

Does burning affect species diversity and abundance of the understory flora of the upland white oak forest at CERA?

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Abstract

Controlled burning is a widely-used tool in prairie restoration. Its effects have been extensively studied in open prairie, but less studied in prairie-region forests. This study examines the effects of burning on understory species populations in a central Iowa oak-hickory forest. We conducted the experiment in eighteen plots (ten burned, eight unburned) in Conard Environmental Research Area (CERA) in Iowa. We found no significant difference between the treatments in diversity, species richness, or total number of stems per plot. However, three of the most abundant species showed significant differences in abundance between treatments. The numbers of individuals of *Sanicula gregaria* and *Cryptotaenia canadensis* were significantly greater in burned plots than in unburned, while the reverse was true of individuals of *Galium aparine*.

Introduction

Abundant research has been done on the effects of burning on open prairies. Little research, however, has been done on oak forests. This is surprising because these forests are an integral part of prairie succession (Freeman 2002). Before human intervention, natural fires had a major effect on the balance of stages of succession on the prairie (Reichman 1987). Studies conducted on open prairies consistently show that timing and frequency of fire has a tremendous effect on species diversity. Summer fires can injure dominant prairie species, which are frequently C4 grasses, and give subdominant species a chance to thrive. This increases overall diversity. Spring fires can damage new shoots of species with early growing seasons, many of which use C3 photosynthesis. Fall and spring burns favor C4 grasses and forbs more than summer burns (Howe 1999). The balance between biodiversity and abundance of dominant species is a difficult one to strike; finding that balance through such methods as controlled burns is a major challenge in restoration. Currently, burn techniques developed in open prairie studies are being applied to prairie forests. We focused on the effects of autumn burning on understory diversity in CERA's upland white oak forest because further study is needed to determine the effects of open prairie methods on forest ecosystems.

A burning experiment has been conducted in part of CERA's upland white oak forest since 1999, with ten of the nineteen experimental plots being burned every fall except in one year when plots were not burned. The other nine have been

left unburned during that time. We studied all of the twenty-two species (eighteen forbs, four sedges) we encountered in our random samples.

Tester (1996) found that thirty-four of thirty-nine prairie forbs increased with frequency of burning in an oak savannah, and Nuzzo et al. (1996) that white snakeroot (one of the forbs in our study) becomes dominant with regular burning in a sand forest. This information led us to predict that our study at CERA would show a decrease in overall diversity with burning but an increase in individual species abundance.

Methods

Between October fourth and November second, 2004, we measured diversity and abundance of different under-story species in eighteen experimental 25x25m plots in the oak-hickory forest of CERA. Ten of the plots have been burned every fall since 1990 (Figure 1). We chose three random

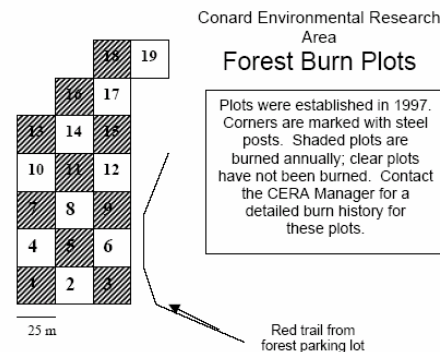


Figure 1: map of CERA oak-hickory forest burn experiment courtesy of <http://www.grinnell.edu/academic/biology/cera/data/maps> (plot nineteen was not sampled)

Table 1: Identified species, listed by family.

Apiaceae:	<i>Sanicula gregaria</i> , <i>Cryptotaenia canadensis</i> , <i>Osmorhiza (claytonia or longistylis)</i>
Asteraceae:	<i>Eupatorium rugosum</i>
Balsaminaceae:	<i>Impatiens (pallida or capensis)</i>
Bosayinaceae:	<i>Hackelia virginiana</i>
Cyperaceae:	<i>Carex hirtifolia</i> , <i>Carex</i> (unknown)
Hydrophyllaceae:	<i>Hydrophyllum virginianum</i>
Poaceae:	<i>Leersia</i> , <i>Festuca obtuse</i>
Polypodiaceae:	<i>Polygonum virginianum</i>
Ranunculaceae:	<i>Ranunculus abortivus</i>
Rosaceae:	<i>Geum (canadense or laciniata)</i>
Rubiaceae:	<i>Galium aparine</i> , <i>Gallium triflorum</i>
Urticaceae:	<i>Urtica dioica</i> , <i>Pilea pumila</i>
Violaceae:	<i>Viola sororia</i> , <i>Viola pubescens</i> , two unknown <i>Viola</i> species

points and sampled at these points in every plot. Working in 50x50cm quadrats within the plots, we counted the number of species present and individual numbers of each species. We compared treatments using t-tests on species abundance, Simpson's diversity index, and richness.

Results

Species identified are listed in Table 1. Only *Sanicula gregaria* and *Cryptotaenia* were significantly more abundant in burned plots; only *Galium aparine* was significantly more abundant in unburned plots (Figure 2). These three species were the most abundant overall. Of the remaining species only *Impatiens* had a mean of greater than 10/m² in either treatment.

There is a nonsignificant difference ($p = 0.205$) in the average number of stems per square meter between burned and unburned, with more stems in burned plots on average (Figure 3). There was no significant difference between treatments in species diversity (Figure 4) or richness.

Discussion

The growth seasons of C3 plant species start in the spring, earlier than those of C4 species (Reichman 1987). On the prairie, the timing of fires helps determine dominance between C3 and C4 species. C3 plant species thrive in cool moist

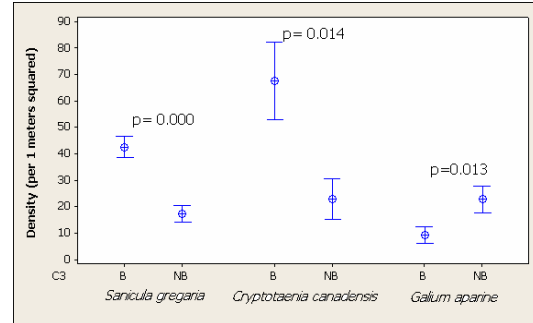


Figure 2: most abundant species in burned vs. unburned plots at CERA (+/- 1 S.E.)

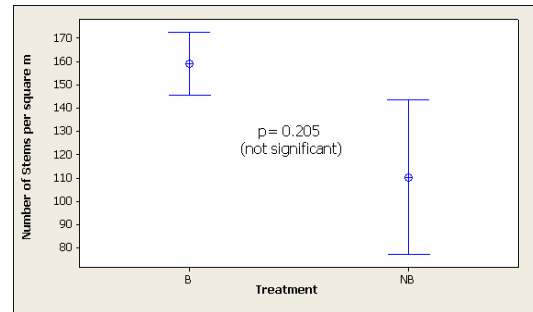


Figure 3: interval plot of number of stems/m² vs. plot treatment (+/- 1 S.E.)

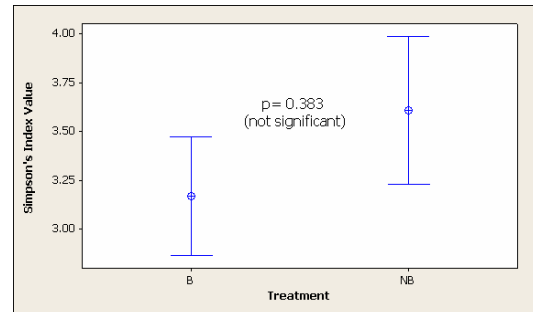


Figure 4: interval plot of Simpson's Diversity Index vs. treatment (+/- 1 S.E.)

environments; thus, they are dominant in forest understories (Reichman 1987). Most of the species involved in this study use C3 photosynthesis; the lack of C4 competition in the understory diminishes the effect of fire on dominance patterns, which may account for the nonsignificant differences between treatments. The only three species that did show significant differences are *Galium aparine*, *Cryptotaenia canadensis*, and *Sanicula gregaria*. *G. aparine* thrived in unburned plots, while *C. canadensis* and *S. gregaria* both thrived in the burned. The second and third species are both from the family Apiaceae. A study of *Zizia aurea*, another member of this family, found that fall burns increase the population size of that species

(Howe 1999); the fact that three Apiaceae species have been shown to benefit from fall burns suggests that the family as a whole is affected this way.

There are other differences between burned and unburned forest that may affect understory growth. A recent study in the CERA upland white oak forest shows that canopy percent cover is lower in annual fall burn plots, and there exists a gradient in canopy cover over the area (Isis-Brown et al. 2004). There are nonsignificant ($p = 0.114$ and 0.181 , respectively) negative correlations between canopy cover and numbers of both *Sanicula gregaria* and *Cryptotaenia canadensis* (Figures 5 and 6). There was no correlation between canopy cover and numbers of *Galium aparine*. Another study found that carbon and nitrogen levels were higher in burned plots, although the increases were not significant (Fenster et al. 2004); however, there were no correlations between these elements and the three most abundant species.

The lack of significant data and correlations is intriguing. The part of the understory that we studied seems to be little affected by fall burning. Our data should be compared with similar studies on woody species to determine the overall impact of prairie forest burning.

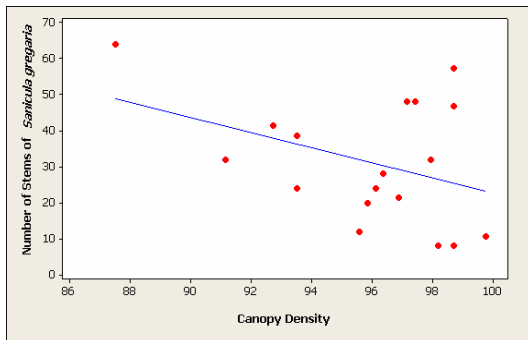


Figure 5: Regression of canopy density and number of *Sanicula gregaria* per plot (± 1 S.E.)

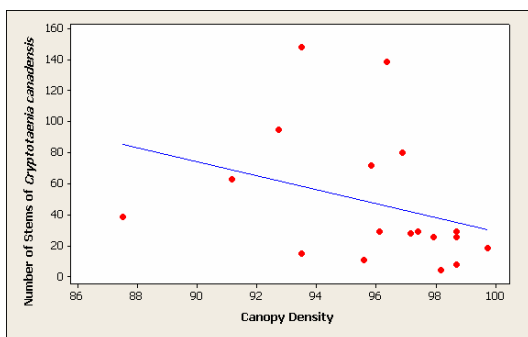


Figure 6: Regression of canopy density and number of *Cryptotaenia canadensis* per plot (± 1 S.E.)

Acknowledgments

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