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Abstract

The relative abundance of grassland birds was estimated on an 81-ha (200-acre) dry to dry-mesic sand prairie in southwest Wisconsin over an 18-year period (1987–2004). Birds were surveyed three times during the breeding season on seven, 2-ha (5-acre) strip transects in six different burn units. We compared results to time since fire and other habitat features. The average rotation of prescribed fires in the burn units ranged from three to six years. Seven species were selected for detailed analysis. These were grasshopper sparrows (*Ammodramus savannarum*)—18-year average of 1.33 birds per ha, field sparrows (*Spizella pusilla*) at 0.64 birds/ha, eastern meadowlarks (*Sturnella magna*) at 0.54 birds/ha, lark sparrows (*Chondestes grammicus*) at 0.50 birds/ha, mourning doves (*Zenaida macroura*) at 0.18 birds/ha, dickcissels (*Spiza americana*) at 0.17 birds/ha, and vesper sparrows (*Pooecetes gramineus*) at 0.07 birds/ha. Observed bird densities by burn year indicated the year of burning to be unique in relation to other years in the burn cycle. Mourning doves and vesper and lark sparrows were detected in greater densities in the year of a burn compared to the years pre- or post-burn. In contrast, grasshopper sparrows, eastern meadowlarks, field sparrows, and dickcissels were observed at lower densities during the year of a burn than in the pre- or post-burn years, but they were never eliminated. For some species, such as lark, field and vesper sparrows, the removal of woody vegetation during the early years of the study period may have affected abundance. With the exception of vesper sparrows, overall management actions at Spring Green Preserve, including the prescribed burning regimen, appear to allow its grassland bird populations to be maintained.

Keywords: birds, prescribed burning, natural area management, grasshopper sparrow, lark sparrow, field sparrow, vesper sparrow, eastern meadowlark, mourning dove, dickcissel

Restoring and maintaining prairie remnants and the wildlife that inhabit them by the judicious use of prescribed fire has a long history of effective use in grassland management, beginning with Native Americans, who played a significant role historically in maintaining open prairie in Wisconsin (Curtis 1959), and continuing through the early use of prescribed burning for management of grassland wildlife, birds in particular (Leopold 1933, Grange 1948, Stoddard 1963). Managing prairies and other grasslands with prescribed fire has continued to increase in popularity in recent years. Prudent stewardship requires us to monitor its effects on the species we aim to foster, which increasingly include non-game species. Accordingly, numerous studies have reported on the impacts of fire on grassland birds (e.g., Johnson and Temple 1986, Vickery 1993, Herkert 1994 and 1999, Swengel 1996, Johnson 1997).

Since species have been found to respond differently to prescribed fire in different parts of their ranges (e.g., Hull 2000), local or regional knowledge is most relevant in informing our management decisions. Perhaps the longest ongoing attempt to monitor bird response to fire in Wisconsin is this 18-year project ongoing at Spring Green Preserve.

The grassland bird community at The Nature Conservancy's (TNC) Spring Green Preserve has been systematically surveyed, in all years but one, since 1987. This work is administered through the Wisconsin State Natural Areas Breeding Bird Survey and the Wisconsin Department of Natural Resources (WDNR) Bureau of Integrated Science Services. Here we relate what this 18-year monitoring effort has revealed about how several grassland bird species respond to burn management.

Study Site

Spring Green Prairie lies on a terrace of the Wisconsin River, close to the southern edge of Sauk County, Wisconsin. The Nature Conservancy made its initial purchase there in 1971. The site now includes about 201 hectares (500 acres), 105 hectares (260 acres) of which are designated as a State Natural Area. It is a remnant of what was once a 5,242-ha (13,000-acre) area known as the "Wisconsin Desert," which was composed of xeric habitats of dry sand and bluff prairie and barrens formed out of the sands originating from glacial

outwash. The preserve includes what is considered the best remnant of sand prairie in the state and, unlike many smaller parcels of this type, most of the plant and animal communities are largely intact and functioning. Spring Green is home to exceptional biological diversity, holding many rare and threatened species in addition to the birds of focus here.

After a long history of land use changes, including extensive pasturing and crop production in some locations, the preserve has been and continues to be managed to restore the land to its pre-settlement condition, mostly by tree removal (largely from 1985 through 1991) and burning. The property has been divided into 12 burn management units, which are generally burned every three to six years on a rotational basis. Typically, only one to a few units are burned each year (although in some years none is burned), ensuring a habitat mosaic.

The open habitats at Spring Green Prairie and the distribution of the seven bird transects we used within them can be described as follows. When woody cover is mentioned in these descriptions, it typically refers to scattered, low [less than 2-m (6.6-ft) tall] shrubs and saplings, including some oaks (*Quercus* spp.) and red cedars (*Juniperus virginiana*) up to 5 m (16.4 feet), and smooth sumac (*Rhus glabra*). Overall, woody canopy cover is usually less than five percent. While most major woody vegetation was removed prior to 1991, some remains.

Dry prairie was the dominant habitat for two transects, and could be characterized as having considerable bare soil, relatively sparse vegetation of low stature, and little woody structure. Dry sand prairie and barrens were the dominant habitat for one transect, characterized as having vegetation structure similar to dry prairie, but with even more open ground cover and with the added presence of open sand blows, scattered woody cover, and reduced plant diversity due to past agricultural uses. Dry-mesic prairie was the dominant habitat for one transect lying at the base of a dolomite-capped, south-facing bluff, characterized by a more diverse vegetation structure and plant species community than the dry prairie, including some woody species (primarily smooth sumac), and a recent history of grazing and cedar invasion. Finally, oldfield was the dominant habitat for three transects. Oldfields were characterized by better soils than the prairies and barrens, a recent history in row crops and current domination by a variety of non-native, cool season grasses (primarily quackgrass, *Elytrigia repens*), taller and more uniform vegetation than the other habitats, and little open ground or woody vegetation. Each of these seven bird survey transects was contained within its own burn unit except for the dry-mesic and one of the dry prairie transects, which were both within the same burn unit. Nearest point distances between transect perimeters were typically on the order of 100 meters [range from 90 to 500 meters (295 to 1,640 feet)].

Methods

Bird Surveys

Bird monitoring took place on seven 100 x 200 meter [2-ha (5-acre)] strip transects arrayed to include all of the grassland and open habitats except for the steep slopes of the bluff prairies. Surveyors were Dave Sample and Randy Hoffman from 1987 to 1989 and in 1991, and Greg Geller from 1992 to 2004. No survey was conducted in 1990. We walked midline of the transect stopping several times (Hoffman and Sample–5, Geller–4) and recorded all birds seen or heard within transect boundaries. The survey time period ranged from 28 May to 3 July, with three replicates completed each field season. Surveys were conducted between 5:30 a.m. and 10:00 a.m. and were restricted to conditions of 0 to 19 km/h (0 to12 mi/h) wind speeds (Beaufort Scale 0–3) with no more than light drizzle or fog being present.

Data Analysis

For any given species, transect and year, the bird count used in our analyses was the highest value obtained during the course of that year's three survey replicates. We calculated an index to density for each species based on mean count values divided by transect area. To apply a uniform standard, we derived these density figures by computing the mean counts from all transects in which the species occurred at least once across the whole timeline of the study. In the case of a species only rarely occurring in a particular transect, many zero counts may significantly lower the derived density value. For omparative purposes, we also report mean densities for habitats.

To assess bird response to prescribed burning, we derived overall mean densities for each species by burn year and compared these values to each other. (Due to concerns of possible confounding, we have not included data from the two transects with the most woody cover for the period of 1987 through 1991 in our analysis of bird response to prescribed burning because those transects were undergoing considerable tree removal management during that time.) To facilitate interpretation, we use charts to depict how each species responded numerically to burn management, with the year of burning called BY 0. Fall burns, though rare, are counted as if they occurred in the following year. The trends that have emerged represent the average response of a species during the course of the entire study in all transects in which it occurred. We generally found good agreement in species' density trends to burn year between cycles. However, the responses in an individual transect or burn cycle may not always mirror the overall trend presented in the figures.

The reliability of bird field survey data is subject to confounding factors and various sources of error and bias. Among others, these include the level of the surveyor's bird detection and identification skills, ability to estimate distances to transect boundaries, ability to discriminate juvenile from adult birds at a distance, and efforts and methods to avoid double counting individual birds. Also, since grassland birds are often concealed by ground-level vegetation, the effects of burning on reducing this cover will facilitate the detection of all birds, especially non-singing individuals, in the year of burning relative to following years in the burn cycle. Theoretically, this effect has the potential to reduce the

apparent magnitude of burning impacts for those species preferring more dense vegetation and litter layers (since more undetected birds may actually be present later in the burn cycle) and enhance apparent burning effects for those species preferring sparse vegetation. However, because most of the vegetation at Spring Green Prairie is short and sparse, problems with detectability are minimal compared to tall and dense grassland habitats. By virtue of a consistent technique applied over a long timeline, overall burn response trends emerge for each species.

Since this is an observational study and was not designed to specifically test hypotheses about bird response to fire, and since independence of observations for transects cannot be assumed (because both temporal and spatial correlation of transects are likely), our data are difficult to analyze using standard statistical procedures. There are additional difficulties associated with accurately accounting for differences between short- and long-term effects of burning, and with confounding between environmental factors and time since burning, that argue for a simple approach to examining our study data. We have, however, included standard error bars in the burn year charts to give an estimate of the variability about each data point and to indicate standards for evaluating differences in an exploratory manner. Results are interpreted primarily in terms of their biological significance.

Table 1. All-transect mean densities (birds per hectare) by species (n = no. transect/year combinations) from 1987–2004 transect surveys, Spring Green Preserve, Sauk County, Wisconsin

	Mean Density (n)	Std. Error
Grasshopper sparrow	1.33 (118)	0.0881
Field sparrow	0.64 (118)	0.0586
Eastern meadowlark	0.54 (118)	0.0420
Lark sparrow	0.50 (118)	0.0561
Mourning dove	0.18 (118)	0.0342
Dickcissel	0.18 (110)	0.0555
Savannah sparrow	0.08 (68)	0.0249
Vesper sparrow	0.07 (118)	0.0194
Western meadowlark	0.03 (101)	0.0184
Bobolink	0.01 (17)	0.0058
Henslow's sparrow	0.01 (17)	0.0084

Table 2. Mean bird counts per hectare by habitat (sample size) from 1992–2004 transect surveys, Spring Green Preserve, Sauk County, Wisconsin

	Dry-Mesic Prairie	Dry Prairie	Barren	Old Field
Dickcissel	0.46 (12)	0.29 (15)	0.12 (3)	0.12 (9)
Eastern meadowlark	0.00 (0)	0.54 (28)	0.65 (17)	0.78 (61)
Field sparrow	1.85 (48)	0.29 (15)	0.77 (20)	0.44 (34)
Grasshopper sparrow	0.54 (14)	1.54 (30)	1.08 (28)	1.24 (97)
Lark sparrow	0.31 (6)	0.88 (46)	0.88 (23)	0.21 (16)
Mourning dove	0.00 (0)	0.08 (4)	0.77 (20)	0.08 (6)
Vesper sparrow	0.00 (0)	0.04 (2)	0.12 (3)	0.03 (2)

Results and Discussion

Species Frequency

We analyzed survey data for 11 bird species (Table 1) and report response to burn management for seven of these (Figures 1 and 2). These seven include ground-nesting grassland bird species of conservation concern for which we have larger sample sizes plus the commonly ground-nesting mourning dove. Vesper sparrows are included since their response to burn management was instructive, in spite of their low densities.

Grasshopper sparrows occurred most frequently and at the highest average abundance throughout the years of the study, with the next most common species, field and lark sparrows and eastern meadowlarks, at about half their number. These four species dominated the avifauna at Spring Green Preserve (Table 1).

Most species were not at all common on the preserve. This is largely due to the limited range of habitat structure present. Species, such as bobolinks and Henslow's sparrows, that like dense, mesic vegetation rather than the relatively sparse, dry habitats at Spring Green are generally not found on the Preserve.

Preferred Habitats and Response to Prescribed Burning

Grasshopper sparrows

Grasshopper sparrows were found on all seven grassland transects in this study but were most abundant on transects that are characterized as dry prairie habitats, at a mean density of 1.54 birds per hectare (Table 2).

Sample (1989) found grasshopper sparrows in highest densities in Wisconsin in relatively dry habitats with short grass structure, such as native dry prairies and dry pastures. He noted that grasshopper sparrows were somewhat tolerant of woody vegetation, as has also been noted by others (e.g., Smith 1963; Cody 1968; Wiens 1969, 1973a). Many researchers have noted the particular importance of bunchgrasses and partially open ground for this species for foraging (e.g., Smith 1963, Bent 1968, Whitmore 1981).

Observed grasshopper sparrow density was lowest in the year of burning (Figure 1). However, in the first year post-burn and for the rest of the burn series, observed densities equaled or exceeded those pre-burn. The density decline in the year of burning is consistent with this species' affinity for habitats with at least modest grass, particularly bunchgrass, cover and some litter cover for nesting (e.g., Kahl and others 1985, Arnold and Higgins 1986). It is likely that the removal of litter after the most complete burns makes it difficult for this species to construct nests (which also usually include a dome of dead vegetation) (Vickery 1996).

Insect prey-base reduction post-burn has also been claimed as one of the mechanisms

for lower grasshopper sparrow density in the year of burning by Forde and others (1984). However, they presented no data on insect numbers in the year of the burn to support this contention. Grasshopper sparrow diet during the breeding season is made up primarily of Orthoptera (grasshoppers) (Judd 1901 in Smith 1968, Wiens 1973b), and Orthoptera numbers and biomass in the year of a burn are, for the most part, unaffected and sometimes even increase (Rice 1932; Nagel 1973; Evans 1984, 1988; Anderson and others 1989; Boyd and Bidwell 2001; Vermeire et al, 2004). Further, any putative reduction in the insect food base would be perhaps compensated for by the increased detectability of seeds after burn-induced litter removal. Therefore, we find the theory that grasshopper sparrows experience a significantly reduced food supply during the year of the fire unsupported.

The density recovery at one year post-burn in our study possibly reflects this species' use of open spaces amongst the vegetation for foraging.

Many studies have found burning to benefit grasshopper sparrows. And most other studies have reported burn management responses similar to ours with highest densities following within a few years of fire after declines in the year of burning (e.g., Forde and others 1984, Volkert 1992, Vickery 1993). In some studies, researchers have found numbers going down again late in the series (Vickery 1993, Swengel 1996), possibly in response to excessive litter cover build-up and grass height beyond this species' preferences. It may be that we do not see a late series density decline because the dry prairies at Spring Green do not build up a litter and grass component as quickly, if ever.

However, grasshopper sparrows are known to exhibit different responses to burning across their wide range. For instance, densities in southwestern Missouri were not found to be affected by burning, according to Winter (1998).

Lark sparrows

Lark sparrows, mourning doves, and vesper sparrows were detected in highest densities in barrens habitat (Table 2). Although lark sparrows were also commonly found in dry prairie, they were often keying in on barrens features within that habitat—open sand, woody structure. Lark sparrow density in these favored habitats was 0.88 birds per hectare.

Regarded as a habitat specialist (Sample and Mossman 1997), many have noted the strong preference of lark sparrows for disturbed, open habitats, characterized by short vegetation, extensive bare ground (often exposed sand) and small trees or

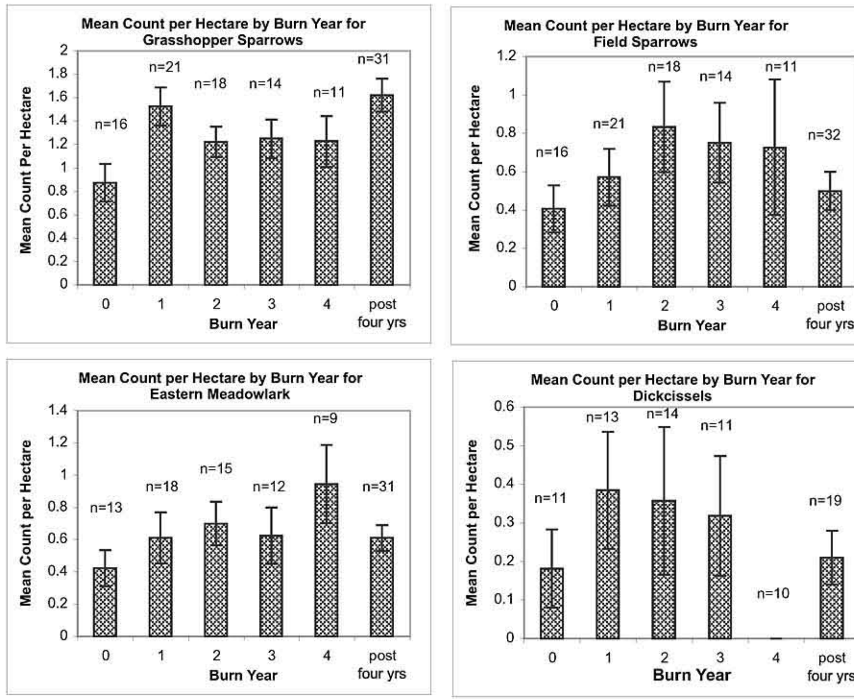

Figure 1. Mean density by burn year for bird species that had fewer individuals in the year of burning.

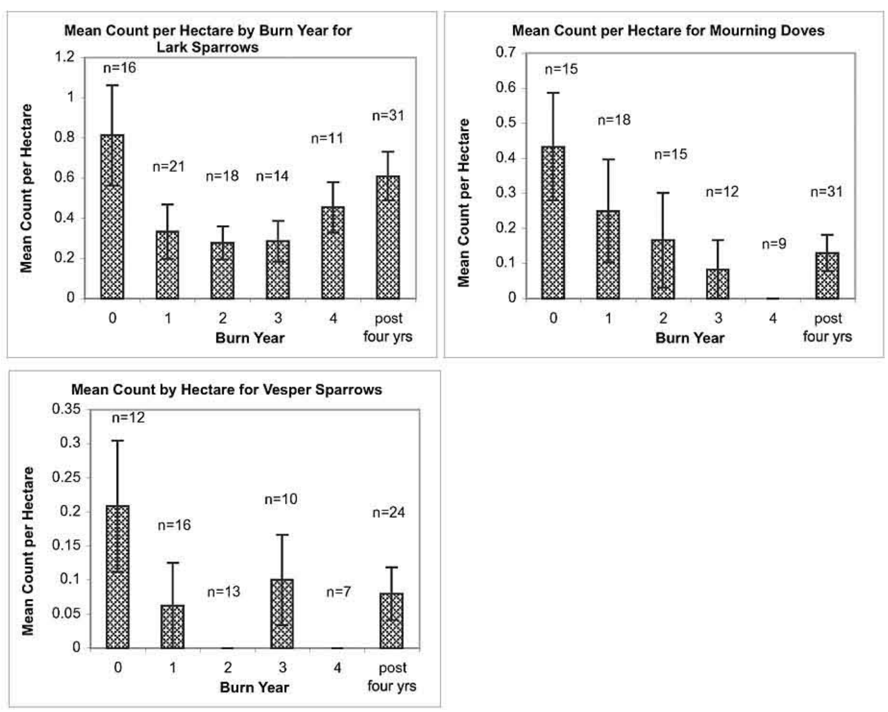

Figure 2. Mean density by burn year for bird species that had more individuals in the burn year.

other structures for singing perches. It is an uncommon bird of localized distribution in Wisconsin, and often occurs in small numbers where found.

Our data for lark sparrows show a strong increase in detected numbers in the year of burning, followed by a decline that persists for a number of years thereafter (Figure 2). Typically, burning has been found in other studies to be beneficial to this species (e.g., Renwald 1977, Kahl and others 1985). Our findings are consistent with this species' known preference for open lands with plenty of bare ground. Furthermore, in contrast to the largely insect prey of the grasshopper sparrow, this bird, and the other two in this trio with highest observed densities in barrens habitat, all utilize seeds to great extents in their diets (Terres 1980), and are likely aided in their foraging by the burning off of the litter.

Mourning doves

Mourning doves, like lark sparrows, were found to frequent the barrens habitat in greatest numbers at Spring Green, at a mean density of 0.77 birds per hectare (Table 2). Similar to lark sparrows, mourning doves were detected in highest densities in the year of burning (Figure 2). Our observed density by burn year trend is in alignment with mourning doves' preferred habitats and food foraging strategies. Mourning doves prefer habitats with some open ground—often edge habitats, such as woodland/grassland ecotones. They use patchy vegetation for foraging and adjacent woody cover for perching and nesting (Sample and Mossman 1997). While mourning doves prefer to nest in trees, especially conifers, they will nest on the ground where trees are lacking (Cooperrider and others 1986, DeGraaf and others 1991). They are ground foragers, finding their food—almost entirely seeds—by visual searches and commonly search newly burned areas (Mason 1981, Tesky 1993). Mourning doves do not scratch in the litter for seeds and are known to avoid areas of dense vegetation while feeding (Landers 1987). It is likely that the apparent declines post-burn in our study reflect an increasing avoidance with vegetation re-growth as the burn series advances.

Vesper sparrows

Vesper sparrows are the remaining species in this group of three that share a preference for the sparsely vegetated barrens habitat at the preserve (Table 2). Vesper sparrows density in barrens habitat was 0.12 birds per hectare. This species has a well-known affinity for open, bare ground with little cover and the presence of woody structure for song perches (e.g., Terres 1980). These sparrows both nest and concentrate their foraging activity in areas with sparse vegetation. Wiens (1969) reported that vesper sparrows occupied the most xeric, sparsely vegetated sites of all the grassland birds he studied in southern Wisconsin. Similarly, Sample (1989) found this species frequenting sites with 4% woody cover and 13% bare ground—finding them positively associated with percent bare ground and negatively associated with vegetation height-density and percent standing residual cover, as have several other researchers (Whitmore 1979, Rodenhouse and Best 1983, Sedgwick 1987, Frawley and Best 1991, Camp and Best 1994).

Vesper sparrows were found in much smaller numbers than either lark sparrows or mourning doves in all the years of these surveys and we would be reluctant to report much here due to these small sample sizes, except that their numerical response to burn management is in line with what we would predict based on our knowledge of the species. Like the other two species showing a preference for barrens habitat, vesper sparrows were detected at highest densities in the year of burning (Figure 2). However, given the low sample sizes for this species, this result should be interpreted with caution.

Our finding of highest vesper sparrows densities in the year of burning was also noted by Herkert (1991) in Illinois. Vickery (1993), working in Maine, also found similar increases in density in the both the year of burning and the next. In Iowa, Camp and Best (1993) found that vesper sparrows were more abundant in burned roadsides than in unburned ones. Our result aligns well with their known habitat preferences and food foraging strategies for this species: an affinity for open, bare ground with little cover, and the utilization of seeds to large extents in their diet.

Overall, vesper sparrows may have declined since the early survey years. While we are not certain, it may be that the early years of tree removal negatively affected them. Vesper sparrows prefer elevated perches, many workers considering them an important, or even necessary, territory component for singing and courtship (Berger 1968, Wiens 1969, Rodenhouse and Best 1983, Sample 1989). While the barrens transect still retains numerous small black oaks (*Quercus vetulina*), vesper sparrows currently appear to be present at only a quarter of their 1987–1991 numbers in barrens habitat [0.50 birds per hectare for period 1987 through 1991 (n=4) compared to 0.12 birds per ha for period 1992 through 2004 (n=13)], with the earlier period coincident with tree removal management. The density figures for vesper sparrows in all habitats parallel these findings [0.26 birds per hectare for period 1987 through 1991 (n=23) and 0.05 birds per hectare for period 1992 through 2004 (n=65)]. Further, comparison of vesper sparrow densities between transects with trees and those largely lacking trees during the period of tree removal management show higher detected densities for this species in the transects with trees [0.36 birds per hectare (n=7) compared to 0.16 birds per hectare (n=16)].

As alternative explanations, there may be a difference in the surveyors' ability to detect vesper sparrows, the prescribed burning intervals may be too long to be optimal for vesper sparrows, some change in the landscape around the Spring Green Preserve may have occurred which we have not measured, or there is a regional decline that is reflected here.

Field sparrows

Field sparrows have a pronounced preference for some woody structure in their habitat, which is also characterized by a sparse to moderate herbaceous and litter cover, usually on dry,

upland sites (Sample and Mossman 1997). Accordingly, they were detected at highest densities—at 1.85 birds per hectare—in the dry-mesic habitat at Spring Green (Table 2). This structurally diverse transect had the highest amount of smooth sumac (around twenty percent canopy cover) of any of the surveyed areas.

Our surveys indicate a reduction in observed field sparrow density in the year of burning followed by increasing counts for the next couple of years and then a general leveling off and possible late-series reduction (Figure 1). This trend is in general agreement with a number of other studies. For instance, in Illinois, field sparrows were found to prefer areas three to four years after burning (Westemeier and Buhnerkempe 1983; Herkert 1991, 1994) but then were absent from year five on. Our data show the same increase in numbers Vickery (1993) found for this species in Maine. However, he found no field sparrows at all in his study area until three years after burning, as did Zimmerman (1997), who attributed this absence to a lack of woody vegetation. We observed a marked reduction in numbers in the year of burning followed by a quick recovery—not the absence found in Vickery's or Zimmerman's work. This may be due to the persistence of woody stems (primarily smooth sumac) at SGP post-burn.

Dickcissels

Dickcissels were the other species found in highest densities in dry-mesic habitats at Spring Green. The surveyors detected them at a mean density of 0.46 birds per hectare in this habitat (Table 2). Other studies have noted this species' preference for moderately tall grasslands with diverse structure (e.g., Sample and Mossman 1997). Sample (1989) found preferred habitat to contain 74% herbaceous cover and found the density of males to be positively related to the volume of herbaceous vegetation, as did Zimmerman (1971).

Our survey data indicate an increase in dickcissel density after burning at Spring Green (Figure 1). However, there was a rapid and (as far as we can tell from our relatively small data set) total recovery in numbers for this species at the first year post-burn. Our data are in accord with Robel and others (1998) working with spring-burned CRP lands in Kansas, where they found lowered densities in the year of burning. Similarly, Zimmerman (1992), also in Kansas, reported that spring burning had negative effects in drought years. An Illinois study (Westemeier and Buhnerkempe 1983), indicated that this species preferred tallgrass areas three years post-burn. However, Swengel (1996) and Winter (1998) in their work in Missouri both found that dickcissel abundance was not related to the numbers of years since burn.

As noted, other studies have shown that dickcissels have a preference for moderately tall grasslands with diverse structure, with the presence of song perches and dense herbaceous cover also being important components (e.g., Zimmerman 1971). Given this,the density reduction we found in the year of burning is probably biologically meaningful, however, we regard the magnitude of the increase in burn year one to be somewhat tenuous, even recognizing the persistence of smooth sumac post-burn. Our study would benefit by larger sample sizes to give us confidence in our understanding of how they respond to fire management. Larger samples may be difficult to generate since the habitats at Spring Green are mostly too sparse and short-statured for this species to be consistently present.

Eastern meadowlarks

A species present in good numbers at the Preserve in all but dry-mesic prairie, we detected eastern meadowlarks at the highest densities in oldfield habitat, at a mean density of 0.78 birds per hectare (Table 2). While several researchers have considered eastern meadowlarks to be habitat generalists (Lanyon 1957, Speirs and Orenstein 1965, Sample 1989), it is also recognized that they often show positive correlations between their abundance and percent litter cover and grass stem presence (Roseberry and Klimstra 1970, Rotenberry and Wiens 1980, Sample 1989). Accordingly, at SGP we found them in highest densities in the lushest habitat present—the oldfield. The absence of this species from the dry-mesic habitat was unexpected and may have resulted from a relative lack of grass cover due to extensive smooth sumac presence on this transect.

Our data show a drop in observed eastern meadowlark densities in the year of burning followed by a slow building of numbers through the first years of the series (Figure 1). This general increase through the burn series—as litter and vegetation builds—is consistent with elements of eastern meadowlark biology, at least as we know this bird in our region (see above). We remain uncertain as to the reasons for the post-burn year four declines we found, but this species is perhaps not benefited by long burn series at the preserve.

The response of eastern meadowlarks to fire is known to vary across their range. Our results are very similar to those of Vickery (1993) in Maine, who found lowered densities at in the year of burning followed by a rapid recovery and modest increases through at least year three post-burn. However, in contrast, Herkert (1991) did not find differences in abundance with burn year in western Illinois, and he concluded that eastern meadowlark was not numerically influenced by burning. A similar situation was reported by Zimmerman (1997) and Robel and others (1998) who found abundance to be similar on burned and unburned CRP lands one year post-burn in eastern Kansas. And finally, Zimmerman (1992) related that meadowlark abundance was not affected by burning in moist years, but may be reduced in drought years in northeastern Kansas.

These last studies point up some of the variables and complexities, such as climatic influences, that can lead to divergent research findings. As we have seen, the present study produced results in good accord with other mid- and eastern North American field studies of burn effects on grassland bird abundance. That is, those species that prefer rather open habitats for nesting or foraging exhibit greater relative densities in the year of burning, while those which prefer

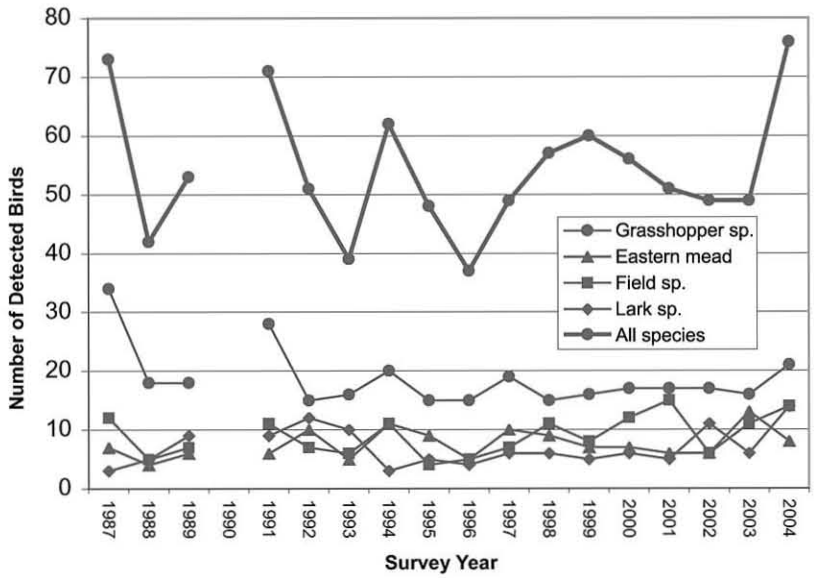

Figure 3. All bird species and dominant species counts from 1989 through 2004.

more dense vegetation structure appear in greater numbers later in a burn series.

Superimposed on these general, habitat- and ecological niche-related burn responses are persistent local site factors such as topographical factors, including slope and degree of rockiness and initial plant community composition, that, along with weather conditions during the burn, can influence the completeness of burn events and the amount of woody structure remaining post-burn. Furthermore, regional differences in climate, habitat structure, levels of inter-specific competition, and divergent habitat preferences of species with wide geographic ranges (for instance the "reversal" of preferred habitats among eastern and western meadowlarks in Arizona) can also influence habitat selection and numerical response within a burn cycle. Thus, due to the local context, burn management effects on grassland birds may deviate to some degree from broadly expected patterns.

Spring Green Preserve Population Trends

We charted the total number of individuals detected of the four species with the largest sample sizes by year to gain a visual assessment of how these dominant species were faring at the Spring Green Preserve (Figure 3). For these species, we found generally stable population trends. While noting the probable decline of vesper sparrows, a look at how all species combined are doing on the Preserve also shows long-term stability within the framework of the year-to-year variability to be expected in a biological system (Figure 3). This is especially evident for the longer period of 1992 through 2004, when the senior author was conducting the surveys, which removes the variable of different observers. These fluctuations point up the value of long-term monitoring of grassland bird populations, as a shorter view may misread what may actually be a long-term trend of dynamic stability. Given the region- and often continent-wide declines many of these species were and are still experiencing during this same time period outside of the preserve boundaries (e.g., Sauer and others 2005), we believe these long-running surveys have also lent a measure of quantitative support and validation to the management approach adopted by TNC at this site.

Major Findings and Conclusions

In spite of our small sample sizes for some species and burn years, we believe the results obtained from this 18-year effort to be biologically meaningful since they are consistent with our knowledge of species' known habitat affinities and natural histories and are in good accord with other published work related to bird response to fire.

Our major findings include the following:

- Species at Spring Green Preserve were distributed according to their typical habitats.
- Grasshopper sparrows were the most abundant species on the transects, and were found at around twice the detected numbers of the next most common species—field sparrows, eastern meadowlarks, and lark sparrows.
- For all species surveyed, the observed density in the year of the burn was unique (either the lowest or highest mean count) compared to all other years in the burn cycle.
- Species detected numbers trends within burn cycles were consistent with their known habitat preferences and natural histories.
- Grasshopper and field sparrows, eastern meadowlarks, and dickcissels were detected in lower numbers in the year of a burn compared to years following in the burn cycle.
- Lark and vesper sparrows and mourning doves were detected in highest numbers in the year of burning.
- Population trends for the four species with the largest sample sizes appear to be dynamically stable over the entire 18-year survey period on the Preserve.
- Vesper sparrows appear to have declined during the survey period for unclear reasons.
- With the exception of vesper sparrows, overall management actions at Spring Green Preserve, including the prescribed burning regimen, appear to allow its grassland bird populations to be maintained.

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