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EFFECTS OF PRESCRIBED BURNING AND GRAZING ON NESTING AND REPRODUCTIVE SUCCESS OF THREE GRASSLAND PASSERINE SPECIES IN TALLGRASS PRAIRIE

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Abstract. In 1992 the George M. Sutton Avian Research Center initiated a five-year project to examine the nesting ecology of birds using tallgrass-prairie habitats in Oklahoma. The project was designed to help determine why grassland bird populations in the southern Great Plains are experiencing widespread and rapid declines. One of our objectives was to determine the effects of contemporary fire and grazing regimes on the nesting ecology of birds breeding in tallgrass prairie. From 1993 to 1995 we monitored nests on six 16.2-hectare plots at The Nature Conservancy's Tallgrass Prairie Preserve in Osage County, Oklahoma. Three of these plots were undisturbed (unburned and ungrazed), and three were disturbed (burned and/or grazed) during each year of the study. We monitored nesting success, clutch size, and fledging rates at each of 313 Eastern Meadowlark (*Sturnella magna*), Grasshopper Sparrow (*Ammodramus savannarum*), and Dickcissel (*Spiza americana*) nests on the six plots. We observed 42, 12, and 87 Eastern Meadowlark, Grasshopper Sparrow, and Dickcissel nests, respectively, on undisturbed plots and 60, 26, and 86 nests, respectively, on disturbed plots. On undisturbed plots, the average Mayfield probabilities of nesting success for the incubation and brood-rearing periods combined were 0.17, 0.17, and 0.19 for Eastern Meadowlarks, Grasshopper Sparrows, and Dickcissels, respectively; the average probabilities of success on disturbed plots were 0.07, 0.06, and 0.06, respectively. Clutch sizes and fledging rates from successful nests were not statistically different between plot types. These results suggest that physiologically the reproductive performance of these species was not affected by burning and grazing; however, rates of nesting success for Eastern Meadowlarks and Dickcissels may be negatively affected by these activities. Through cooperative efforts with private landowners, we are currently developing management recommendations to mitigate the effects of burning and grazing on these species.

LOS EFECTOS DE FUEGO PROGRAMADO Y DE APACENTAMIENTO EN EL NIDAJE Y EN EL ÉXITO REPRODUCTIVO DE TRES ESPECIES PASERIFORMES DE PASTIZAL EN PRADERA DE HIERBA ALTA

Sinopsis. En 1992 el Centro George M. Sutton de Investigaciones Avícolas inició un proyecto de cinco años para examinar la ecología del nidaje de aves que utilizan hábitats en las praderas de hierba alta en Oklahoma. Se diseñó el proyecto para determinar por qué las poblaciones de aves de pastizal en el sur de la Gran Llanura experimentan rápidas y extensas disminuciones. Uno de nuestros objetivos fue determinar los efectos de regímenes contemporáneos de fuego y de apacentamiento en la ecología del nidaje de aves que se reproducen en pradera de hierba alta. Entre 1993 y 1995 vigilamos nidos en seis parcelas de 16,2 hectáreas en la Reserva de Pradera de Hierba Alta de The Nature Conservancy en el Condado de Osage, Oklahoma. Tres de estas parcelas no fueron alteradas (ausencia de fuego y de apacentamiento), y tres fueron alteradas (con fuego y/o con apacentamiento) durante cada año del estudio. Recolectamos datos del éxito de los nidos, del tamaño de la nidada y del número de polluelos volantones en 313 nidos del Pradero Común (*Sturnella magna*), del Gorrión Chapulín (*Ammodramus savannarum*) y del Arrocero Americano (*Spiza americana*) en las seis parcelas. Observamos 42, 12 y 87 nidos del Pradero Común, del Gorrión Chapulín y del Arrocero Americano, respectivamente, en parcelas sin alteraciones y 60, 26 y 86 nidos, respectivamente, en parcelas con alteraciones. En las parcelas sin alteraciones, las probabilidades promedio Mayfield de éxito del nido para los períodos combinados de incubación y de cría fueron 0,17, 0,17 y 0,19 para los Praderos Comunes, los Gorriones Chapulines y los Arroceros Americanos, respectivamente; las probabilidades promedio de éxito en las parcelas con alteraciones fueron 0,07, 0,06 y 0,06, respectivamente. Los tamaños de la nidada y los números de polluelos volantones de los nidos exitosos no se diferenciaron estadísticamente entre los tipos de parcela. Estos resultados indican que la capacidad reproductiva de estas especies no fue influida fisiológicamente por el fuego o por el apacentamiento; sin embargo, el éxito de los nidos de los Praderos Comunes y de los Arroceros Americanos puede ser influido negativamente por estas actividades. Hoy estamos elaborando recomendaciones de manejo por medio de colaboraciones con los propietarios, para atenuar los efectos del fuego y del apacentamiento en estas especies.

Key Words: fire; grazing; nest success; prescribed burning; tallgrass prairie.

Grassland birds are declining faster than any other behavioral or ecological group of avian species in North America (Knopf 1994, Peterjohn et al. 1994). Biologists have postulated several reasons for the geographically widespread and precipitous decline of grassland birds, including habitat loss, changes in agricultural and ranching practices, pesticide use, and habitat loss and persecution on the wintering grounds (Bock et al. 1993, Gard et al. 1993, Rodenhouse et al. 1993). In many grassland areas, prescribed burning and grazing of prairie habitats may affect populations of grassland birds.

Grazing is a major land use in the United States, particularly in the West where 70% of the land area in 11 western states is grazed by livestock (Fleischner 1994). In regions where tallgrass prairie persists, such as portions of Oklahoma, prescribed burning is frequently associated with cattle grazing. Tallgrass-prairie rangeland is often burned in the spring to encourage the subsequent growth of highly nutritious and palatable grasses such as big bluestem (*Andropogon gerardi*), little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*; scientific names in accordance with Great Plains Flora Association 1986). Spring burning also discourages the growth of woody plants and undesirable forbs. These prescribed burns typically occur in March and April, and many areas are burned annually or biennially. After spring burning, relatively high densities of cattle are placed in pastures to forage for approximately 100 d. This grazing regime is known as early intensive stocking (Smith and Owensby 1978).

Tallgrass-prairie habitats have evolved with grazing and fire. Historically, grazing occurred by bison (*Bison bison*), elk (*Cervus elaphus*), and pronghorn (*Antilocapra americana*), and fires were ignited by lightning strikes and Native Americans (J. H. Shaw and M. Lee, unpubl. data). These natural and anthropogenic fires are believed to have occurred most frequently in late summer and early fall in areas where fuel had accumulated because of a lack of recent fire (J. H. Shaw and M. Lee, unpubl. data). Although there is no way to determine accurately how natural grazing and fire regimes affected grassland birds in past centuries, we do know that grazing and fire shaped the prairie into a mosaic of habitats that probably differed spatially and temporally in age, structure, and floral and faunal compositions. This mosaic presumably created suitable habitat for populations of wintering and breeding birds with diverse habitat requirements. The effect of fire and/or grazing on grassland vegetation and the breeding biology of birds has been the subject of several studies, including Wiens 1973; Whitmore 1981; Johnson and Temple 1986, 1990; Zimmerman 1988, 1996; and Herkert 1994. Specific management recommendations that may be drawn or inferred from these studies are often interspecifically contradictory, with a particular burning or grazing regime benefiting one species to the detriment of another.

Our objective was to determine how contemporary grazing and burning practices in tallgrass-prairie habitats affect the nesting and reproductive success of Eastern Meadowlarks (*Sturnella magna*), Grasshopper Sparrows (*Ammodramus savannarum*), and Dickcissels (*Spiza americana*). We chose these species because they commonly nest in undisturbed as well as burned and grazed prairie and are showing significant population declines in several regions of North America (Peterjohn et al. 1994, 1995). Furthermore, Eastern Meadowlarks, Grasshopper Sparrows, and Dickcissels represent three migratory classes: residents, temperate-zone migrants, and neotropical migrants, respectively.

TABLE 1. TREATMENTS AND LIVESTOCK DENSITIES (HEAD/HECTARE) FOR THREE 16.2-HA TREATED PLOTS AT THE NATURE CONSERVANCY'S TALLGRASS PRAIRIE PRESERVE IN NORTHCENTRAL OKLAHOMA, 1992–1995

	Year			
Plot number	1992	1993	1994	1995
T1	UD	BG	BG	BG
	NA	0.99	1.11	1.09
T2	UD	BG	BG	GR
	NA	0.98	0.82	0.86
T3	UD	BG	BG	GR
	NA	0.98	0.82	0.86

Note: UD = undisturbed, BG = burned and grazed, GR = grazed, NA = not applicable.

STUDY AREA

Field work was conducted during 1993–1995 at The Nature Conservancy's Tallgrass Prairie Preserve in Osage County, northcentral Oklahoma. The Nature Conservancy manages this area with prescribed burning as well as grazing by cattle and bison. The 14,800-ha preserve is mainly contiguous tallgrass prairie interspersed with riparian forests and blackjack oak (*Quercus marilandica*) and post oak (*Q. stellata*) thickets and savannas. Common herbaceous plant species include switchgrass, Indian grass, little bluestem, big bluestem, common broomweed (*Gutierrezia dracunculoides*), dogbane (*Apocynum cannabinum*), ironweed (*Veronia baldwinii*), aster (*Aster* spp.), goldenrod (*Solidago* spp.), and lespedeza (*Lespedeza* spp.).

We conducted our research in six 16.2-ha square study plots. Three of these plots were undisturbed (no fire or grazing) since at least 1990. The remaining three plots were considered disturbed and were undisturbed, grazed, or burned and grazed during 1992–1995 (Table 1). Treated plots were burned in March, and cattle were placed on them in late April to early May of each year. When placed on the plots, cattle were either yearling heifers or steers weighing approximately 227 kg each. The mean duration that cattle grazed on treated plots was 99.5 d, and the mean stock density was 0.95 head per hectare.

Disturbed and undisturbed plots were located in contiguous tallgrass prairie that was dominated by herbaceous plants. The greatest distance between disturbed and undisturbed plots was 8.6 km and the shortest distance was 1.1 km, as measured on U.S. Geological Survey topographical maps.

METHODS

Each plot contained 13 north-south and 13 east-west transect lines set at 33.5-m intervals. A 41-cm-long wooden stake was driven into the ground at the intersection of each transect line to identify the 169 grid-point locations. These semipermanently marked grid points aided in nest relocation. We began searching for nests in mid-April and continued through July of each year. Nests were located by systematic searching and observation of flushes and carries of nesting material, food, and fecal sacs to and from nests. When we discovered a nest, we recorded the grid-point coordinates and discreetly marked the location with vinyl flagging approximately 10 m from the nest. Nests were monitored at 3- to 4-d intervals until fledging or failure to determine rates of nesting and reproductive success. Nest-searching effort was similar among treatments and years. We followed guidelines outlined by Ralph et al. 1993 to minimize observer-related effects on rates of predation caused by nest monitoring.

We compared numbers of nests observed, mean clutch sizes, numbers of young fledged, and Mayfield probabilities of nesting success between disturbed and undisturbed plots for each of the three species. Clutch size was defined as the maximum number of eggs contained in successful nests or the number of eggs contained in a nest when the female began incubating. Number of young fledged from successful nests was estimated based on the number of young last observed in those nests. We calculated Mayfield probabilities for the incubation, brood-rearing, and combined phases of the nesting cycle for each species (Mayfield 1961, 1975). Mayfield probabilities for the combined phase were calculated by multiplying the incubation-phase probability by the brood-rearing-phase probability. Mayfield probabilities were computed using the Mayfield Nesting Success Modeling System developed by WordTech Systems, Inc. The numbers of incubation and brood-rearing days used in the Mayfield calculations for Eastern Meadowlarks, Grasshopper Sparrows, and Dickcissels were 14 and 11, 11 and 9, and 12 and 9, respectively.

Differences in number of nests observed between plot types and among years were tested for significance using Student's t-test and chi-square contingency tables, respectively. Differences in clutch sizes and number of young fledged among years and between plot types were tested for significance using univariate analyses of variance (ANOVA). Differences in Mayfield probabilities between plot types were tested for significance using chi-square tests of independence, based on procedures similar to those outlined by Dow 1978. Differences for all statistical tests were considered to be significant at alpha levels ≤ 0.05.

RESULTS

We observed 42, 12, and 87 Eastern Meadowlark (EAME), Grasshopper Sparrow (GRSP), and Dickcissel (DICK) nests, respectively, on undisturbed plots and 60, 26, and 86 nests, respectively, on disturbed plots. The mean number of nests observed for each species did not differ significantly between undisturbed and disturbed plots for the 3 yr combined (EAME: $t = -2.04$, df = 4, $P = 0.11$; GRSP: $t = -2.40$, df = 4, $P = 0.07$; DICK: $t = 0.02$, df = 4, $P = 0.98$). However, the number of Eastern Meadowlark and Grasshopper Sparrow nests differed significantly among years on undisturbed plots. We observed significantly fewer Eastern Meadowlark ($\chi^2 = 20.40$, df = 2, $P < 0.01$) and Grasshopper Sparrow ($\chi^2 = 8.49$, df = 2, $P = 0.01$) nests than expected on undisturbed plots in 1994 and 1995 (Fig. 1).

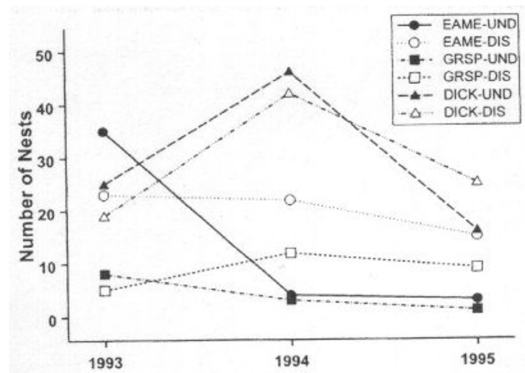

FIGURE 1. Numbers of Eastern Meadowlark (EAME), Grasshopper Sparrow (GRSP), and Dickcissel (DICK) nests observed on six 16.2-ha undisturbed (UND) and disturbed (DIS) tallgrass-prairie study plots in northcentral Oklahoma, 1993–1995.

Overall mean clutch sizes for Eastern Meadowlarks, Grasshopper Sparrows, and Dickcissels were 4.3 (N = 70, SE ± 0.10), 4.2 (N = 32, SE ± 0.20), and 3.8 (N = 102, SE ± 0.08), respectively. Mean clutch sizes for the three species were not significantly different between undisturbed and disturbed plots (EAME: $F_{1,68} = 0.49$, $P = 0.48$; GRSP: $F_{1,30} = 0.11$, $P = 0.75$; DICK: $F_{1,100} = 1.77$, $P = 0.19$). Similarly, the average number of young fledged from successful nests was not significantly different between plot types (EAME: $F_{1,22} = 0.32$, $P = 0.58$; GRSP: $F_{1,4} = 0.00$, $P = 1.00$; DICK: $F_{1,33} = 2.56$, $P = 0.12$). The average number of young fledged from successful nests was 3.3 (N = 24, SE ± 0.24), 3.7 (N = 6, SE ± 0.42), and 2.8 (N = 35, SE ± 0.17) for Eastern Meadowlarks, Grasshopper Sparrows, and Dickcissels, respectively.

Mayfield probabilities of nesting success for Eastern Meadowlarks were significantly higher on undisturbed plots in the brood-rearing period ($\chi^2 = 6.02$, df = 1, $P = 0.01$) but did not vary significantly in the incubation ($\chi^2 = 0.07$, df = 1, $P = 0.79$) and combined ($\chi^2 = 1.47$, df = 1, $P = 0.23$) periods (Fig. 2). Mayfield probabilities of nesting success for Grasshopper Sparrows were not significantly different between undisturbed and disturbed plots for any of the three phases of the nesting cycle (incubation: $\chi^2 =$

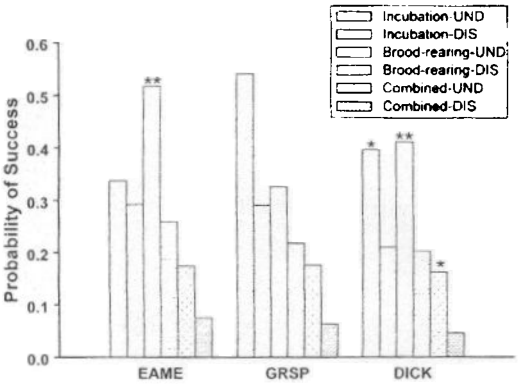

FIGURE 2. Mayfield probabilities of nesting success for Eastern Meadowlarks (EAME), Grasshopper Sparrows (GRSP), and Dickcissels (DICK) on undisturbed (UND) versus disturbed (DIS) tallgrass-prairie plots during incubation, brood-rearing, and combined phases of the nesting cycle in northcentral Oklahoma, 1993-1995. * Denotes $P \leq 0.05$ difference between plot types, ** denotes $P \leq 0.01$ difference between plot types.

1.27, df = 1, P = 0.26; brood-rearing: $\chi^2 = 0.09$, df = 1, P = 0.76; combined: $\chi^2 = 0.24$, df = 1, P = 0.62; Fig. 2). However, Mayfield probabilities of nesting success for Dickcissels were significantly lower on disturbed plots during all three phases of the nesting cycle (incubation: $\chi^2 = 5.66$, df = 1, P = 0.02; brood-rearing: $\chi^2 = 6.41$, df = 1, P = 0.01; combined: $\chi^2 = 5.56$, df = 1, P = 0.02; Fig. 2).

On disturbed plots, at least 13.5, 9.1, and 1.5% of Eastern Meadowlark, Grasshopper Sparrow, and Dickcissel nests, respectively, were trampled by cattle.

DISCUSSION

The temporal decline in numbers of Eastern Meadowlark and Grasshopper Sparrow nests on undisturbed plots was probably due largely to changes in the vegetation profile and composition owing to ecological succession, although finding nests in the denser vegetation of undisturbed plots was also more difficult. Ecological succession of grassland habitats following disturbances is known to affect the composition and structure of grassland bird communities (Johnson and Temple 1990, Herkert 1994, Zimmerman 1996). In the absence of disturbances such as burning, grazing, or mowing, tallgrass prairie becomes more densely vegetated with forbs and woody plant species (Gibson and Hulbert 1987, Hulbert 1988). For example, the mean density of woody plants on undisturbed plots in our study was 10,287 per hectare, whereas the mean on disturbed plots was 4,344 per hectare (George M. Sutton Avian Research Center, unpubl. data). Eastern Meadowlarks and Grasshopper Sparrows are most frequently associated with habitats characterized by vegetation with low to intermediate density and height (Whitmore 1981; Herkert et al. 1993; George M. Sutton Avian Research Center, unpubl. data). Thus, over time, increasing vegetation density and height may have rendered control plots less suitable for use by nesting Eastern Meadowlarks and Grasshopper Sparrows.

In addition to preferring vegetation of low to intermediate height, Eastern Meadowlarks also prefer habitats with low forb-to-grass ratios. These habitats are most often created by episodes of periodic fire. We speculate that because of a lack of fire, habitat conditions on our undisturbed plots were probably unfavorable for Eastern Meadowlarks in 1994 and 1995, thus explaining the low numbers of nests observed in those years. Herkert (1994) noted that Grasshopper Sparrows were more abundant in recently burned areas than in areas in their third or later growing season since last burning. The number of Grasshopper Sparrow nests on our undisturbed plots was probably declining when we initiated our study in 1993, as this was at least the third consecutive year since these plots had been burned.

Whitmore (1981), Zimmerman (1988), and Herkert (1994) noted the importance of periodic fire in maintaining suitable habitat for several species of grassland birds. Johnson and Temple (1990) observed higher probabilities of nesting success for Western Meadowlarks (*Sturnella neglecta*) and Grasshopper Sparrows in recently burned (1 yr postburn) prairie than in prairie that had not been burned in at least 2 yr. Zimmerman (1996) reported lower nesting-success probabilities for Eastern Meadowlarks, Grasshopper Sparrows, and Dickcissels in burned and grazed prairie. We found no evidence that annual spring burning negatively affected the reproductive performance of Grasshopper Sparrows. In addition, the increase in relative abundance of Eastern Meadowlarks in burned areas may have offset the slightly lower rate of nesting success meadowlarks experienced in these areas. Furthermore, the 13.5% of Eastern Meadowlark nests that failed on our disturbed plots because of trampling by cattle was an effect that was not a direct result of burning, although burned areas were then preferentially grazed if livestock were subsequently introduced. Therefore, we concur with Whitmore (1981), Zimmerman (1988), and Herkert (1994) and suggest that a regime of rotational prescribed burning would benefit these avian species by providing a mosaic of habitats in various stages of ecological succession.

In our study it was difficult to isolate the effects of grazing from the effects of burning. For Eastern Meadowlarks, trampling of nests by cattle coupled with higher rates of predation (62% on disturbed plots, 50% on undisturbed plots) accounted for the lower rate of nesting success on burned and grazed plots. Dickcissels are less susceptible to trampling because they nest an average of 21.7 cm (N = 738, range 0–540, SE ± 1.64) above the ground (George M. Sutton Avian Research Center, unpubl. data). The primary causes of lower nesting success by Dickcissels on disturbed plots were higher rates of nest predation (75% on disturbed plots, 64% on undisturbed plots) and abandonment (5% on disturbed plots, 1% on undisturbed plots).

We are currently analyzing data on habitat structure and predation to determine if spatial heterogeneity and specific habitat characteristics are related to nesting success or avian community composition and structure. In addition, we are analyzing nest, point-count, habitat, and insect data from these and 12 other tallgrass-prairie study plots on privately owned ranches and The Nature Conservancy's Tallgrass Prairie Preserve. These plots have been burned and/or grazed by bison or cattle during the past 5 yr. Results of these analyses combined with results reported in this paper will be used to draw specific conclusions regarding the effects of burning and grazing on the nesting ecology of tallgrass-prairie avifauna. Conclusions from our studies combined with input from ranchers will be used to formulate conservation strategies for grassland birds that incorporate the financial and logistical needs of private landowners.

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