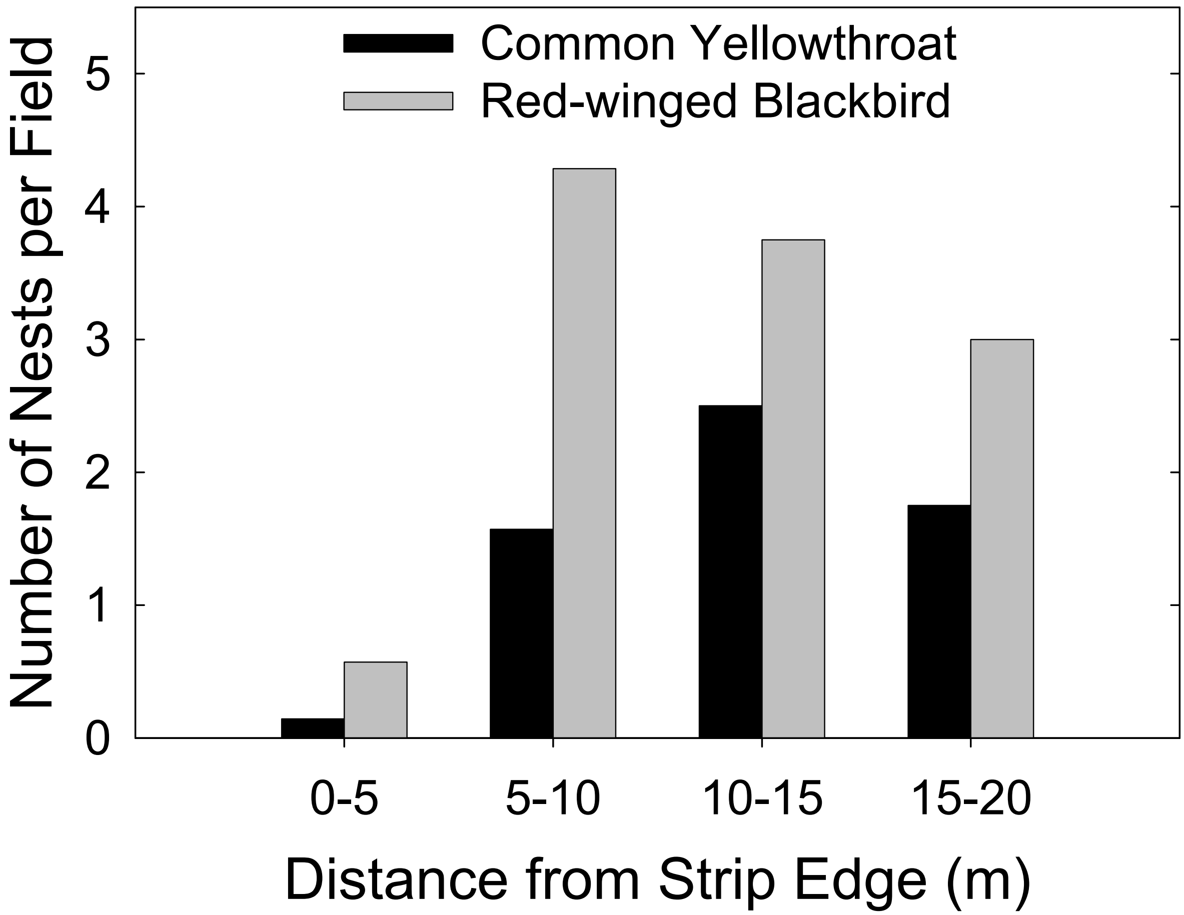


Fig. 3. Distribution of common yellowthroat and red-winged blackbird nests in relation to the edge of uncut strips of strip-harvest switchgrass fields in southern Iowa in 1999 and 2000.

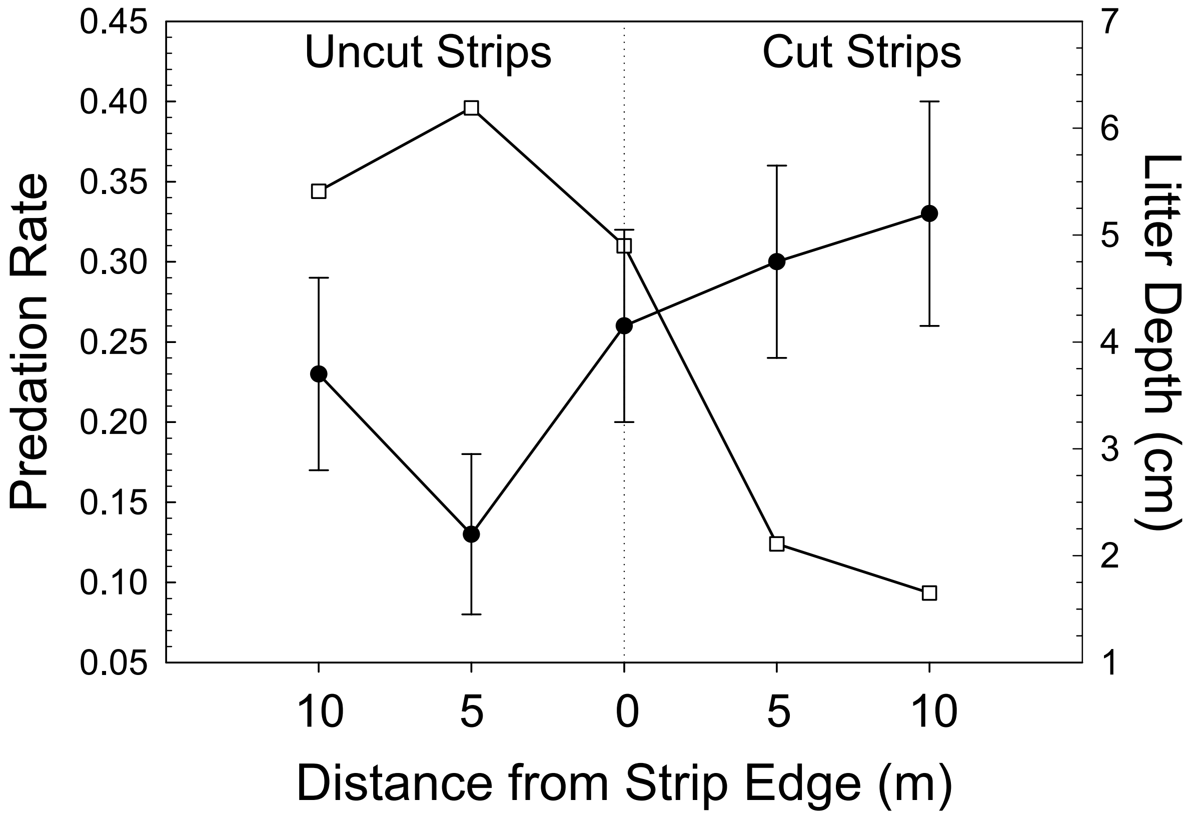


Fig. 4. Predation rate of artificial nests (circles) and standard error, and litter depth (squares) in uncut and cut strips at different distances from the strip edge in switchgrass fields in southern Iowa in 1999 and 2000.

Appendix 1. Bird abundance per 100 ha, and number of nests found in total-, strip-, and non-harvest switchgrass fields in the Rathbun Lake Watershed in southern Iowa during 1999 and 2000.

	Total-harvest			Strip-harvest			Non-harvest		
Species	$\bar{x}$	SE	Nests[a]	$\bar{x}$	SE	Nests	$\bar{x}$	SE	Nests
Great blue heron (*Ardea herodias*)	0.0	0.0	0	0.0	0.0	0	0.6	0.4	0
American woodcock (*Scolopax minor*)	0.1	0.1	1	0.5	0.4	0	0.1	0.1	0
Upland sandpiper (*Bartramia longicauda*)	0.7	0.5	0	2.2	1.2	1	0.2	0.2	0
Killdeer (*Charadrius vociferous*)	0.8	0.5	1	0.1	0.1	0	0.0	0.0	0
Northern bobwhite (*Colinus virginianus*)	0.9	0.4	0	0.3	0.3	0	0.4	0.2	0
Ring-necked pheasant (*Phasianus colchicus*)	2.9	0.9	1	3.1	1.0	1	5.6	1.5	4
Wild turkey (*Meleagris gallopavo*)	0.4	0.3	0	0.4	0.4	4	0.0	0.0	1
Mourning dove (*Zenaida macroura*)	0.7	0.6	0	0.8	0.4	1	0.3	0.2	0
Turkey vulture (*Cathartes aura*)	0.3	0.2	0	1.2	0.7	0	3.0	2.0	0
Northern harrier (*Circus cyaneus*)	0.1	0.1	0	0.9	0.5	2	3.4	1.8	5
Red-tailed hawk (*Buteo jamaicensis*)	0.1	0.1	0	0.1	0.1	0	0.1	0.1	0
American kestrel (*Falco sparverius*)	0.0	0.0	0	0.0	0.0	0	0.4	0.2	0

Appendix 1. Continued.

Species	Total-harvest			Strip-harvest			Non-harvest		
	$\bar{x}$	SE	Nests[a]	$\bar{x}$	SE	Nests	$\bar{x}$	SE	Nests
Barred owl (*Strix varia*)	0.0	0.0	0	0.0	0.0	0	0.2	0.2	0
Belted kingfisher (*Ceryle alcyon*)	0.0	0.0	0	0.0	0.0	0	0.1	0.1	0
Northern flicker (*Colaptes auratus*)	1.6	0.5	0	0.6	0.3	0	0.2	0.2	0
Chimney swift (*Chaetura pelagica*)	0.2	0.2	0	0.3	0.3	0	0.0	0.0	0
Eastern kingbird (*Tyrannus tyrannus*)	1.9	0.6	0	2.2	0.7	0	1.3	0.5	0
Blue jay (*Cyanocitta cristata*)	0.1	0.1	0	0.0	0.0	0	0.1	0.1	0
American crow (*Corvus brachyrhynchos*)	0.3	0.2	0	3.0	2.2	0	1.9	1.6	0
European starling (*Sturnus vulgaris*)	2.0	2.0	0	0.0	0.0	0	54.6	54.6	0
Bobolink (*Dolichonyx oryzivorus*)	2.5	0.8	1	6.4	3.0	0	2.0	1.1	0
Brown-headed cowbird (*Molothrus ater*)	4.0	1.4	__[b]	3.9	1.4	__	5.1	3.9	__
Red-winged blackbird (*Agelaius phoeniceus*)	102.6	21.5	100	116.6	35.9	89	124.9	50.7	88
Meadowlark species (*Sturnella* spp.)	5.0	1.4	4	3.6	1.9	1	1.2	0.6	0
Baltimore oriole (*Icterus galbula*)	0.0	0.0	0	0.0	0.0	0	0.1	0.1	0

Appendix 1. Continued.

Species	Total-harvest			Strip-harvest			Non-harvest		
	$\bar{x}$	SE	Nests[a]	$\bar{x}$	SE	Nests	$\bar{x}$	SE	Nests
Common grackle (*Quiscalus quiscula*)	0.1	0.1	0	0.5	0.5	0	3.2	1.5	0
American goldfinch (*Carduelis tristis*)	2.5	0.9	0	4.0	1.3	0	3.1	1.2	1
Vesper sparrow (*Pooecetes gramineus*)	0.8	0.5	2	0.0	0.0	0	0.3	0.2	0
Savannah sparrow (*Passerculus sandwichensis*)	0.4	0.3	0	0.2	0.2	0	0.2	0.1	0
Grasshopper sparrow (*Ammodramus savannarum*)	35.1	8.2	14	7.2	2.6	1	0.7	0.4	0
Henslow's sparrow (*Ammodramus henslowii*)	0.5	0.2	0	0.1	0.1	0	0.0	0.0	0
Field sparrow (*Spizella pusilla*)	1.0	0.4	1	3.1	2.1	1	3.8	2.2	5
Song sparrow (*Melospiza melodia*)	8.8	2.0	2	10.2	2.9	1	11.3	4.6	6
Northern cardinal (*Cardinalis cardinalis*)	0.0	0.0	0	0.0	0.0	0	0.1	0.1	0
Rose-breasted grosbeak (*Pheucticus ludovicianus*)	0.2	0.2	0	0.0	0.0	0	0.0	0.0	0
Indigo bunting (*Passerina cyanea*)	0.1	0.1	0	0.3	0.2	0	0.3	0.2	0
Dickcissel (*Spiza americana*)	7.5	3.0	5	5.2	1.8	0	0.4	0.2	0
Purple martin (*Progne subis*)	0.3	0.3	0	0.0	0.0	0	0.0	0.0	0

Appendix 1. Continued.

Species	Total-harvest			Strip-harvest			Non-harvest		
	$\bar{x}$	SE	Nests[a]	$\bar{x}$	SE	Nests	$\bar{x}$	SE	Nests
Cliff swallow (*Petrochelidon pyrrhonota*)	0.1	0.1	0	0.0	0.0	0	0.0	0.0	0
Barn swallow (*Hirundo rustica*)	13.6	3.0	0	11.0	2.0	0	9.7	2.6	0
Tree swallow (*Tachycineta bicolor*)	1.2	0.4	0	2.3	1.4	0	0.2	0.2	0
Northern rough-winged swallow (*Stelgidopteryx serripennis*)	0.0	0.0	0	3.3	2.2	0	0.0	0.0	0
Common yellowthroat (*Geothlypis trichas*)	71.0	10.1	24	106.5	13.5	44	114.6	14.1	69
Gray catbird (*Dumetella carolinensis*)	0.2	0.2	0	0.2	0.2	0	0.2	0.2	0
Brown thrasher (*Toxostoma rufum*)	0.4	0.3	0	0.0	0.0	0	0.3	0.2	0
Sedge wren (*Cistothorus platensis*)	7.4	2.7	0	10.7	2.5	1	30.2	9.4	5
Black-capped chickadee (*Poecile atricapilla*)	0.0	0.0	0	0.4	0.4	0	0.0	0.0	0
American robin (*Turdus migratorius*)	0.5	0.3	0	0.0	0.0	0	0.2	0.2	0
Eastern bluebird (*Sialia sialis*)	0.1	0.1	0	0.0	0.0	0	0.0	0.0	0
Total abundance	274.9	22.3	159[c]	309.6	67.6	147	342.7	70.8	185[d]

[a] Number of nests found during systematic searches for nests and incidentally during other activities in 36 ha of each habitat.

Appendix 1. Continued.

[b] Brown-headed cowbirds lay their eggs in nests of other species.

[c] Three sparrow nests could not be identified to species.

[d] One mallard (*Anas platyrhynchos*) nest was found, but mallards were not observed during surveys.

CHAPTER 3. POTENTIAL EFFECTS OF CONVERTING MARGINAL CROPLAND TO BIOMASS SWITCHGRASS PRODUCTION ON GRASSLAND BIRD ABUNDANCE IN SOUTHERN IOWA, USA

A paper to be submitted to Biomass and Bioenergy.

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Abstract

Habitat loss is a major reason for the decline of grassland birds in North America. Five habitats (pastures, hayfields, rowcrop fields, small-grain fields, Conservation Reserve Program [CRP] fields) compose most of the habitat used by grassland birds in the Midwest United States. Growing and harvesting switchgrass (*Panicum virgatum*) as a biomass fuel would create another habitat for grassland birds. Bird abundance information from studies conducted in Iowa and adjacent states and land-use data for the Rathbun Lake Watershed in southern Iowa were used in a Geographic Information System to model the effects on bird abundances of converting rowcrop fields to biomass production. Total bird abundance and abundances for 13 selected species were calculated for the existing land use, a total-harvest biomass scenario, and a scenario in which 60% of the biomass within each field was harvested in strips. Total bird abundance increased minimally in the biomass scenarios compared with the existing land use. But abundances of some species (e.g., common yellowthroat [*Geothlypis trichas*], grasshopper sparrow [*Ammodramus savannarum*]) increased by >15% in both biomass scenarios compared with the current condition. Other species (e.g., horned lark [*Eremophila alpestris*], killdeer [*Charadrius vociferous*]) were more abundant in the existing land use than in the biomass scenarios, and conversion of

fields from rowcrop to biomass production could be detrimental to these species. In general, biomass fields will provide habitat for grassland birds that are management priorities, but future monitoring of birds in such fields is needed as conversion of rowcrop fields to biomass production continues.

Keywords: biomass; birds; energy crops; switchgrass (*Panicum virgatum*); watershed; wildlife

1. Introduction

The Midwest region of the United States is highly dependent on fossil fuels from other areas of the country; 70% of the electricity in the Midwest is generated by coal-fired power plants.[1] Use of biomass fuels would reduce non-renewable resources used in the region. Growing and harvesting switchgrass (*Panicum virgatum*), and burning the switchgrass biomass in combination with coal could decrease coal use by 5% in some areas of the Midwest.[2] Switchgrass is used as a biomass fuel because it yields more biomass per unit area than other herbaceous plants that have been tested,[1] and it requires minimal maintenance once established in a field.

In the Rathbun Lake Watershed in southern Iowa, tests are underway to evaluate the use of switchgrass as a biomass fuel. The switchgrass fields being used for the tests are currently enrolled in the Conservation Reserve Program (CRP) and were previously planted to switchgrass. The CRP, established in 1985, reimburses farmers for removing highly erodible cropland from production and planting it to perennial cover, commonly grasses in the Midwest.[3] Future plans for biomass production in the area include converting rowcrop (corn, soybeans) fields and CRP fields planted to switchgrass to biomass fields. The conversion of rowcrop fields to biomass fields would increase water quality, help control soil erosion, and create habitat for grassland birds.[4]

Grassland birds are declining faster than any other group of birds in North America,[5,6] and habitat loss is considered a major reason for their decline.[7] Currently, 5 habitats that occur in non-linear patches in southern Iowa are commonly used by grassland birds (pastures, hayfields, rowcrop fields, small-grain fields, CRP fields). Bird communities in pastures and hayfields vary greatly because of differences in vegetation structure caused by different grazing and mowing regimes.[8,9] Mortality of adults, eggs, and nestlings and interruption of the nesting cycle from mowing and grazing also cause lower reproductive success in these habitats.[10-12] Rowcrop fields are used by grassland birds, but very few species nest there.[13] Some species, however, (e.g., horned lark [most scientific names are given in Appendix 1]) commonly nest in rowcrop fields[14] and benefit from the large acreages of rowcrops in the Midwest. Small-grain fields (oats and wheat) are used by fewer species of grassland birds than the other habitats, and most species are less abundant in small-grain fields.[15]

Many bird species are more abundant in CRP fields than in rowcrop fields[14] and experience better nest success in CRP fields than in pastures and hayfields because CRP fields are usually idle.[8,16] In southern Iowa, CRP fields are commonly planted to either switchgrass or smooth brome (*Bromus inermis*); the vegetation structure in switchgrass fields is taller and denser than that in brome fields. The differences in vegetation structure result in differences in the bird communities[17] because some species (e.g., grasshopper sparrows) prefer short, sparse vegetation whereas others (e.g., sedge wren) prefer tall, dense vegetation.[18]

Biomass switchgrass fields would provide yet another habitat for grassland birds. Grassland birds in biomass fields would not experience the low nest success associated with hayfields because biomass fields are harvested in the fall and winter. The harvest of biomass fields, however, does alter the vegetation structure. Early in the season, total-harvest fields have shorter, sparser vegetation than non-harvest fields.[19] Harvesting biomass fields by alternating cut and uncut strips (strip-harvest) would provide both short and tall vegetation early in the season and may provide habitat for more species of bird than total-harvest fields.

The objective of our study was to model the regional effects of converting rowcrop fields and CRP switchgrass fields to biomass production. A Geographic Information System (GIS) land-use coverage was created for the Rathbun Lake Watershed, Iowa. Bird abundance values for each habitat were then used to model bird abundances in the watershed before and after the conversions. A scenario in which biomass fields were totally harvested and a scenario with strip-harvest biomass fields were modeled.

2. METHODS

2.1. GIS data

A GIS model was used to identify areas of marginal cropland in the watershed to be targeted for conversion to biomass production. Land-use and soil data from the United States Geological Survey, Iowa Department of Natural Resources, United States Army Corp of Engineers, local Soil Conservation Districts, and United States Department of Agriculture Natural Resource Conservation Service (NRCS) were used to calculate the erosion (Sutter J, NRCS, Appanoose County, Iowa, personal communication)[20,21] and leaching[22] indices for soils in the watershed. Rowcrop areas in the watershed with a leaching index of 2 or greater and/or an erosion index greater than 50 were then targeted for conversion to biomass fields.

The 1992 National Land Cover Data (United States Geological Survey) were then used to create a GIS land-use coverage for the Rathbun Lake Watershed. CRP fields planted to switchgrass were appended to the coverage by using information obtained from the United States Army Corp of Engineers; Iowa Department of Natural Resources; the Chariton Valley Resource Conservation and Development, Inc.; and Appanoose, Lucas, Monroe, and Wayne county conservation boards. The land use for the watershed was then grouped into habitat categories (Table 1). The satellite imagery used to generate the land-use coverage could not separate pastures and hayfields, therefore these categories were combined. In the watershed, 65% of the pasture/hay category was pasture, 21% mixed hay (cool-season grass and alfalfa), 11% cool-season grass hay, and 4% alfalfa hay (Bahl D, NRCS, Wayne County, Iowa, unpublished data). To model the two scenarios, the land use for targeted rowcrop areas (21,835 ha) and switchgrass fields currently enrolled in CRP (1,836 ha) in the watershed were changed to total-harvest or strip-harvest biomass production.

2.2 Bird species used

For this paper, we selected 13 grassland associated species (Table 2) that are management priorities (Fitzgerald and Pashley),[23] a game species, and/or abundant in switchgrass and/or rowcrop fields in Iowa or Missouri.[14,17,19] Although 14 grassland or grassland-shrubland species that breed in the Dissected Till Plains are considered management priorities, only 4 priority species (bobolink, dickcissel, field sparrow, grasshopper sparrow) were observed frequently enough in switchgrass or rowcrop fields to model their abundance in the watershed. Sedge wrens are not considered management priorities, but are species of concern and are grouped with priority species for this paper. Species that spend most of their time flying (i.e., swallows and raptors) were excluded because some studies only recorded birds that landed in the habitat. We also removed species that are not active in the morning (e.g., owls) when most surveys are conducted. Brown-headed cowbird abundance also was modeled because it lays its eggs in nests of other species and is considered a conservation threat to some species of management concern.[24]

2.3 Bird abundance values

Bird use of total-, strip, and non-harvest switchgrass fields in southern Iowa was evaluated in 1999 and 2000.[19] Strip-harvest fields consisted of alternating cut and uncut strips of different widths (4 fields: 60 m cut, 40 m uncut; 3 fields: 30 m cut, 20 m uncut), with 60% of the field being harvested. Strip width did not affect bird abundance in strip-harvest fields, thus estimates of bird abundance are combined across strip widths.

Abundance values for other habitats were taken from journal publications, theses, and dissertations derived from studies conducted in Iowa and adjacent states that reported bird abundance values for the habitats of interest. We averaged bird abundance values from the 2 studies closest to the Rathbun Lake Watershed that used transect surveys and presented abundance values such that the number of birds per hectare could be calculated (Appendix 1).

Only bird abundances from Graber and Graber[25] were used for wetlands. Other studies of bird use of wetlands in Iowa were not used because the zone of emergent vegetation was sampled disproportionate to other areas of the wetland. Graber and Graber reported bird abundance for 3 regions of Illinois (northern, central, southern), and we used bird abundance values from the central region because it is closest to the Rathbun Lake Watershed. The exception was values for wetlands because wetlands were surveyed only in the northern region. In Best et al.[14] the bird abundance values reported for different states were considered to be derived from independent studies because the data were collected by independent research teams. Iowa and Missouri bird abundance values were used for rowcrop fields, but only Iowa values were used for CRP fields because abundance values for Missouri CRP fields were for switchgrass fields and smooth brome fields combined.

Bird abundance values for mixed hay were used to represent all 3 types of hay because mixed hay composes most of the hay in the area and no bird abundance data were available for cool-season grass hay. Most of the pasture in the area is continuously grazed (Bahl D, NRCS, Wayne County, Iowa, personal communication), so we used bird abundance values from Temple et al.[9] because it was the only study in the region that reported bird abundances in continuously grazed pasture. Bird abundances for the pasture/hay category were then calculated by using a weighted average based on the amounts of pasture and hay in the watershed.

Average bird abundance values for each habitat (Appendix 1) were used in the GIS model. Total bird abundance and abundance of each species were then calculated for the entire watershed for the current land-use coverage, and the scenarios with the targeted rowcrop area and CRP switchgrass fields converted to total-harvest or strip-harvest biomass fields.

2.4 Variation in bird abundances

Although average bird abundance values for each habitat are the best estimates of abundance in the habitats, abundances do vary between fields. To estimate variation in bird abundances we calculated coefficients of variation (standard deviation of the mean divided by the mean) for rowcrop and switchgrass fields because the coefficients are standardized and can be compared among habitats and species. Coefficients of variation for Iowa and

Missouri rowcrop fields were calculated from Patterson and Best[26] and McCoy[27] because standard deviations could not be determined from Best et al.[14] because they did not provide standard errors of the means. We did not calculate coefficients for other habitats because changes in abundance in our model were only dependent on the change in the amount of rowcrop and switchgrass in the watershed and bird abundances in those habitats.

3. Results

Bird abundances in rowcrop and switchgrass were highly variable within habitats (Table 2). Standard deviations of abundance for most species in most habitats were often equal to or greater than the mean (coefficient > 1).

Total abundance of management priority species increased in both biomass scenarios (Table 3) compared with the current land use. Abundances of each priority species also increased in both scenarios, except for field sparrows which were less abundant in the total-harvest scenario.

As a whole, abundances of other species increased by 11% in the strip-harvest scenario, but decreased in the total-harvest scenario. Abundances of 4 species (brown-headed cowbird, horned lark, killdeer, vesper sparrow) combined decreased by more than 11,000 birds in each biomass scenario, but large increases in common yellowthroat abundance compensated for decreases in these other species. The number of ring-necked pheasants, an important upland game species, also increased in both scenarios compared with the current condition.

4. Discussion and Conclusions

Converting rowcrop and CRP land to biomass production would create habitat for some bird species of management concern. Abundance of species that are management priorities increased in both scenarios. Species that are not management priorities also increased as a group, but horned lark and killdeer abundances were lower in the biomass scenarios than in the existing land use and may be negatively impacted by biomass switchgrass production.

Coefficients of variation for estimates of bird abundance in rowcrop and switchgrass fields were very high. Therefore, although our estimates of changes in abundance in the watershed are the best available, the lack of precision in the estimates should be incorporated in the interpretation of results. The high variability in abundances also suggests that other factors besides habitat type may affect bird abundance in the watershed. For example, the landscape surrounding the field could affect bird abundance in the field. A switchgrass field surrounded by grassland could have a different bird community than a field surrounded by rowcrop.

Some species that we did not model also should be considered in land-management decisions. For example, the northern harrier (*Circus cyaneus*), an endangered species in Iowa,[28] could not be modeled because it is usually seen flying and was not recorded in some studies. Harriers use a variety of habitats to meet their needs, but often nest in areas of dense grassland vegetation.[29] Murray[19] found more nests in uncut strips of strip-harvest switchgrass fields than in total-harvest fields. Thus, strip harvesting of biomass fields may be more beneficial to harrier populations than total harvesting of the fields.

Estimated grasshopper sparrow abundance, however, was greater in the total-harvest scenario than in the strip-harvest scenario. The number of grasshopper sparrows in the watershed increased by 19% in the total-harvest scenario and only 4% in the strip-harvest scenario compared to the current land use. In contrast, sedge wren and field sparrow numbers were greater in the strip-harvest scenario than the total-harvest scenario. Field sparrows commonly nest in areas where successional woody plants are abundant [30] and mowing of these plants in harvested areas limits field sparrow use in total-harvest fields compared with strip-harvest fields.

Strip-harvest fields provide habitat both for species that prefer tall vegetation (e.g., sedge wren, northern harrier) and those that prefer short, sparse vegetation (i.e., grasshopper sparrow), but grasshopper sparrows were most abundant in total-harvest fields and sedge wrens and harriers are most abundant in non-harvest fields.[19] Thus a mixture of total-harvest fields and non-harvest fields may be more beneficial to the entire suite of species of management priority than totally harvesting or strip harvesting all the fields. A mixture of total-harvest and non-harvest fields in a region could be accomplished by selecting some fields to remain idle or through a rotational harvest regime. The intervals between harvests in a rotational regime should be sufficient to allow the buildup of residual vegetation to provide nesting cover for harriers and pheasants.

The conversion of rowcrops to biomass in the watershed also could affect aspects of avian biology other than abundance. For example, replacing rowcrop fields with switchgrass fields may initially increase pheasant abundance in the watershed by providing more roosting and nesting cover, but corn is an important food for pheasants during winter[31] and a decline in the amount of rowcrops in the watershed could lower winter survival rates.

In addition to examining the effects of biomass production on winter survival of pheasants, future studies should include long-term monitoring of bird populations in the watershed as biomass production is continued to ensure that species not currently of management concern do not become so. Also, the conversion of rowcrop to switchgrass production would not cause instantaneous changes in bird abundance in the watershed. First, populations of birds would have to discover the new habitat before abundance values in the habitat would begin to reach a maximum. Second, limitations in population biology would require many years to produce a surplus of birds to occupy all the habitats in the watershed. Therefore, it would probably take decades for changes in bird abundance in the watershed to approach our estimates.

Some factors (e.g., habitat patch size and shape, juxtaposition of habitat patches) known to affect bird abundance [32,33] were not included in our model because of the resolution of the GIS land-use coverage and incomplete understanding of how these factors affect bird abundance. A better understanding of the effects of field size and shape, and adjacent habitats on bird abundance in biomass fields would allow land managers to maximize benefits of biomass production to grassland birds by choosing potential biomass fields based on how these factors affect bird abundance. In addition, bird response in habitats adjacent to switchgrass fields should be examined because changes in the food supply and the landscape context could affect bird species in adjacent habitats. The feasibility of a mixture of total-harvest and non-harvest fields in the watershed also should be examined because this management option may benefit some species (e.g., grasshopper sparrows, northern harriers) more than totally harvesting or strip harvesting all biomass fields.

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Table 1. Descriptions and areas of the habitats used in the Geographic Information System (GIS) models of bird abundance for the Rathbun Lake Watershed, Iowa, USA.

Habitat	Habitat description	Area (ha)
Rowcrop	Corn and soybeans	41,339
Cool-season grass	Areas dominated by cool-season grasses (predominantly CRP fields)	14,844
Small grains	Oats and wheat	2,173
Pasture & Hay	Continuously grazed pasture: 65%[a]	55,223
	Mixed hay[b]: 21%	
	Cool-season grass hay: 10%	
	Alfalfa hay: 4%	
Wetland	≥75% perennial herbaceous vegetation and periodically covered or saturated with water	2,248
Woodland	≥25% woody cover	17,982
Non-harvest switchgrass	Conservation Reserve Program fields planted to switchgrass	1,836
Strip-harvest biomass	60% harvested switchgrass fields	—[c]
Total-harvest biomass	100% harvested switchgrass fields	—
Open water	Lakes, ponds, and reservoirs	5,447
Other	Residential, industrial, bare rock, quarries, mines, gravel pits, and urban grasses	3,008

[a] Percentage of the pasture/hay category in the Rathbun Lake watershed.

[b] Cool-season grasses and alfalfa planted in the same field.

[c] These habitats do not currently exist in the watershed, but were modeled using the GIS land-use coverage.

Table 2. Coefficients of variation (standard deviation of the mean divided by the mean) for bird abundances in rowcrop and switchgrass fields calculated from Murray,[19] Patterson and Best,[26] McCoy.[27]

		Switchgrass		
Species	Rowcrop	Non-harvest	Strip-harvest	Total-harvest
Bobolink	—[a]	2.1	1.8	1.2
Brown-headed cowbird	0.8	2.9	1.3	1.3
Common yellowthroat	2.4	0.5	0.5	0.5
Dickcissel	2.5	1.9	1.3	1.5
Field sparrow	2.0	2.2	2.5	1.5
Grasshopper sparrow	2.1	2.1	1.4	0.9
Horned lark	0.7	—	—	—
Killdeer	0.7	—	3.7	2.3
Meadowlark	1.6	1.9	2.0	1.0
Red-winged blackbird	0.3	1.5	1.2	0.8
Ring-necked pheasant	1.4	1.0	1.2	1.2
Sedge wren	—	1.2	0.9	1.4
Vesper sparrow	0.4	2.5	—	2.3

[a] Species not observed in that habitat.

Table 3. Estimated bird numbers in thousands and the percent change in numbers (in parentheses) in the Rathbun Lake Watershed, IA, USA for the current land-use coverage and for 2 scenarios with 21,835 ha of rowcrops, and 1,836 ha of CRP switchgrass fields converted to biomass production.

Species[a]	Existing landuse	Strip-harvest biomass	Total-harvest biomass
Management priorities[b]			
Bobolink	61.8	63.3 (2)	62.3 (1)
Dickcissel	55.9	56.6 (1)	57.2 (2)
Field sparrow	3.3	3.5 (7)	3.0 (-9)
Grasshopper sparrow	42.3	43.8 (4)	50.3 (19)
Sedge wren	6.8	8.8 (29)	8.0 (18)
Total	170.1	176.0 (4)	180.9 (3)
Other			
Brown-headed cowbird[c]	8.1	7.2 (-11)	7.3 (-10)
Common yellowthroat	10.9	33.7 (209)	25.3 (132)
Horned lark	11.0	6.2 (-43)	6.2 (-43)
Killdeer	17.5	13.1 (-25)	13.2 (-25)
Meadowlark	21.4	21.2 (-1)	21.5 (1)
Red-winged blackbird	162.0	178.9 (11)	175.6 (8)
Ring-necked pheasant[d]	2.1	2.5 (16)	2.4 (14)
Vesper sparrow	9.3	7.8 (-16)	8.0 (-14)
Total	242.4	270.6 (12)	259.7 (-4)

Table 3. Continued.

[a] Species of management priority or concern, game species, and/or species that are abundant (neutral) in rowcrop and/or switchgrass fields. Scientific names are given in Appendix 1.

[b] Based on Partners in Flight Priority Scores for the Dissected Till Plains.[22] Sedge wrens are not listed as a management priority, but are a species of management concern.

[c] A brood parasite in that it lays eggs in nests of other species and thus decrease nest success of host species.

[d] Game species

Appendix 1. Bird abundances per 100 ha and sources (superscripts) for each habitat type used in a GIS model of changes in bird abundance associated with the conversion of marginal cropland to switchgrass in the Rathbun Lake Watershed in southern Iowa.

Species	Row-crops[14]	Cool-season grass[14,17]	Small grains[15,25]	Pasture & hay[9,15,25]	Wet-land[25]	Wood-land[34,35]	Switchgrass[19] Non-harvest	Switchgrass[19] Strip-harvest	Switchgrass[19] Total-harvest
Bobolink (*Dolichonyx oryzivorus*)	0.0	37.2	37.9	69.9	9.0	0.0	2.0	6.4	2.4
Brown-headed cowbird (*Molothrus ater*)	0.8	0.1	0.0	6.0	10.1	8.5	0.3	0.0	0.5
Common yellowthroat (*Geothlypis trichas*)	1.0	23.2	5.0	17.0	17.2	27.2	114.6	106.5	71.0
Dickcissel (*Spiza americana*)	1.7	44.1	26.1	108.9	0.0	1.9	0.4	5.1	7.5
Field sparrow (*Spizella pusilla*)	0.9	4.9	3.2	0.0	0.0	15.3	3.8	3.1	0.9
Grasshopper sparrow (*Ammodramus savannarum*)	1.4	61.5	2.1	121.9	0.0	0.0	0.7	7.2	35.1

Appendix 1. Continued.

Species	Row-crops[14]	Cool-season grass[14,17]	Small grains[15,25]	Pasture & hay[9,15,25]	Wet-land[25]	Wood-land[34,35]	Switchgrass[19] Non-harvest	Strip-harvest	Total-harvest
Killdeer (*Charadrius vociferous*)	21.3	0.2	6.8	6.1	13.1	0.0	0.0	0.1	0.8
Meadowlark (*Sturnella* spp.)	3.4	4.4	25.2	47.7	8.1	0	1.1	3.5	5.0
Red-winged blackbird (*Agelaius phoeniceus*)	47.4	113.5	102.8	213.8	384.6	8.7	124.9	116.6	102.6
Ring-necked pheasant (*Phasianus colchicus*)	1.0	10.8	0.0	0.0	7.4	0.0	5.6	3.3	3.1
Sedge wren (*Cistothorus platensis*)	0.0	8.8	0.0	1.5	15.1	0.0	30.0	10.8	7.4
Vesper sparrow (*Pooecetes gramineus*)	2.3	0.7	1.0	0.3	0.0	0.0	0.3	0.0	0.9

CHAPTER 4. WINTER BIRD USE OF CONSERVATION RESERVE PROGRAM FIELDS HARVESTED FOR BIOMASS

A paper to be submitted to the Wilson Bulletin.

Les D. Murray and Louis B. Best

ABSTRACT

Conservation Reserve Program (CRP) fields have created habitat for grassland birds in the Midwest, but when many CRP contracts expire, fields may be returned to rowcrop production. Growing and harvesting switchgrass (*Panicum virgatum*) as a biomass fuel is one proposed alternative to returning fields to rowcrop production. Switchgrass biomass fields would provide habitat for grassland birds similar to CRP fields. Bird use of CRP fields during the summer is well studied, but little information exists on winter bird use. CRP fields provide more protective cover than rowcrop fields during winter months, but the harvest of biomass would remove most of this protective cover and could limit bird use of biomass fields. To evaluate the effects of biomass harvest on winter birds, we used transect surveys to estimate bird abundance in non-harvest, total-harvest, and strip-harvest (alternating cut and uncut strips with 60% of each field harvested) CRP switchgrass fields during January and February 2000. American Tree (*Spizella arborea*) and Song (*Melospiza melodia*) Sparrows were observed more frequently in strip-harvest fields than in fields of the other two treatments, and Ring-necked Pheasants (*Phasianus colchicus*) were only observed in non-harvest fields and uncut strips of strip-harvest fields. The dense vegetation in non-harvested areas provided protection from predators and adverse weather, but it also deterred

foraging by American Tree and Song Sparrows because they usually feed in open areas by scratching the ground. Harvested areas provided foraging sites for the sparrows, but in total harvest fields the lack of protective cover limited bird use. Thus strip-harvest biomass switchgrass fields are more beneficial to birds during winter than total-harvest fields.

The Conservation Reserve Program (CRP) was established in 1985 to reduce soil erosion and improve water quality by reimbursing farmers for removing highly erodible land from rowcrop production and planting it to perennial cover, commonly grasses in the Midwest (Heard et al. 2000). In addition, the CRP provides habitat for grassland birds. Eight of the 10 species of grassland birds with significant negative population trends in the Midwest, according to North American Breeding Bird Survey data (Sauer et al. 2001), are more abundant in CRP fields in the summer than in rowcrop fields (Best et al. 1997). Many CRP contracts will expire in the near future, and some CRP fields may be returned to rowcrop production (Kurzejeski et al. 1992).

One proposed alternative to returning CRP fields to rowcrop production is to grow and harvest switchgrass (*Panicum virgatum*) for use as a biomass fuel. In southern Iowa, studies of CRP fields planted to switchgrass are underway to determine the feasibility of using switchgrass as a biomass fuel. In addition to reducing fossil fuel use in the Midwest, biomass switchgrass fields would provide erosion control and water quality benefits similar to CRP fields (McLaughlin and Walsh 1998) and provide habitat for breeding grassland birds (Chapter 2).

Breeding birds are not directly affected by the harvest of biomass fields because it occurs in the fall and winter. The vegetation structure, however, is altered by the harvest, and grassland bird communities are strongly influenced by vegetation structure (Herkert et al. 1993). The bird communities in harvested and non-harvested switchgrass fields differ during the summer because of differences in vegetation structure (Chapter 2).

Biomass fields could also provide habitat for birds during the winter. Relative to the breeding season, little information exists on bird use of CRP fields during the winter (Hull et al. 1995, Best et al. 1998, McCoy et al. 2001). CRP fields provide more protective cover from predators and adverse weather conditions than rowcrop fields, and Ring-necked Pheasants (*Phasianus colchicus*), American Tree Sparrows (*Spizella arborea*), Northern Bobwhites (*Colinus virginianus*), Dark-eyed Juncos (*Junco hyemalis*), and American Goldfinches (*Carduelis tristis*) were more abundant and/or more widely distributed in CRP fields planted to smooth brome (*Bromus inermis*) than in rowcrop fields (Best et al. 1998). Harvesting of biomass switchgrass fields will remove most of the protective cover and may limit bird use of biomass fields to those with cover available in adjacent habitats, as suggested by Rodenhouse et al. (1993).

To evaluate the effects of biomass harvest on winter bird use of switchgrass fields, we compared bird abundance in non-harvest (control), total-harvest, and partially harvested (strip-harvest) CRP switchgrass fields. We reasoned that the uncut strips of strip-harvest fields would provide protective cover for some species (e.g., Song Sparrows [*Melospiza melodia*], Watts 1990), while allowing the harvest of portions of the field. Therefore, we expected greater bird abundance in strip-harvest fields than in total-harvest fields because of the presence of more protective cover. In addition to protective cover, food availability affects bird abundance in the winter (Beck and Watts 1997). The harvest would not affect seed abundance because switchgrass seed falls in mid-November (West 1967) before most biomass fields are harvested, but the removal of vegetation in harvested areas may make fallen seeds more accessible.

STUDY AREA AND METHODS

Our study was conducted during January and February 2000 and was located in the rolling hills of the Southern Iowa Drift Plain in south-central Iowa (Prior 1991). The primary land cover is grasslands (pastures, hayfields, CRP fields) mixed with rowcrops (corn, soybeans) and riparian woodlands. The average temperature for January and February is –6 and –3°C (National Oceanic and Atmospheric Administration 2000c), respectively, and the average snowfall for the same months is 18 and 15 cm (Midwestern Climate Center 2000). In 2000, the average temperature for the 2 months was –3 and 1°C and there was 13 and 12 cm of snowfall (National Oceanic and Atmospheric Administration 2000a,b). At the time surveys were conducted snow accumulation was negligible.

We used 21 CRP switchgrass fields in Appanoose, Lucas, Monroe, and Wayne counties that ranged from 4 to 13 ha ($\bar{x} = 6.6$) and were >0.5 km apart. Fields were grouped into seven replicates of three fields each. Fields in each replicate were of similar size and had similar surrounding habitat to reduce variation in bird abundance caused by these factors. Each of the three harvest treatments (total-, strip-, and non-harvest) was then randomly assigned to one field in each replicate. Strip-harvest fields consisted of alternating cut and uncut strips, with 60% of each field being harvested. Four strip-harvest fields had 60-m-wide cut strips and 40-m-wide uncut strips; three fields had 30-m-wide cut strips and 20-m-wide uncut strips. The residual switchgrass was cut with a disc mower set at a height of 9 cm, baled, and removed from the fields from November 1999 through February 2000.

We surveyed birds between 2 hours after sunrise and 1.5 hours before sunset once in January and once in February by using 50-m fixed-width, non-overlapping transects that covered each field entirely. Transects were perpendicular to the strips in strip-harvest fields. Birds flying overhead in search of food were considered to be using the field and were included in the counts. Total-harvest and strip-harvest fields were surveyed after they were harvested. One total-harvest field was not surveyed either month because the field was not harvested until late February, and three strip-harvest fields and one total-harvest field were not surveyed in January because they were not harvested before surveys were conducted.

Vegetation structure was measured at a random point for each 0.5 ha of each field once in January or February. In strip-harvest fields measurement points were alternated between cut and uncut strips. Vegetation density was measured as visual obstruction 4 m from a Robel pole in the 4 cardinal directions and at a height of 1 m, and the lowest decimeter that was visible was recorded for each direction (Robel et al. 1970). Maximum height was measured as the tallest piece of vegetation within 1 cm of the Robel pole. Litter was defined as dead plant material lying flat on the ground, and litter depth was measured to the nearest centimeter.

A one-way ANOVA for a randomized block design, with each replicate of three fields treated as a block, was used to test for differences in total bird abundance, abundances of bird species with > 10 observations, and vegetation structure among the three treatments (SAS Institute, Inc. 1999). All variables were log-transformed to meet the assumption of equal variances, and type III Sums of Squares were used because of unbalanced sample sizes.

Fisher's least significant difference tests were used to test for pair-wise differences between treatments. Differences in vegetation height and density, and litter depth between cut and uncut strips in strip-harvest fields were evaluated by using paired t-tests.

RESULTS

Residual vegetation in total-harvest fields was significantly shorter and sparser than that in the other two treatments (Table 1). In total-harvest fields the lowest decimeter of the Robel pole was visible at each sampling point. Vegetation density and maximum vegetation height were greater in uncut strips than cut strips (density: cut = 1.00 dm, uncut = 3.50 dm, $t = 38.19$, 6 df, $p = 0.005$; height: cut = 8.55 cm, uncut = 119.63 cm, $t = 112.64$, 6 df, $p < 0.001$). Vegetation structure in uncut strips of strip-harvest fields was similar to that in non-harvest fields, and cut strips were similar to total-harvest fields. Litter depth did not differ among treatments (Table 1) or between strip types (cut = 2.27 cm, uncut = 6.20 cm, $t = 2.20$, 6 df, $p = 0.110$).

Mean total bird abundance in strip-harvest fields was more than twice that in fields of the other two treatments (Table 1). Ring-necked Pheasants were observed only in non-harvest and strip-harvest fields. Pheasant abundance in strip-harvest fields was 45% of that in non-harvest fields, and all pheasant observations were in uncut strips which composed 40% of the strip-harvest fields. More American Tree Sparrows were observed in strip-harvest fields than in fields of the other two treatments (Table 1), and 87% of the observations ($n = 55$) in strip-harvest fields were in uncut strips. Song Sparrows were only seen in strip-harvest fields, and all observations were in uncut strips ($n = 13$).

Eight of the eleven species observed were recorded fewer than ten times in all treatments. In non-harvest fields three Red-tailed Hawks (*Buteo jamaicensis*) were seen searching for food overhead, and three species were observed once (Rough-legged Hawk [*Buteo lagopus*], Red-winged Blackbird [*Agelaius phoeniceus*], Wild Turkey [*Meleagris gallopavo*]). A single Dark-eyed Junco, Field Sparrow (*Spizella pusilla*), Northern harrier (*Circus cyaneus*), and Red-tailed Hawk were observed in strip-harvest fields. In total-harvest fields three American Crows (*Corvus brachyrhynchos*) and one Northern Harrier were recorded.

DISCUSSION

Only three bird species (Ring-necked Pheasant, American Tree Sparrow, Song Sparrow) were observed frequently enough to evaluate their habitat use patterns. That all Song Sparrow and most American Tree sparrow observations in strip-harvest fields were in uncut strips suggests that residual vegetation in uncut strips provides more protection from predators than cut strips. Watts (1990) showed that Song Sparrow abundance was greater in unmowed sections of horse weed (*Conyza canadensis*) fields, but that the proportion of kills by raptors was greater in the mowed sections. Even though non-harvest fields have more protective cover than strip-harvest fields, Song and American Tree sparrow relative abundances were lower in non-harvest than in strip-harvest fields because less area was available for these species to forage.

Both American Tree and Song Sparrows commonly forage in open areas by scratching the ground to remove food items (West 1967, Whalen and Watts 2000). The dense residual vegetation in non-harvest fields and uncut strips probably hindered ground foraging. Cut strips and total-harvest fields, however, provided more bare ground (Chapter 2) for these species to forage. In strip-harvest fields sparrows were able to forage in cut strips but could quickly retreat to nearby uncut strips when confronted by a predator. Total-harvest fields provided foraging areas for sparrows, but protective cover in adjacent habitats and fencerows was more distant than in strip-harvest fields. The greater distance to protective cover in total-harvest fields probably deterred sparrows from foraging in these open habitats, as has been seen at feeding stations in other studies (Grubb and Greenwald 1982, Lima 1987, Giesbrecht and Ankney 1998).

Ring-necked Pheasants may have spent more time foraging in nearby rowcrop fields than in switchgrass fields. Bogenschutz et al. (1995) found that when rowcrops were available nearby, pheasant diets usually included small amounts of wild material (e.g., weed seeds, insects) and large amounts of crop grain (i.e., corn and soybeans). Protective cover, however, is important for pheasant survival in the winter (Gabbert et al. 1999). In our study, pheasants were observed only in non-harvested areas of fields, and their abundance was roughly proportional to the amount of non-harvested area in each treatment. Thus pheasants probably used switchgrass fields primarily for escape and roosting cover and not as foraging sites. The non-harvested areas of switchgrass fields provided better cover than either rowcrop or harvested areas of switchgrass fields.

Availability of both food and protective cover affects bird abundance (Beck and Watts 1997). Thus, providing both food and cover in the same habitat patch would benefit birds during winter. Conservation Reserve Program fields planted to switchgrass provided protective winter cover for American Tree and Song Sparrows, and Ring-necked Pheasants, but harvesting such fields for biomass would drastically reduce this cover. Strip-harvest biomass fields provide foraging areas for Song and American Tree Sparrows without completely removing protective cover important for winter survival. Thus, if switchgrass fields are to be harvested, harvesting them in alternating cut and uncut strips is more beneficial to the winter bird community than harvesting them completely.

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Table 1. Mean bird abundance (per survey per 100 ha) and vegetation structure in total-, strip-, and non-harvest switchgrass fields in southern Iowa during January and February 2000.

	Total-harvest (n = 6)			Strip-harvest (n = 7)			Non-harvest (n = 7)			ANOVA[a]	
	Mean		SE	Mean		SE	Mean		SE	F	p
Bird Abundance											
Ring-necked Pheasant[b]	0.0	A[c]	0.0	9.3	A	7.2	20.1	A	9.1	1.90	0.195
American Tree Sparrow	26.0	A	12.7	98.3	A	44.7	24.0	A	6.7	2.25	0.151
Song Sparrow	0.0	*A*	0.0	20.4	B	15.9	0.0	A	0.0	4.32	0.041
Total abundance[d]	31.2	A	14.6	137.9	B	62.6	52.1	AB	11.6	3.71	0.059
Vegetation Structure											
Density (dm)	1.0	A	0.0	2.3	B	0.3	4.1	B	1.1	9.58	0.004
Height (cm)	7.0	A	0.7	65.5	B	4.8	120.2	C	13.0	123.43	<0.001
Litter depth (cm)	1.8	A	0.2	4.3	A	1.2	5.1	A	1.2	1.98	0.185

[a] One-way analysis of variance test for differences among treatments (df = 2, 11).

[b] Only species that were observed at least 10 times are listed separately. Scientific names are given in the text.

[c] Means within rows with different letters are significantly different ($p < 0.05$), Fisher's least significant difference tests.

[d] Includes all bird species observed.

CHAPTER 5. GENERAL CONCLUSIONS

Growing and harvesting switchgrass for use as a biomass fuel would provide economic and environmental benefits to southern Iowa. Switchgrass is a homegrown energy source that could reduce the local dependency on coal by up to 5% (Teel 1998). In addition, switchgrass would provide environmental benefits to the area. Burning of switchgrass in combination with coal would reduce carbon dioxide pollution compared with the burning of coal alone (Boman and Turnbull 1997), and the extensive root system of switchgrass would reduce soil erosion and increase water quality (McLaughlin and Walsh 1998). Biomass switchgrass fields also would provide habitat for declining grassland birds.

Converting rowcrop fields to biomass switchgrass fields would create more habitat for grassland birds in the region. A Geographic Information Systems (GIS) model showed that species that are management priorities would increase if rowcrop fields in areas of marginal soil were replaced by biomass fields in the Rathbun Lake Watershed. Abundances of species that are common in rowcrop fields (e.g., horned lark, killdeer), however, could decrease by more than 25% in the watershed.

The harvest of biomass fields occurs in the fall and winter and did not have direct effects on reproductive success of grassland birds. Other grasslands (e.g., hayfields) in the region are often disturbed during the breeding season and thus experience low nest success in these habitats. McCoy et al. (1999) calculated that nest success rates in Conservation Reserve Program (CRP) fields in Missouri were sufficient to maintain stable populations. Nest success rates estimated in our study were similar to those of CRP fields in Missouri; thus switchgrass fields would likely support stable populations of grassland birds.

The harvest altered vegetation structure in the fields and thus affected bird abundances in the fields. Bird communities are closely related to the vegetation structure in grassland patches (Wiens 1974, Herkert et al. 1993). Some species prefer shorter, sparser vegetation (e.g., grasshopper sparrow [*Ammodramus savannarum*]), and others prefer tall, dense vegetation (e.g., common yellowthroat [*Geothlypis thricas*]). In switchgrass fields abundances of species that commonly nested in the fields were related to vegetation structure. Grasshopper sparrows preferred total-harvest fields and cut strips of strip-harvest fields, and sedge wrens (*Cistothorus platensis*) and northern harriers (*Circus cyaneus*) preferred the residual vegetation in non-harvest fields and uncut strips. Although strip-harvest fields provide habitats for species that prefer short vegetation and those that prefer tall vegetation, grasshopper sparrow density in cut strips was lower than in total-harvest fields. Grasshopper sparrows are an area sensitive species in that their probability of occurrence and/or density are lower in smaller habitat patches than in larger ones (e.g., Herkert 1994). Thus totally harvesting 60% of the switchgrass fields in southern Iowa each year and not harvesting the remaining fields would allow the harvest of the same amount of biomass as strip harvesting of all fields, while increasing grasshopper sparrow abundance and providing habitat for sedge wrens, and northern harriers.

During winter Song (*Melospiza melodia*) and American Tree (*Spizella arborea*) sparrows used strip-harvest switchgrass fields more than total-harvest fields because strip-harvest fields provided foraging sites in cut strips and protective cover in uncut strips. Ring-necked Pheasants (*Phasianus colchicus*), however, feed mostly in rowcrop fields (Bogenschutz et al. 1995) and only used non-harvested areas of switchgrass fields for protective cover. Thus strip harvesting biomass fields would be more beneficial to birds during winter than totally harvesting fields.

In conclusion, switchgrass fields grown for biomass provide habitat for grassland birds, and replacing rowcrop fields with biomass fields would benefit some bird species of management concern in the Dissected Till Plains. Strip-harvest fields will provide habitat for more species of concern than total-harvest fields, but grasshopper sparrows are more abundant in the latter. In the winter sparrow species were more abundant in strip-harvest fields than total-harvest fields, and pheasants used the uncut strips of strip-harvest fields for protective cover. Detailed and long-term studies should monitor bird use of switchgrass fields as biomass production continues and evolves.

Recommendations for future research

Future research should examine the effects of long-term management on bird use of biomass fields, particularly if biomass switchgrass production is continued or increased. In particular, grasshopper sparrow response to fertilization should be studied because the effects of annual fertilization may negate the benefits of biomass fields for these birds. Landscape-level effects on bird abundance also should be studied because abundances of some species are related to the amount of different habitats in the surrounding landscape (O'Connor et al. 1999, Ribic and Sample 2001). Northern harriers have a larger home range than most other species that use switchgrass fields (MacWhirter and Bildstein 1996), and a better understanding of how harriers use agricultural landscapes would guide land managers in determining where non-harvest switchgrass patches should be located to maximize benefits to harrier populations.

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