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THE EFFECTS OF SUMMER BURNS ON BREEDING FLORIDA GRASSHOPPER AND BACHMAN'S SPARROWS

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Abstract. The dry prairie grasslands of central Florida once dominated the landscape from Lake Kissimmee to Lake Okeechobee, encompassing 1.1 million hectares. These prairies have been largely reduced to four protected sites, where the federally endangered Florida Grasshopper Sparrow (*Ammodramus savannarum floridanus*) and Bachman's Sparrow (*Aimophila aestivalis*) are year-round residents. Management of dry prairie habitat has usually involved late-fall and winter prescribed burns to maintain habitat in an early successional state, which is preferred by these sparrows. Naturally ignited fires on dry prairie ecosystems, however, occur most frequently in summer. Because this grassland evolved with summer wildfires, we sought to understand how prescribed summer burns affected the two rare emberizid sparrows that breed and winter there. Between 1994 and 1996 we studied the effects of prescribed summer fires on Florida Grasshopper and Bachman's sparrows at the Kissimmee Prairie Sanctuary and Three Lakes Wildlife Management Area. Grasshopper Sparrows were more sensitive to timing of prescribed fires than were Bachman's Sparrows. Both species increased in density following mid-June fires, but only Bachman's Sparrows responded positively to July fires. We found that both species occupied burned areas one week after burning and remained reproductively active into September.

LOS EFECTOS DE INCENDIOS ESTIVALES EN LOS GORRIONES REPRODUCTIVOS *AMMODRAMUS SAVANNARUM FLORIDANUS* Y *AIMOPHILA AESTIVALIS*

Sinopsis. En otro tiempo los pastizales secos de las llanuras del centro de Florida dominaban el paisaje desde el Lago Kissimmee al Lago Okeechobee, abarcando 1,1 millones de hectáreas. Estas llanuras se redujeron considerablemente a cuatro lugares protegidos, donde residen todo el año dos gorriones clasificados En Peligro: *Ammodramus savannarum floridanus* y *Aimophila aestivalis*. El manejo del hábitat de llanura seca normalmente incluye incendios intencionales durante el fin del otoño y el invierno para mantener el hábitat en un estado preliminar de sucesión, que estos gorriones prefieren. Sin embargo, los fuegos de ignición natural de los sistemas ecológicos de llanura seca ocurren con mayor frecuencia en verano. Dado que este pastizal evolucionó con fuegos estivales, procuramos entender como los fuegos estivales intencionales afectaban a estos dos gorriones escasos que se reproducen y que pasan el invierno allí. Entre 1994 y 1996 estudiamos los efectos de los fuegos estivales intencionales en los gorriones *Ammodramus savannarum floridanus* y *Aimophila aestivalis* en el Santuario Kissimmee de Llanura y en el Area de Manejo de Fauna Tres Lagos. Los gorriones *Aimophila aestivalis* fueron más sensibles a la programación de los fuegos intencionales que los gorriones *Ammodramus savannarum floridanus*. Ambas especies aumentaron en densidad después de los fuegos de mediados de junio, pero sólo los gorriones *Aimophila aestivalis* respondieron positivamente a los fuegos en julio. Descubrimos que ambas especies ocuparon áreas quemadas una semana después del fuego y permanecieron activas reproductivamente hasta septiembre.

Key Words: *Aimophila aestivalis*; *Ammodramus savannarum floridanus*; Bachman's Sparrow; Florida Grasshopper Sparrow; prairie management; prescribed fire.

The dry prairie of central Florida is an endemic grassland system composed of pyrogenic plant associations that have evolved with frequent natural fires (Snyder et al. 1990). The natural fire frequency of this system appears to be every 1–4 yr, a slightly higher frequency than occurs in mesic flatwoods, which contain a pine (*Pinus*) overstory (Florida Natural Areas Inventory 1990). Fires on dry prairie were ignited naturally by lightning, primarily during the summer months when thunderstorms are most frequent (Snyder et al. 1990). Plants of the dry prairie are dependent on these summer fires. For example, wire grass (*Aristida beyrinchium*), the dominant grass in this habitat, flowers and sets seed more profusely after summer fires than after winter fires (Lewis 1964). It is likely that the fauna of this system also adapted to this pattern of frequent summer fire.

The Florida Grasshopper Sparrow (*Ammodramus savannarum floridanus*), a federally endangered grassland sparrow endemic to central Florida dry prairie (Federal Register 1986), has evolved in this fire-adapted ecosystem and prefers areas burned within the past 24 mo (Delany et al. 1985, Delany and Cox 1986, Walsh et al. 1995). Federal guidelines recommend prescribed burns as part of a management plan to maintain and enhance populations of this endemic sparrow (U.S. Fish and Wildlife Service 1988). Nearly all prescribed fires, however, have been conducted in late fall or winter (e.g., Walsh et al. 1995), to

reduce potential nest mortality resulting from fire. Questions concerning whether the season of prescribed burns (winter vs. summer) affects the Florida Grasshopper Sparrow's breeding biology and, ultimately, potential recovery have not been carefully examined or tested in the field.

Bachman's Sparrow (*Aimophila aestivalis*) is also a resident breeder of the dry prairies of central Florida. Historically this species has been associated with mature longleaf pine (*Pinus palustris*) forests with grassy, open understories (Brooks 1938, Stoddard 1978, Haggerty 1986). Dunning and Watts (1990) reported that Bachman's Sparrows consistently occupied areas with abundant grasses and forbs in the vegetative layer 1 m above ground but with reduced vegetation in the layer 2–4 m above ground. For breeding Bachman's Sparrows, the age class of the canopy was not as important a predictor of occupancy as was the structure of the vegetation in the first meter above ground (Dunning and Watts 1990).

The objectives of this study were to determine how prescribed summer burns affect breeding densities and phenology of these two species. Having documented the extension of the breeding season after summer fires (Shriver et al. 1996), we sought to determine if the prolonged singing period (to early September) on burned areas observed in the initial study reflected actual breeding activity.

METHODS

Between 1994 and 1996 we measured sparrow response to summer fire using standard spot-map censusing methods (International Bird Census Committee 1970). All plots were rectangular (8–18 ha), more than 100 m from any other plot, and more than 50 m from unsuitable habitat (e.g., wetlands, tropical hammocks). Plots were censused every 4–8 d from March to September, and a territory was defined as an area where a male was present for 4+ wk (Vickery et al. 1992). The breeding success of each territory was ranked based on observed breeding behaviors (Vickery et al. 1992). We used three-way analysis of variance (ANOVA) to test for differences in sparrow densities between burned and unburned plots, study sites, and years.

STUDY SITES

Kissimmee Prairie Sanctuary

The National Audubon Society Ordway-Whittell Kissimmee Prairie Sanctuary in Okeechobee County (27°34′ N, 80°58′ W) is a 3,071-ha portion of prairie habitat that historically covered much of central Florida. As part of our study on the breeding biology of these two species, we established eight plots (92 ha total) in three burn units at this site. In June 1992 more than 75% of the sanctuary was burned by a lightning-ignited fire (S. Hedges, pers. comm.). Since that time, Kissimmee Prairie has been managed on a 2-yr summer-fire rotation. During our research, specific plots were burned and then left for 2 yr or more before the next prescribed burning; thus, they changed burn status from one year to the next. Both treatment and control areas were not burned for at least 2 yr in all years of this study.

We conducted three prescribed burns at Kissimmee Prairie between 1994 and 1996 and measured Grasshopper and Bachman's sparrow densities before and after all burns. On 15 July 1994, a 250-ha unit was burned; three plots (35 ha) were located in the burn unit and two plots (33 ha) in the unburned unit. On 30 June 1995, a 240-ha unit was burned; three plots (39 ha) were burned, and two plots (16 ha) were not burned. On 17 June 1996, a 112-ha unit was burned; two plots (16 ha) were burned, and three plots (35 ha) were not burned.

Three Lakes Wildlife Management Area

Approximately 4,000 ha of dry prairie occur on the southern portion of Three Lakes Wildlife Management Area (WMA) in Osceola County (27°47′ N, 81°06′ W). This property is owned and managed by the Florida Game and Fresh Water Fish Commission which, prior to our research, conducted a 2- to 3-yr fire rotation in the fall and winter. During our study, all plots had not been burned for at least 2 yr prior to summer burning.

We conducted three prescribed burns at Three Lakes WMA between 1994 and 1996 and measured Grasshopper and Bachman's sparrow densities before and after all burns. On 22 June 1994, three plots (26 ha) were burned, and three unburned plots (31 ha) served as controls. On 31 July 1995, three plots (43 ha) were burned, and three unburned plots (31 ha) served as controls. On 17 June 1996, three plots (30 ha) were burned, and two plots (16 ha) served as controls.

RESULTS

When all six burns were analyzed together, there was no clear difference in Grasshopper Sparrow densities on burned spot-map plots compared to unburned plots (Table 1, Fig. 1). There were increases in Grasshopper Sparrow densities, however, following three mid-June fires (Fig. 1, A–C). When mid-June fires were tested alone (Fig. 1, A–C), densities between burned and unburned areas differed ($F = 4.26$, $df = 1$, $P = 0.05$). Grasshopper Sparrow territory densities did not increase on plots that were burned later than 29 June (Fig. 1, D–F). There was a significant interaction between year, site, and burn treatment for changes in Grasshopper Sparrow densities (Table 1).

Grasshopper Sparrows established territories on burned areas within 1 wk of mid-June fires. Males were observed singing and aggressively defending territories in areas that were vacant before the burn. We observed females in territories, suggesting that Grasshopper Sparrows were breeding on burned areas. On 23 July 1996 we discovered a nest with four nestlings at Three Lakes WMA. This nest was located on a plot that was burned 17 June 1996. The nest was considered successful: four nestlings were observed on 29 July, and the nest was empty on 5

TABLE 1. THREE-WAY ANOVA FOR CHANGES IN FLORIDA GRASSHOPPER SPARROW BREEDING DENSITY AFTER SUMMER PRESCRIBED FIRES AT KISSIMMEE PRAIRIE AND THREE LAKES WMA, FLORIDA, 1994–1996

Source	Sum of squares	df	Mean square	F-ratio	P
Burn	0.025	1	0.025	0.010	0.919
Site	13.541	1	13.541	5.599	0.026
Year	64.751	2	32.375	13.386	0.000
Burn × Year × Site	16.959	2	8.479	3.506	0.045
Error	60.466	25	2.419		

August. This was the first confirmed breeding by Florida Grasshopper Sparrows on prairie fragments that were burned in summer.

Bachman's Sparrows were observed singing on burned plots within 1 wk of prescribed fires, and densities on burned plots increased after fires conducted from 17 June to 31 July (Table 2, Fig. 2). At Kissimmee Prairie in 1994 and 1995, females were observed with males in burned territories. At Three Lakes WMA in 1994–1996, juvenile Bachman's Sparrows were observed in postburn territories more than 5 wk after the fires. There was a significant interaction between year and site for changes in Bachman's Sparrow densities (Table 2).

DISCUSSION

The dry prairie of central Florida is a pyrogenic assemblage of grasses, forbs, and shrubs that depends on fire to maintain the composition and structure of the vegetation. The season in which fire occurs has profound effects on vegetation structure and phenology. Lewis (1964) reported that wire grass in South Florida flowered profusely after summer fires but exhibited little or no response after winter fires. The flow-

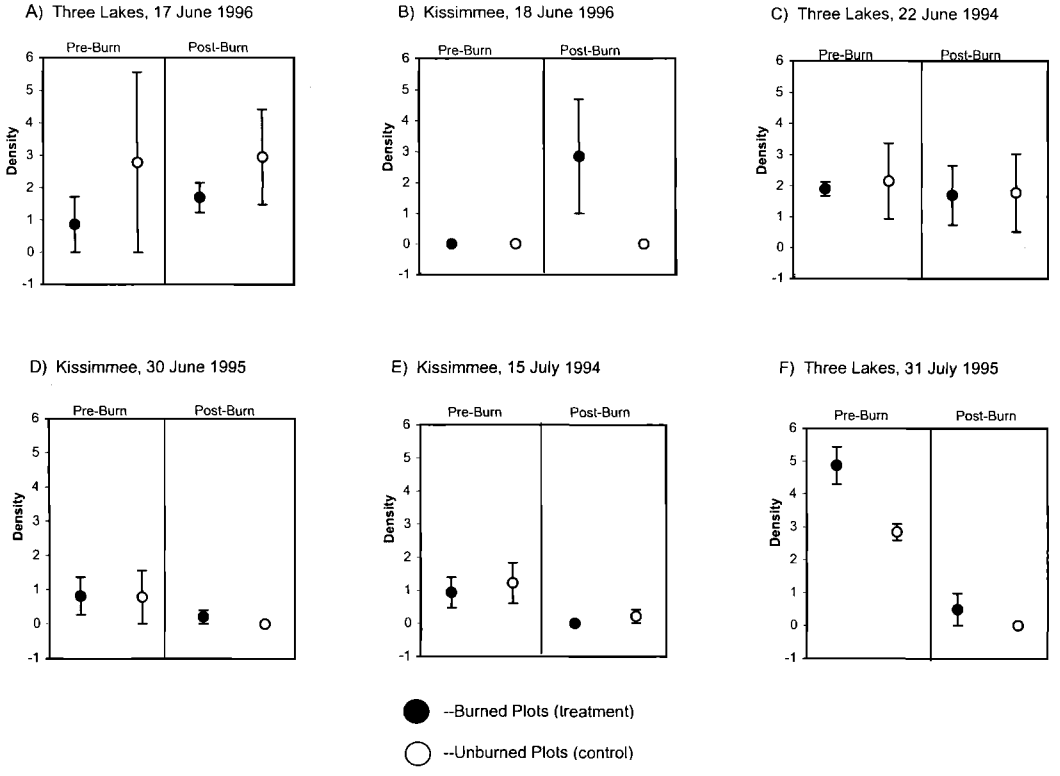

FIGURE 1. Mean number (± 1 SE) of Florida Grasshopper Sparrow territories per 10 ha ("Density") before and after summer prescribed fires. Graphs (A–F) are ordered by seasonal date of fire to show how timing of burning influenced sparrow response.

TABLE 2. THREE-WAY ANOVA FOR CHANGES IN BACHMAN'S SPARROW BREEDING DENSITY AFTER SUMMER PRESCRIBED FIRES AT KISSIMMEE PRAIRIE AND THREE LAKES WMA, FLORIDA, 1994–1996

Source	Sum of squares	df	Mean square	F-ratio	P
Burn	16.662	1	16.662	19.830	0.000
Site	3.529	1	3.529	4.201	0.051
Year	0.238	2	0.119	0.142	0.868
Year × Site	6.524	2	3.262	3.882	0.034
Error	21.005	25	0.840		

ering of the dominant grass on the prairie has a profound effect on the structure of the vegetation; flower stalks exceed 1 m on summer burns but are nonexistent on winter burns (W. G. Shriver, pers. obs.). These changes in vegetative structure may affect breeding sparrow populations and may have important implications for endangered-species management.

For Florida Grasshopper Sparrows, it is important to consider the timing of summer burns when attempting to predict sparrow response. As the length of the "typical" breeding season for Florida Grasshopper Sparrows on winter-burned areas is reported to end in mid-July (Delany et al. 1985), hormone levels at this time in the breeding season may drop below a point such that breeding is no longer possible. This study demonstrates that Florida Grasshopper Sparrows were breeding only on plots that were burned in mid-June. Florida Grasshopper Sparrows established territories but did not initiate late-season breeding activity after the late June or July burns. Although we indicated that there was a positive response to a 15 July burn (Shriver et al. 1996), the more extensive spot-map data demonstrated that these birds did not establish territories for a period of 4 wk or more.

Bachman's Sparrows were not sensitive to timing of summer burns. We measured higher territory densities on burned areas regardless of when the burns occurred. Bachman's Sparrows in central Arkansas were reported to continue breeding into October (Haggerty 1986), much later than Florida Grasshopper Sparrows. The longer breeding season documented for Bach-

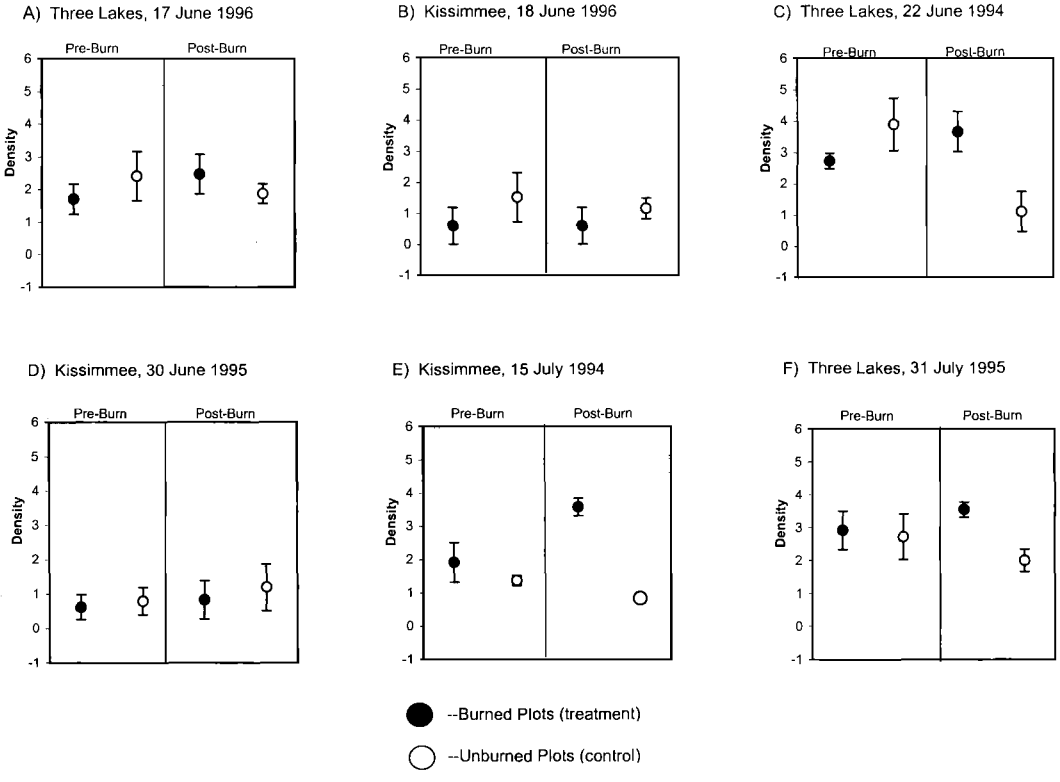

FIGURE 2. Mean number (± 1 SE) of Bachman's Sparrow territories per 10 ha ("Density") before and after summer prescribed fires. Graphs (A–F) are ordered by seasonal date of fire to show how timing of burning influenced sparrow response.

man's Sparrows may explain why they responded positively to late-season burns and Grasshopper Sparrows did not.

We think the year and site interaction we detected for both species was caused by the 1995 burn at Kissimmee Prairie where severe inundation resulted in low sparrow densities during this breeding season (Figs. 1 and 2D). For Grasshopper Sparrows, the inclusion of burn treatment in the interaction term is explained by the variability in sparrow densities in relation to the timing of fires.

Our previous research indicated that Grasshopper Sparrows on burned areas extended their breeding activity into September, whereas on unburned areas breeding ended in late July (Shriver et al. 1996). We have now documented that Florida Grasshopper Sparrows will successfully breed after mid-June burns, indicating that this species is not simply extending singing behavior but is actively breeding later into the season on summer-burn areas. This extension of the breeding season has important implications for endangered-species management and the long-term persistence of this subspecies. If this grassland ecosystem is adapted to summer fires, continuous winter burning may be not be the appropriate management tool for species endemic to this system.

We recommend incorporating mid-June burns into fire-management regimes where Florida Grasshopper and Bachman's sparrows coexist. Both sparrows responded favorably to mid-June burns, whereas only Bachman's Sparrows exhibited a positive response to late-season burns. These two species are sympatric throughout the range of the Florida Grasshopper Sparrow. Management practices that are adopted for the endangered Florida Grasshopper Sparrow therefore will inevitably affect and should benefit Bachman's Sparrows.

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