P1C.9 EFFECTS OF FIRE SEASON AND FREQUENCY ON THE PLANT COMMUNITY OF A RESTORED TALLGRASS PRAIRIE

Thomas B. Bragg* and Nathan D. Birks
University of Nebraska at Omaha, Omaha, Nebraska

INTRODUCTION

Since European settlement of the Great Plains in the mid 1800's, 99% of the tallgrass prairie of the region has been lost to activities such as agriculture and urbanization (Samson and Knopf 1996). This loss resulted in recent efforts to restore some of this ecosystem and to manage restorations with fire applied at different seasons and frequencies. Historically, fires occurred throughout the year, although summer fires most likely were less intense and smaller in size than dormant season fires (Bragg 1994). The frequency with which fires occurred in the region is estimated to have varied from 1-7 years (Frost 1999). Variation in the season and frequency of burning may account for much of the diversity of the tallgrass prairie thus the interest in evaluating these variables. Most studies, to date, however, have been conducted over relatively short periods of time (e.g. Kucera and Ehrenreich 1962, Bragg et al. 1999) and thus may not reflect long-term effects. This study was initiated to provide such a long-term perspective.

EXPERIMENTAL DESIGN

The study was conducted at Allwine Prairie Preserve, a 65 ha restored prairie in eastern Nebraska (Becic and Bragg, 1978). In 1970, the preserve was seeded to a mixture of big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), sideoats grama (*Bouteloua curtipendula*), and switchgrass (*Panicum virgatum*) (Bragg, 1976) and has been managed using a 3-year fire return interval of spring burns (late April – early May) with occasional haying in early July. In 1976, a 5 ha area was set aside for a study designed to test the hypothesis that long-term fire treatments could significantly affect species composition. In 1978, treatment plots, each replicated three times, were established and subsequently managed using annual or quadrennial burns conducted in spring (ca. 1 May), summer (ca. 1 July), or fall (ca. 1 November) with additional treatments varying season-of-burning; one treatment was *unburned*. In 1979, in order to address plant community diversity and to better allow for extrapolation of results to native prairie, porcupine grass (*Stipa spartea*) was transplanted to each treatment plot from local prairies. In addition, locally collected seeds from eight species of prairie forbs were scattered throughout each plot. Forb species scattered were: black-eyed Susan (*Rudbekia hirta*), downy gentian (*Gentiana puberulenta*), white aster (*Aster ericoides*), Illinois tickclover (*Desmodium illinoense*), leadplant (*Amorpha canescens*), tall cinquefoil (*Potentilla arguta*), white prairie clover (*Dalea candida*), and wild white indigo (*Baptisia lactea*). No burns occurred two years before or three years after the introduction of these species.

In the spring of 1978, a 10-m long transect was established in the center of each plot and the endpoints marked with metal poles to enable relocation. Ten, 30 by 50 cm microplots were systematically located along each transect and evaluated in both 1979 and 2001. Evaluations were based on canopy cover procedures (Daubenmire, 1959) by species and species groups (grass, forb, and woody).

RESULTS AND DISCUSSION

Diversity

Overall, Species Richness (the number of species) of native plants increased from 17 in 1979 to 27 in 2001, although total Species Richness increased only from 28 to 30, largely reflecting the offsetting effect of an increase in the native species that were seeded or immigrated, and a decline in ruderal species. While the increase in total Species Richness is only slight, the Shannon-Wiener

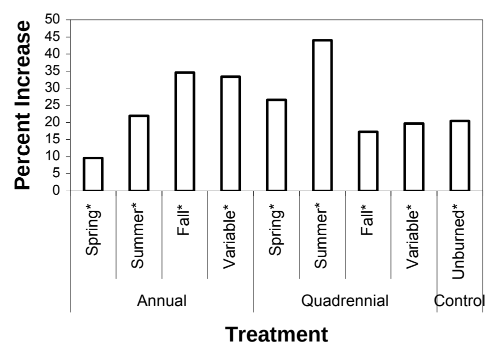

Figure 1. Percent increase in Shannon-Weiner diversity (H') between 1979 and 2001. * = significant difference between 1979 and 2001 (P≤0.05, t-Test)

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* *Corresponding author address:* Thomas. B. Bragg, Dept. of Biology, Univ. of Nebraska at Omaha, Omaha, NE 68182-0040; e-mail – tbragg@mail.unomaha.edu

Diversity Index (H'), a measure of evenness, increased significantly from 1979 (H' = 0.5171) to 2001 (H' = 0.7700) in treatments, including the control ($P \leq 0.05$, t-Test) (Zar 1984) (Fig. 1). Differences in species diversity among treatments in 2001 suggested two general trends. First, among annual burns, diversity in those occurring later in the season, or with a varied season of burn, was significantly higher than those burned in spring or summer. Diversity, however, was lower in the absence of burning (H' = 0.7203) than with annual burning, except for those occurring in the spring (H' = 0.6639) where diversity declines, results consistent with other studies (e.g. Towne and Kemp, 2003). The second trend was observed among quadrennial treatments where the highest diversity occurred with summer burns rather than with fall burns, as was observed with annual burning. For example, summer burns resulted in the greatest diversity (H' = 0.8463) and the greatest increase in diversity (+109%) (Fig. 2). In addition, all quadrennial treatments (average H' = 0.7807) resulted in significantly higher diversity than the unburned control treatment (H' = 0.7203).

Effect on Grass and Forb Cover

Neither canopy cover of grass nor that of forbs differed significantly among treatments in 1979. In 2001, however, grass cover had increased significantly in all treatments from an average of 81% in 1979 to 100% in 2001. No significant differences in cover were found among treatments in 2001 except for annual variable-season treatment where the difference (<1%) is probably not biologically meaningful. Forb cover also increased significantly between 1979 and 2001 from an average of <1% to 18%. This increase parallels the overall increase in Shannon diversity observed during the same time period and, thus, is consistent with the idea that the majority of plant diversity in the tallgrass prairie resides in the forb component as suggested by Bragg and Steuter (1996).

The increase in overall forb cover from 1979 to 2001 was expected due to the intentional introduction of forbs in 1979 and the expectation for species immigration over time. Except for spring burning (cover = 6%), forb cover for all annual burn treatments in 2001 averaged higher (21%) than the control (10%) (Fig. 2). Differences, however, were significant only for annual fall (26%), annual variable-season (35%), and quadrennial summer (19%) treatments. As with Shannon diversity, in 2001 there was a trend of increasingly higher forb cover with annual burns occurring later in the year (Fig. 2) although differences were not significant among all treatments. Unlike annual burns, however, quadrennial burns did not result in a general trend of increasing forb cover with increasingly later season burns. There were, however, significant differences in treatment with quadrennial summer burns resulting in significantly more forb cover (22%) than either fall burns (15%) or in the absence of burning (10%) (Fig. 2). In combination, these results suggest that the season of quadrennial prescribed burning is less critical in affecting plant response than is the frequency of burning.

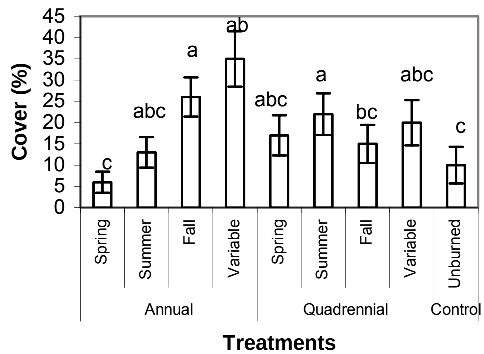

Fig. 2. Mean canopy cover of forbs in 2001. Letters above each bar indicate significant differences in mean canopy cover between treatments ($P \leq 0.05$, Student-Newman-Keuls Test, n=30). Vertical lines within each bar show the standard error

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Effect on Individual Species

Of the 40 species recorded, 19 showed a significant (*P* 0.05; ANOVA) change in canopy cover between 1979 and 2001 in at least one treatment with changes in ten species exceeding 10%: big bluestem (+79%), little bluestem (-28%), Indiangrass (+20%), sideoats grama (-16%), switchgrass (+29%), Kentucky bluegrass (*Poa pratensis*) (+65%), sedges (*Carex* spp.) (+19%), wild white indigo (+11%), leadplant (+11%), and white prairie clover (18%). Sixteen species, including some of the 19, also showed a significant difference among treatments in 2001. Among tall, warm-season grasses, big bluestem, Indiangrass, and switchgrass all increased with burning, although their response varied by treatment. Of these, big bluestem was most responsive, increasing significantly in all treatments, from an average cover of 11% in 1979 to 75% in 2001 ($P \leq 0.05$, *t*-test), results consistent with those of Bragg et al. (1999). Little bluestem, a short-statured, warm-season grass, characterized the warm-season grasses that generally declined with burning over time. This species appears to be the most sensitive of the principal warm-season grasses of any stature to the effects of variation in treatment, with responses varying from significant increases to significant decreases (P≤0.05, *t*-test) (Fig. 3). The diversity of response of warm-season grasses to variation in fire season and frequency appears to have a logical common denominator. Fire treatments in general maximize growth,

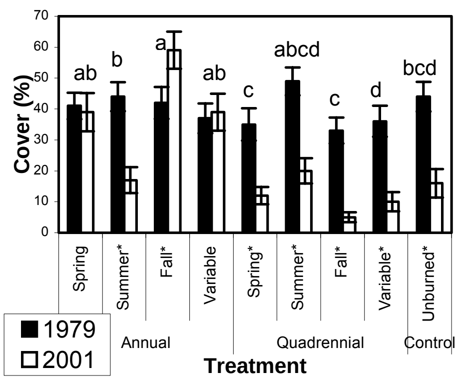

Fig. 3. Mean canopy cover of little bluestem (*Schizachyrium scoparium*) in 1979 and 2001. * = significant differences between 1979 and 2001 ($P \leq 0.05$, *t*-test). Letters above each bar indicate significant differences in mean canopy cover among treatments in 2001. Bars with the same letter are not significantly different ($P \leq 0.05$, Student-Newman-Keuls test). Vertical lines shown for each bar indicate the standard error.

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including stature, of taller grasses such as big bluestem (Benning and Bragg, 1993). This, in turn, reduces the amount and quality of light available for shorter grasses. Over the long term, reduced photosynthesis would reduce the vigor of short-statured grasses resulting in the kind of reduced cover of these species observed in this study.

In contrast to warm-season grasses, cool-season graminoids were observed to increase in all plots, although the amount of the increase varied by treatment. Of this group, increases in sedges and Kentucky bluegrass (+43% in quadrennial and unburned treatment plots) were the most common. Probably introduced to the research plots in plugs of porcupine grass (*Stipa spartea*), sedges increased significantly in all treatment areas from trace amounts in 1979 to an average of 12% in 2001 ($P \leq 0.05$, *t*-test). The average increase in cover of sedges among annual treatments (+17%) was higher than that of quadrennial and control treatments (+8%), suggesting that this genus is better suited to expanding its cover with more frequent fire.

The response of individual forb species varied substantially. For example, some species increased significantly with summer treatments (*e.g*. prairie goldenrod (*Solidago missouriensis*) and prairie violet (*Viola pedatifida*)) while others increased with spring treatments (*e.g*. leadplant and white prairie clover) (Fig. 4). Some species increased more with annual burns (*e.g*. white prairie clover) while others did so with quadrennial burns (*e.g*. Illinois tickclover) (Birks 2003).

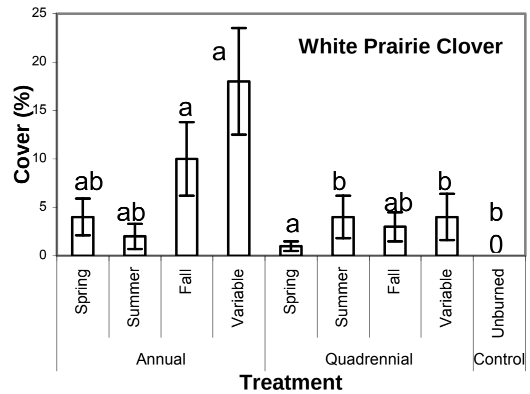

Fig. 4. Mean canopy cover of white prairie clover (*Dalea candida*) in 2001. Letters above each bar indicate significant differences in mean canopy cover among treatments ($P \leq 0.05$, Student-Newman-Keuls test). Vertical lines shown for each bar indicate the standard error.

CONCLUSION

This study indicates the differential response of different species and species groups to different fire regimes and their effect on species diversity. Understanding these differences allows for a more refined generalization of fire effects on the prairie as a whole, even though there almost certainly are interactions that may account for some of the responses observed. Further, the variation in species responses to fire suggests that, to provide high ecosystem diversity, fire management should be applied with a more random and less systematic season and frequency than is typically applied in prescribed burning of tallgrass prairies.

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