Breeding Bird Communities of Midwestern Prairie Fragments: The Effects of Prescribed and Habitat-area
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ABSTRACT: The effects of spring burning and habitat-area on breeding bird communities were studied on 11 Illinois prairie fragments between 1987 and 1990. Comparisons of bird distribution and abundance patterns within prairie fragments showed three species, the Henslow's sparrow, bobolink, and grasshopper sparrow, to be most influenced by prescribed burning. Henslow's sparrows completely avoided prairie areas that had been recently burned, whereas bobolinks and grasshopper sparrows tended to be more common on recently burned prairie areas. A comparison of the relative importance of habitat-area and prescribed burning showed that habitat-area had a much greater influence on breeding bird community composition than prescribed burning. Ten of the 15 most common species examined were significantly influenced by habitat-area. An ordination of bird communities from the different prescribed burn categories showed that bird communities on small prairie fragments were, in general, more similar to one another than they were to bird communities on large prairie fragments, regardless of the current management status of the prairies. I suggest that optimal management strategies for small and large prairie fragments need not be the same. Small prairie fragments can be burned with little regard to breeding birds because the occurrence of their characteristic bird species is not significantly influenced by prescribed burning. In contrast, large prairie fragments must be managed to provide a mosaic of burned and unburned areas to ensure the availability of suitable habitat for management-sensitive bird species, species that in the Midwest are experiencing significant population declines and are predominately restricted to large grassland areas.

INTRODUCTION

Tallgrass prairie was formerly the dominant habitat throughout much of the Midwest, occupying over 31 million ha in Illinois, Indiana, Iowa, Michigan, Minnesota, and Wisconsin prior to European settlement (The Nature Conservancy, unpubl. data). Historically, prairie fires occurred frequently and were essential for the maintenance of this ecosystem (Anderson 1970, Bragg 1982). In the absence of fire, prairie vegetative productivity declines and extensive invasion of forbs and woody plant species occurs (Risser et al. 1981, Hulbert 1986). Woody encroachment can occur rapidly, especially on small prairie patches (Anderson 1970). As a result, managers now widely recognize the importance of regular management in maintaining prairie areas. Yet despite the common use of prescribed fire as a modern management technique, its effect on breeding bird communities has been infrequently studied (Skinner 1975, Risser et al. 1981).

Regular management of prairie areas is important for habitat maintenance, and it appears to be important for bird species management as well. Undisturbed grasslands generally support few bird species and individuals (Skinner 1975, Westemeier and Buhnerkempe 1983). Furthermore, regular burning also may enhance breeding bird nesting success (Johnson and Temple 1990). Removal of dead plant material by burning significantly increases aboveground plant biomass (e.g., Knapp and Seastedt 1986, Hulbert 1988). This increase in plant biomass may provide greater concealment for bird nests, thereby decreasing nest predation rates (see Johnson and Temple 1990, and Mankin and Warner 1992). Burned prairie can also contain higher insect densities than unburned prairie (Evans 1988), which also may enhance breeding bird populations by increasing the amount of food available for nestlings.

Populations of many prairie bird species have undergone significant declines over the last 25 years (Robbins et al. 1986, Herkert 1991a). The magnitude of these declines — some by 15% or more per year in some Midwestern states (e.g., Sample 1989, Droege 1991) — points to the need for more specific information regarding the response of these birds to commonly employed management techniques so that effective conservation strategies can be developed and implemented.

Previous studies of the effects of prescribed fire on birds have been conducted in shrub-steppe (Bock and Bock 1987), sagebrush (Peterson and Best 1987), mixed grasslands (Tester and Marshall 1961, Westemeier and Buhnerkempe 1983, Schramm et al. 1986), and central tall-grass prairie (Zimmerman 1992). Population densities of several bird species have been shown to decline immediately following burning (Tester and Marshall 1961, Westemeier and Buhnerkempe 1983, Bock and Bock 1987, Peterson and Best 1987, Zimmerman 1992). In the two to three years following burning, however, densities of some bird species may be higher than those in unburned areas (Westemeier and Buhnerkempe 1983, Peterson and Best 1987).

Because grassland bird communities are significantly influenced by habitat size (Samson 1980, Herkert 1991b), bird community response to prescribed burning may not be the same for small and large prairie fragments. Furthermore, owing to the widespread lack of prairie habitat in the Midwest, the conservation of prairie birds may depend heavily on the prudent management of remaining prairie areas. Therefore, there is a need for a better understanding of how breeding bird communities respond to prescribed burning so that remaining prairie areas can be managed most effectively for the conservation of breeding birds. This paper documents breeding bird response to prescribed prairie burning and compares the relative importance of prescribed burning and habitat-area on breeding bird communities of Midwestern prairie fragments.

STUDY AREAS AND FIELD METHODS

Breeding bird communities associated with 11 native and restored prairie fragments located in northeastern and east-central Illinois were studied between 1987 and 1990 (Table 1). Dominant grass species from the study areas included big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), panic grass (*Panicum* spp.), cord grass (*Spartina pectinata*), prairie dropseed (*Sporobolus heterolepis*), and upland sedges (*Carex* spp.). Plant species nomenclature follows Mohlenbrock (1986).

Only birds that potentially breed in grassland habitat in Illinois (Graber and Graber 1963, Bohlen 1989) were included in the analyses. Bird censusing was conducted using 4.5-ha (300-m by 150-m) strip transects (Emlen 1977, Conner and Dickson 1980). The number of strip censuses per prairie ranged from one to six and was proportional to prairie fragment size. Each bird transect was censused three to four times between May 15 and June 30, between 0600 and 1000 hours in each year. The average number of territorial (singing) males encountered from each census transect was used for all analyses. Prior to analyses, bird counts were standardized to the average number of territorial males encountered/100 ha.

Each year at 40 randomly located sites within each bird census transect, vegetation structure was sampled by passing a 0.6-cm diameter metal rod through the vegetation and counting the number of contacts by different vegetation types (live grasses, live forbs, and dead plant material) in successive 25-cm intervals of height (see Rotenberry and Wiens 1980). Measurements of litter depth, grass and forb height, and the number of woody stems within 1 m of the sampling point were also obtained at each of the 40 random sampling sites. Eight vegetation variables were collected from each bird census transect: mean litter depth (LD), mean grass height (GHT), mean vegetation height (VGHT), mean number of live grass contacts (HTSGR), mean number of live forb contacts (HTSFB), mean number of total (live grass, live forb, dead plant material) contacts (TOTHT), percentage of total contacts represented by live vegetation (PCTLV), and woody stem density (SHRUB). Measurements of vegetation structure were collected each year between May 10 and 25, with sampling beginning in the southernmost sites and progressing northward.

The effects of prescribed burning on bird communities were assessed by two analyses. The first analysis consisted of a comparison of bird relative abundance within census transects from different burn categories on the largest prairie study area (650 ha) using repeated measures analysis of variance (Neter et al. 1985). The three burn categories were the first, second, and third or more growing season since last burning. The experimental design for the large prairie analyses eliminated the influence of habitat-area (because all census routes were from the same fragment) and route-to-route variability (because all census routes received all three burn treatments) on the comparison of bird species composition and abundance among burn categories. The second analysis consisted of a comparison of the relative importance of prescribed burning and habitat-area on bird communities by comparing the relative abundance of birds within census transects from all 11 prairie fragments using analysis of covariance (Neter et al. 1985). The dependent variables in the anal-

Table 1. Prairie study sites.

Name	Size (ha)	County	Prairie Type
Loda Prairie	0.4	Iroquois	native
Prospect Prairie	2.0	Ford	native
Phillips Prairie	4.0	Champaign	restored
Trelease Prairie	8.0	Champaign	restored
Allerton Prairie	20.2	Piatt	restored
Grant Creek Prairie	31.6	Will	native
Geensburg-Markham Prairie	38.5	Cook	native
Lockport Prairie	100.8	Will	native
Romeoville Prairie	108.0	Will	native
Iroquois Conservation Area	121.0	Iroquois	native
Goose Lake Prairie	650.0	Grundy	native

ysis of covariance models were the relative abundance for each species within each specific transect. Relative abundances were obtained by averaging the number of males encountered in each visit to a specific transect. Independent variables in the models were burn status (first, second, or third or more growing season since last burning) and prairie area. Because of the relatively small sample sizes in the analysis of covariance analyses, a significance level of 0.15 was employed.

The effects of prescribed burning on vegetation structure within census transects also were assessed, using multivariate analysis of variance (Neter et al. 1985). All burns were conducted during March or April.

A comparison of bird communities among burn units was performed by ordinating bird species composition within transects using principal component analysis (Harris 1985). Ninety-five percent confidence ellipses for species relative abundances within bird communities on the first two principal component axes were computed for each burn category within large (>100 ha) and small (<100 ha) prairie fragments separately, using the principal axis technique (Sokal and Rohlf 1981:596).

RESULTS

Fifteen species of grassland birds were encountered during the study (Table 2). The red-winged blackbird (*Agelaius phoeniceus*) was the most widespread species, occurring on all census transects. Other commonly encountered (>40% of census transects) species included the eastern meadowlark (*Sturnella magna*), common yellowthroat (*Geothlypis trichas*), field sparrow (*Spizella pusilla*), grasshopper sparrow (*Ammodramus savannarum*), and song sparrow (*Melospiza melodia*). The brown-headed cowbird (*Molothrus ater*), a nest-parasite of grassland birds, was rarely encountered (<10% of census transects) and was not included in any of the analyses.

On the large prairie study area, three bird species were consistently absent from one of the three burn categories (Table 3). The Henslow's sparrow (*Ammodramus henslowii*) and sedge wren (*Cistothorus platensis*) were never encountered on transects located in recently burned sections (first growing season) of the large prairie, and the savannah sparrow (*Passerculus sandwichensis*) was never encountered on transects located in prairie areas that had not been recently burned (third or more growing season postfire). The repeated measures analyses of variance of bird relative abundance within the large prairie area showed that prescribed burning significantly influenced relative abundances for two species, the Henslow's sparrow and bobolink (*Dolichonyx oryzivorus*). The Henslow's sparrow exhibited a significant preference for unburned areas. Henslow's sparrows had an average relative abundance on areas in their second growing

Table 2. Number of transects of occurrence, F-value for test of significance of area effects from the multiple regression analyses, and population marginal means for breeding bird species encountered within 11 prairie fragments in Illinois. Population marginal means are the expected bird relative abundances (males/100 ha) within the three prescribed burn categories on a prairie of average size (98 ha). The sign of significant area coefficients is shown in parentheses.

Species	No. of Transects (N=42)	Area (F)	Population Mean Burn1	Population Mean Burn2	Population Mean Burn3
upland sandpiper	3	2.78 (+)*	0.1	0.2	0.0
vesper sparrow	3	1.51	0.2	0.0	0.1
ring-necked pheasant	6	1.88	0.1	0.6	0.1
grasshopper sparrow	18	23.00 (+)***	4.2*	3.2*	2.1
Henslow's sparrow	12	29.33 (+)***	0.0***	1.8***	2.2***
field sparrow	23	4.76 (-)**	1.5	5.0	13.1
sedge wren	5	4.91 (+)**	0.0	0.6	0.8
red-winged blackbird	42	12.29 (-)***	33.6	46.2	31.0
eastern meadowlark	33	5.79 (+)**	10.6	15.7	12.8
common yellowthroat	27	2.14	3.8	5.0	11.4
bobolink	15	17.60 (+)***	1.3	0.6	0.5
savannah sparrow	6	3.53 (+)*	0.9	0.3	0.1
song sparrow	17	0.27	6.3	2.6	4.0
dickcissel	6	4.60 (-)**	5.0	5.9	3.4
northern bobwhite	2	0.02	0.3	0.0	0.0

* $p<0.15$, ** $p<0.05$, *** $p<0.001$

Table 3. Average relative abundance (males/100 ha) and standard errors for breeding birds from the large (650 ha) prairie site. Asterisks represent significant differences among means based on the repeated measures ANOVA analyses (*p<0.05, **=p<0.01).

Species	No. of Transects (N=18)	Average Relative Abundance					
		Burn1		Burn2		Burn3	
sedge wren	4	0.0		12.3	(10.9)	7.4	(4.7)
common yellowthroat	10	8.6	(4.0)	4.9	(3.1)	13.5	(5.2)
bobolink	10	14.8*	(5.7)	4.9*	(1.5)	3.7*	(2.5)
eastern meadowlark	17	27.1	(4.9)	19.7	(3.1)	25.9	(6.2)
red-winged blackbird	16	24.6	(7.0)	23.4	(1.2)	20.9	(10.0)
dickcissel	4	7.4	(7.4)	4.9	(3.6)	2.4	(2.4)
savannah sparrow	4	9.8	(7.0)	2.5	(2.5)	0.0	
grasshopper sparrow	13	24.7	(4.9)	23.4	(7.7)	13.5	(9.4)
Henslow's sparrow	12	0.0**		11.1**	(3.7)	28.3**	(4.8)
field sparrow	9	3.7	(2.5)	4.9	(3.6)	8.6	(4.4)
song sparrow	7	8.6	(3.5)	1.2	(1.2)	7.4	(4.6)

season postfire that was less than half their average relative abundance on areas that were in their third or more growing season postfire. The bobolink showed an opposite pattern from the Henslow's sparrow, exhibiting a significant preference for recently burned areas (Table 3). Of the 11 species examined, 7 (64%) recorded their highest relative abundance on areas in their first growing season postfire; only the field sparrow (*Spizella pusilla*), common yellowthroat, sedge wren, and Henslow's sparrow recorded their highest relative abundance on areas other than the most recently burned sections of these prairie fragments (Table 3).

The comparison of the relative importance of prescribed burning and habitat-area showed that habitat-area had a much greater influence on bird species composition within transects than did prescribed burning (Table 2). Habitat-area significantly influenced the relative abundance for 10 of the 15 species examined. Habitat-area was positively associated with the relative abundance of upland sandpipers (*Bartramia longicauda*), grasshopper sparrows, Henslow's sparrows, sedge wrens, eastern meadowlarks, bobolinks, and savannah sparrows (Table 2). Habitat-area was negatively associated with the relative abundance of field sparrows, red-winged blackbirds, and dickcissels (*Spiza americana*).

Only two species showed a statistically detectable ($p<.15$) response to prescribed burning when habitat-area and burning were analyzed simultaneously. Henslow's sparrows always avoided recently burned prairie areas and reached their highest average relative abundance in transects located in prairie areas that were in their third or greater growing season since last burning (Table 2). The grasshopper sparrow showed an opposite response, with a strong tendency ($.05 < p < .15$) to be more abundant in recently burned areas (Table 2). Several other bird species exhibited statistically nonsignificant but probably biologically relevant responses to prescribed burning, including the sedge wren, which avoided recently burned areas, and the bobolink and savannah sparrow, which tended to be more common in recently burned areas (Table 2). Besides the Henslow's and grasshopper sparrows, five other species exhibited a consistent pattern of sequential increase (savannah sparrow, bobolink) or sequential decrease (sedge wren, field sparrow, common yellowthroat) across the three burn categories (Table 2), although none of these trends were statistically significant. In addition, the average relative abundance for all five of these species was either increased or decreased by more than 50% across the three burn categories (Table 2).

Prescribed burning also was found to have a significant (MANOVA; $F=4.0$; $df=16,54$; $p<.001$) overall effect on vegetation structure within bird census transects. Follow-up one-way analyses of variance showed that this overall difference was primarily the result of differences in litter depth, vegetation density, and percent cover by live vegetation among prescribed burning units (Table 4).

In the bird community ordination the first two bird community principal components accounted for about 37% of the variation in bird species composition among transects within fragments. The first principal component accounted for 22% of the variation in bird species distribution and abundance among transects, and separated bird species based primarily on their response to differences in habitat-area. Species with significant positive loadings on the first principal component, such as bobolinks, Henslow's sparrows, grasshopper sparrows, eastern meadowlarks, and savannah sparrows are all species that are sensitive to reductions in habitat-area (Samson 1980, Herkert 1991b). Species with significant negative loadings on the first principal component, such as red-winged blackbirds and

Table 4. Comparison of vegetation attributes among management categories. Asterisks represent significant differences among means based on follow-up one-way ANOVA (*p<0.05, **p<0.01, ***p<0.001).

Variable	Burn1	(SE)	Burn2	(SE)	Burn3	(SE)
mean litter depth (cm)	1.2*	0.3	3.4*	1.0	3.1*	0.7
mean grass height (cm)	25.3	4.1	27.0	2.4	25.2	1.4
mean vegetation height (cm)	45.4	7.0	70.4	12.4	70.8	10.3
mean no. contacts-all vegetation	2.9***	0.4	5.5***	0.6	5.8***	0.7
mean no. contacts-grasses	1.8	0.3	1.5	0.2	2.1	0.3
mean no. contacts-forbs	0.7	0.1	0.4	0.1	0.5	0.1
woody stem density (m^2)	2.0	0.8	1.9	0.8	4.2	1.2
contacts-live vegetation (%)	86.0***	3.6	35.6***	5.6	49.7***	9.2

field sparrows, are species that tend to be more common on small prairie fragments (Herkert 1991b). The second principal component, which accounted for 15% of the variation in species distribution and abundance within transects, appears to represent a gradient of individual species response to habitat structure. Species that were more abundant in recently burned areas (e.g., grasshopper sparrow, savannah sparrow) were positively associated with the second principal component, and species that were most common on unburned transects (e.g., Henslow's sparrow, sedge wren, field sparrow) were negatively associated with the second principal component.

The bird species ordination showed that bird communities on small prairie fragments were, in general, more similar to one another than they were to bird communities on large prairie fragments regardless of their burn status (Figure 1). Moreover, bird species communities within transects on the large prairie site were more similar to one another than they were to transects on the small prairie fragments (Figure 1). There was very little overlap among confidence ellipses for small and large prairie fragments (Figure 1).

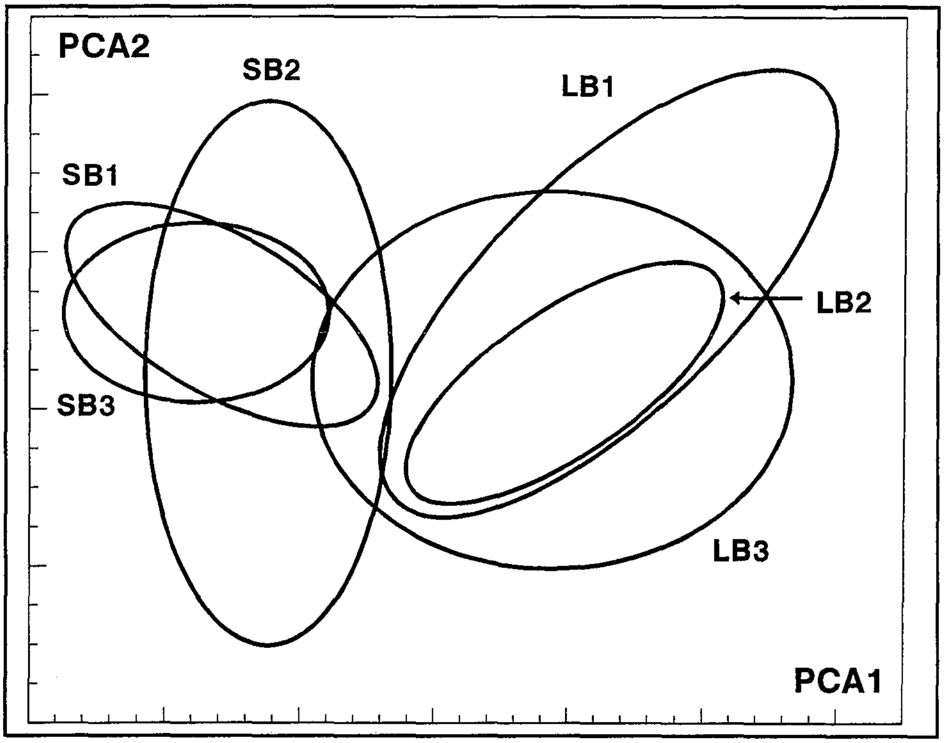

Figure 1. Ninety-five percent confidence ellipses for bird communities within management units on principal components 1 and 2. LB1 = large prairie burn1, LB2 = large prairie burn2, LB3 = large prairie burn3, SB1 = small prairie burn1, SB2 = small prairie burn2, SB3 = small prairie burn3.

DISCUSSION

The results from this study show that habitat-area influences grassland bird distribution and abundance patterns within prairie fragments more than prescribed burning. Ten of the 15 (67%) species examined were significantly influenced by habitat-area, whereas only two species (12%) showed statistically detectable differences in relative abundance among burn units when these two factors were considered jointly. Both burn-sensitive species, however, were also significantly influenced by habitat-area (Table 2). These results show that the preservation of relatively large prairie areas is essential for the conservation of Midwestern prairie bird populations. This is especially true because many of the prairie birds that are experiencing the largest population declines (e.g., bobolink, eastern meadowlark, grasshopper sparrow, savannah sparrow, Henslow's sparrow; Herkert 1991a) are typically restricted to large prairie fragments in the Midwest (Table 2).

Prescribed burning, however, also significantly influences breeding bird populations. Henslow's sparrows were always absent from recently burned prairie areas and were over 2.5 times more numerous in areas in their third or more growing season postfire than they were in areas in their second growing season postfire (Table 3). This result is consistent with other research that has shown this species prefers relatively undisturbed, dense vegetation with a well-developed litter layer and a high density of standing dead vegetation (e.g., Skinner et al. 1984, Zimmerman 1988, Sample 1989). Spring burning reduces the litter and standing dead vegetation this species requires (see Table 4) and apparently precludes its establishment on recently burned areas when it returns from migration in the spring.

Grasshopper sparrows (Table 2) and bobolinks (Table 3), on the other hand, showed a tendency to be more numerous in prairie areas that had been recently burned. Other characteristic prairie bird species, such as the savannah sparrow, although not exhibiting a statistically detectable difference in relative abundance among burn units, showed a tendency to be more common on recently burned sections of these prairie fragments. The tendency for these species to be more abundant on recently burned prairie areas was consistent with other studies that have characterized them as preferring low- to medium-height vegetation (Smith 1963, Wiens 1969, Skinner et al. 1984, Sample 1989, Herkert 1991b), and as somewhat common in managed grasslands (Renken 1983, Skinner et al. 1984, Renken and Dinsmore 1987). These birds' slight preference for recently burned prairie areas, coupled with a possible increase in nesting success in these areas (see Johnson and Temple 1990), demonstrate the importance of prescribed burning in maintaining productive areas for these prairie bird species.

Several bird species examined exhibited no statistically detectable relationship between their abundance and either prescribed burning or habitat-area (Table 2). Analyses of habitat associations for these species from a more inclusive set of native and non-native grassland fragments in Illinois (Herkert 1991b) showed that these species respond to aspects of vegetation structure that were not significantly influenced by burning in this study. For example, common yellowthroat abundance was correlated with vegetation height, whereas song sparrow abundance was correlated with forb and shrub abundance (Herkert 1991b).

Weather, especially rainfall patterns, can also significantly influence grassland bird abundance and nest success within prairie areas (Cody 1985, George et al. 1992, Zimmerman 1992). Breeding grassland bird densities and nest success are generally lowered by severe drought, although this reduction may be short-term if weather conditions return to normal in succeeding years (George et al. 1992). However, drought does not affect all grassland bird species equally. Some grassland bird species are strongly affected by drought, whereas others show very little change in abundance during drought conditions (George et al. 1992). Also, prescribed burning in unusually dry years may influence breeding birds more strongly than in average or wet years (Zimmerman 1992). The data analyzed here included two especially dry years (Illinois January–June rainfall in the study regions was –26% in 1987 and –38% in 1988) and one unusually wet year (1990 Illinois January–June rainfall in the study regions was +20%) and therefore should reflect grassland bird responses to prescribed burning over a wide range of rainfall patterns. However, managers should monitor bird response to prescribed burning during prolonged periods of dry or wet weather and modify management activities as needed.

The bird community ordination (Figure 1) showed that bird species composition on transects in small prairie fragments were, in general, more similar to one another than they were to transects located within the large prairie study site, regardless of their current management status. Bird communities on small prairie fragments differ from those on large prairie fragments because they lack several prairie bird species that are restricted to large prairie fragments (Herkert 1991b). These data suggest that management strategies for small and large prairie fragments need not necessarily be the same. Bird communities on small prairie fragments are dominated by species that are influenced very little by prescribed burning, such as red-winged blackbirds, eastern meadowlarks, and dickcissels (Tables 2 and 3). Therefore small prairie management need not specifically address the needs of breeding birds, since the occurrence of their characteristic bird species is not significantly influenced by prescribed burning.

Management of large prairie fragments, on the other hand, is more complex because large prairie fragments do routinely possess burn-sensitive bird species. The management of large areas is further complicated because these burn-sensitive bird species occupy opposite ends of the management spectrum. Henslow's sparrows and, to a lesser extent, sedge wrens, are restricted to unburned prairie areas, whereas several other characteristic prairie birds, such as grasshopper sparrows, bobolinks, and probably also savannah sparrows and upland sandpipers, tend to be more abundant in recently burned prairie areas. I concur with Renken and Dinsmore (1987) in recommending that managers pay special attention to the habitat requirements of management-sensitive species by providing a mosaic of habitat types. This result could be accomplished by a rotational system of burning in which sections of large prairie areas are burned (or possibly mowed or grazed) on a regular rotating schedule as has been suggested for the Henslow's sparrow in Kansas (Zimmerman 1988). This type of rotational system would provide a variety of habitats in every year and would ensure the availability of suitable habitat for birds at either end of the management spectrum, as well as provide habitat for those species whose preferences lie between these extremes. Unfortunately, just how large or small these prescribed burning subunits should be is not clear. Based on incidental observations in Kansas, Zimmerman (1988) has suggested that these units be at least 30 ha, but this subject deserves more detailed research attention so that mangers can design programs that can be most effective. A good general guideline would be to conduct prescribed burns on large prairie fragments (>80 ha) in a rotation of 20–30% of the area annually. On small, isolated prairie fragments, burn compartments may consist of a larger percentage of the total area but probably should not exceed 50–60% of the area, especially if burn-sensitive bird species are present. In areas where several small prairie fragments are in close proximity, prescribed burning should be directed toward providing both recently burned and unburned areas by coordinating burns among separate units on a rotational schedule, as has been suggested by Ryan (1990).

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