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Fire and mowing have effects on the density of *Asteraceae* and *Fabaceae*

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Abstract

Burning and mowing are two common prairie restoration/reconstruction tools. Both are important in determining the prairie's composition of forbs. We investigated effects on Asteraceae and Fabaceae, the two most common forb families on the tallgrass prairie. We measured the density of both families and species belonging to these families on plots where mowing and burning were treatments. Burning led to a significant increase in the density of Fabaceae but not Asteraceae. Mowing had a significant effect on Amorpha canescens and Solidago sp. The effects of these treatments indicate that they influence the presence of the two largest forb families on tallgrass prairie in Central Iowa.

Introduction

Forbs comprise the majority of species in the tallgrass community, despite being infrequent in comparison to dominant C_4 grasses (Howe 1999). Asteraceae and Fabaceae are two of the most common forb families in the tallgrass prairie region. Species belonging to Asteraceae tend to have daisy-like flowers and bloom from summer into fall. Many species belonging to Fabaceae can fix nitrogen and have compound leaves. Most bloom from spring into summer. To manage the prairie ecosystem, it is necessary to examine the factors that influence the presence of major forb families and their representative species. Fire and grazing are management tools and forms of disturbance that effect the composition of forbs on prairie.

Fire is an environmental factor that has a profound effect on the prairie ecosystem (Whelan 1995). Before European settlement, fires ignited by lightning and set by Native Americans periodically swept across the prairie. Fire may favor Fabaceae on the prairie. Frequent burning may result in chronic nitrogen deficiency (Collins 1992), favoring Fabaceae species capable of fixing their own nitrogen. Asteraceae may be hindered by fire. Fire removes deep litter, and dominant C_4 grasses have been shown to increase after deep litter removal (Hulbert 1969). Competition with grasses may be to the detriment of Asteraceae, especially since many Asteraceae species bloom concurrently with the main thrust of grass growth. Therefore, fire is capable of altering the balance between forbs and grasses on the prairie.

Grazing is another factor that can affect the prairie community. Bison and other large grazers roamed the prairie prior to European settlement. Large generalist grazers tend to increase diversity by reducing dominant vegetation (Howe 1999). Mowing is an appropriate substitution because it is the ultimate generalist, cropping a given area equally. Therefore, grazing (mowing) is likely to favor forb species because it levels the playing field between the forbs and the dominant grasses.

Kucera and Koelling (1964) showed that annual spring burn significantly reduced Asteraceae at a tallgrass prairie site in Missouri. Because of this and what we know about fire's

effects on nitrogen budgets, we expected that annual fire treatment alone would lead to a decrease in Asteraceae density and no change or increase in Fabaceae density. Because grazing (in our experiment, mowing) reduces C_4 dominance, we expected grazing to lead to a general increase in the density of forb species.

Methods

To investigate the effects of annual burning and mowing on the density of Fabaceae and Asteraceae species, we collected data from Conard Environmental Research Center on the following dates: October 4, 9, 11, 23, 25, and 30 2000. We collected data from twenty plots in the burn experiment, ten each on burn and no burn plots. The burn experiment had been burned every spring since 1997. We also collected data from twenty plots on the mow/burn experiment, five replicates each of burn/no mow, burn/mow, no burn/mow, and no burn/no mow (see Appendix A). Each plot measures ten meters by ten meters, and ten-meter strips of uncontrolled prairie separate each plot from the next. To increase our sample size in the mow/burn component of our experiment, we included data from the ten unburned plots and ten burned plots in the burn experiment.

In each replicate we randomly laid a ten meter transect and counted the total number of stems of each forb family and species within half a meter of the transect.

We calculated the density of, total Asteraceae, individual Asteraceae species, Fabaceae, and individual Fabaceae species in each sample. We ran t-tests on Microsoft Excel to compare density between burned and unburned samples in the burn experiment. We ran an ANOVA on Minitab to compare density between all combinations of treatments in the Mow/Burn experiment.

Results

Effects of fire on Asteraceae:

We found that burning did not significantly influence the density of the family Asteraceae in the prairie (t=-0.14, df=18, p=0.89). Mean Asteraceae density was 4% lower on burned than unburned plots, but is not significant (Fig. 1).

Burned plots had a higher mean density of *Solidago* sp. than unburned plots, but the difference was not significant (t=.52, df=16, p=0.61, Fig 2).

Unburned plots had a higher mean density of *Ratibida pinnata* than burned plots, and burning did significantly influence its density (t=-2.38, df=18, p=0.02, Fig 3).

Effects of fire on Fabaceae:

The family Fabaceae was more abundant on burned than unburned plots (t=2.73, df=17, p=0.01, Fig. 4).

Mean *Lespedeza capitata* density was significantly higher on burned than unburned plots(t=2.52, df=18, p=0.02, Fig 5).

Mean *Baptisia leucantha* density was significantly higher on burned than unburned plots (t=2.63, df=16, p=0.02, Fig. 6).

Combined effects of Mow and Burn on Asteraceae and Fabaceae

Mowing, burning, and the combined effects of mowing and burning had no significant effect on the density of Asteraceae or Fabaceae in the two-factor experiment (Table 1). However, mean *Solidago* sp. and *Amorpha canescens* density were significantly reduced by mowing and not burning or the combination of burning and mowing (Table 1).

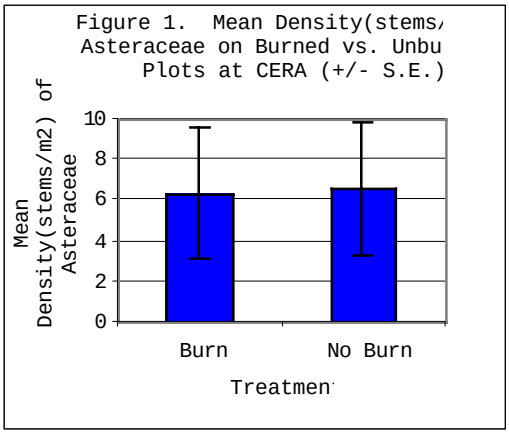


Figure 1. Mean Density(stems/
Asteraceae on Burned vs. Unbu
Plots at CERA (+/- S.E.)
Mean Density(stems/m2) of Asteraceae
10
8
6
4
2
0
Burn
No Burn
Treatmen

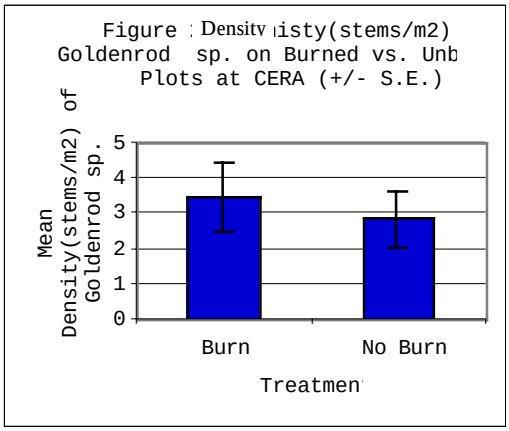


Figure : Density isty(stems/m2)
Goldenrod sp. on Burned vs. Unb
Plots at CERA (+/- S.E.)
Mean Density(stems/m2) of Goldenrod sp.
5
4
3
2
1
0
Burn
No Burn
Treatmen

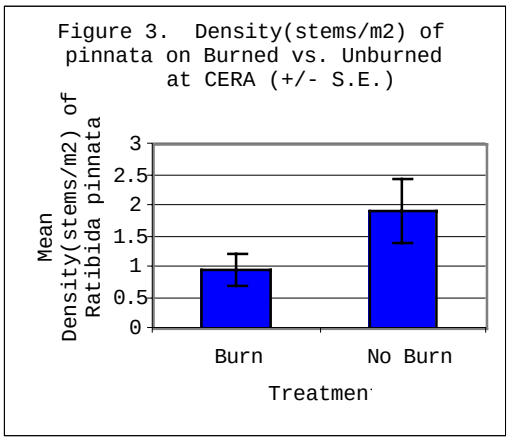


Figure 3. Density(stems/m2) of
pinnata on Burned vs. Unburned
at CERA (+/- S.E.)
Mean Density(stems/m2) of Ratibida pinnata
3
2.5
2
1.5
1
0.5
0
Burn
No Burn
Treatmen

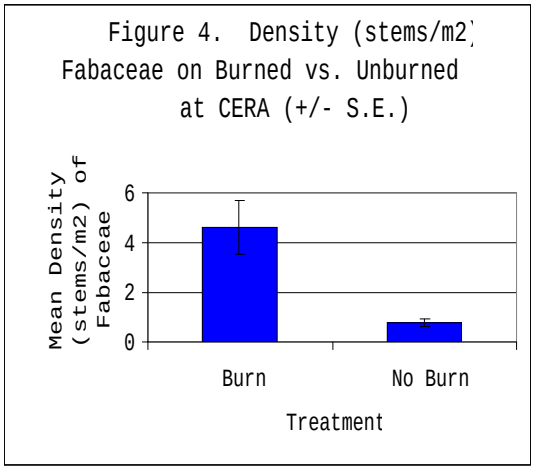
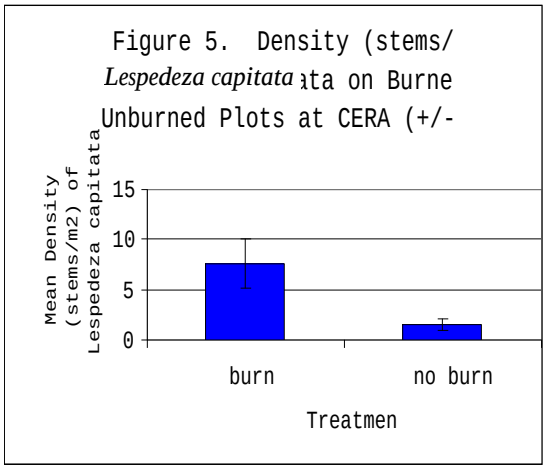


Figure 4. Density (stems/m2)
Fabaceae on Burned vs. Unburned
at CERA (+/- S.E.)
Mean Density (stems/m2) of Fabaceae
6
4
2
0
Burn
No Burn
Treatment



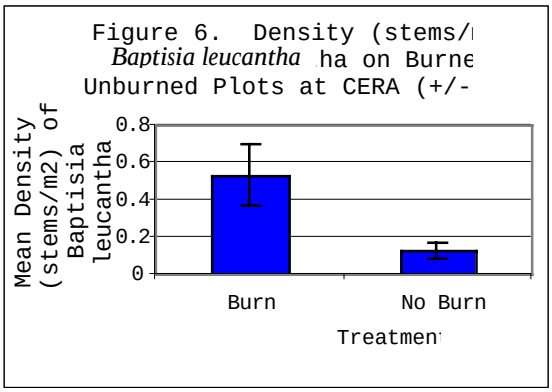


Table 1. Analysis of Variance, using Adjusted SS for Tests

	Burn		Mow		Burn and Mow	
	F-value	P-value	F-value	P-value	F-value	P-value
Asteraceae	0.32	0.575	1.31	0.26	0.05	0.832
Solidago sp.	0.07	0.797	4.56	0.04	0	0.992
Fabaceae	2.4	0.13	1.35	0.253	1.32	0.258
Amorpha canescens	0.17	0.681	4.62	0.038	0.79	0.381

F-value is the ratio of variation among groups to the variation within groups.

Discussion

The Burn Experiment

Our data indicate that the yearly spring burning regime at CERA prairie has a significant impact on Fabaceae but not Asteraceae. Our results showed that Fabaceae was more abundant in burned than unburned plots, so were *Baptisia leucantha* and *Lespedeza capitata*, two Fabaceae species. Kucera and Koelling (1964) found that Fabaceae abundance was not affected by fire but they cited the findings of Whelan (1954) that fire has been shown to increase Fabaceae. Fire decreases the soil nutrient content (Hartnett, 1991). Since most Fabaceae species host nitrogen-fixing bacteria, it makes sense that Fabaceae would have an advantage after fire. Other factors are likely important in determining Fabaceae density. At our site, the prairie is burned every spring before the growing season. This should benefit Fabaceae plants because they generally grow and flower earlier than C_4 grasses and avoid grass competition (Christianson and Muller, 1999). Heat has been shown to increase germination of some Fabaceae species (PBC). This also explains increased numbers on burned plots.

Mean abundance for Asteraceae species was greater on unburned plots than on burned plots, but our data were not significant between burned and unburned plots. However, we also analyzed the individual species *Solidago* sp. and *Ratibida pinnata* and found that fire had no effect on *Solidago* sp. and decreased the abundance of *Ratibida pinnata*. Hartnett (1991) also found that frequent burning reduces *Ratibida pinnata* density. Hartnett suggested that fire increases C_4 grass vigor and density, resulting in decreased soil moisture, decreased nutrient content, and decreased light penetration through the canopy. Howe (1993) found that March fires favored late species such as Asteraceae. Since our study site was burned during the spring before the growing season, Hartnett's effect may have been offset for Asteraceae and *Solidago* sp.

The ability of Fabaceae to fix nitrogen and their time of growth and reproduction gives them an advantage after a fire. Our data for Asteraceae, the largest family on the prairie, shows that, in general, spring burning does not have a significant effect on the prairie. We encourage further study of summer and fall burn treatments and study of less frequent burns, because plants would be impacted at different points in their growth cycle, and effects on soil nutrients with less frequent burns may be different.

The Mow/Burn Experiment

The only significant difference in Asteraceae density in any treatment was a decrease in goldenrod sp. in response to the single factor of mowing, and the only difference in Fabaceae density was *Amorpha canescens* in response to mowing. Our study of Asteraceae and Fabaceae density showed no significant effects from burning or the combination of mowing and burning in this experiment. The decline of these two species because of mowing and the absence of significant change in density for any other species are unexpected. Reduction of dominant grasses is thought to favor the less dominant forbs (Howe 1999). On plots where both burn and mowing treatments were applied, it is possible that these two factors worked against each other to yield the insignificant result.

Mowing may not be truly comparable to grazing. Large grazers tend to graze in large patches (Briggs et. al, 1993). It is possible that within these patches the grazing is more intense, thus compromising the dominant species further. Mowing may have different effects because it is even more general than ungulate grazers are. Reduction of *Amorpha canescens,* for example, could

occur because mowing is too general. *Amorpha canescens* is a shrubby perennial (Christianson and Muller, 1999). Mowing arbitrarily cuts *Amorpha canescens* to a particular height regardless of the coarseness of its stems, but a grazer might avoid eating the woodier parts of the plant. Bison, for example, prefer a diet of grasses (Oakland Zoo). Thus, mowing may unduly reduce the density of *Amorpha canescens* by not allowing it to become a small, woody shrub.

Solidago sp. reduction in response to the mowing factor is difficult to explain. Within the plots included in our study, most Solidago sp. had a tendency to be concentrated into rather dense patches. For example, in plot five, ten plants were recorded, and 127 were recorded in plot seventeen. These plots both received the same treatment. Since our sample size is small for this experiment, missing a patch could account for *Solidago* sp. reduction.

Mowing may have favored forbs to some degree and burning might have favored dominant species to on plots that received both treatments. Our insignificant results on these plots could very well be a result of both factors canceling each other. Burning may have reduced litter, which increased grass dominance, and mowing may have reduced grass dominance by opening up its canopy. Since it is likely that many of the less dominant Fabaceae and Asteraceae family members are at the mercy of dominant C_4 grasses, their net opportunity or loss might have been near zero once both of these factors were taken into account.

Amorpha canescens may illustrate the inability of mowing replicate the influence of grazing. Further scientific study must provide a superior replication or a direct application of grazing if this function is to be clearly defined. Further study of the separate effects of fire and mowing on specific plant characteristics such as reproduction, size, and density would also help to determine where and if these two factors have opposite effects on forb density.

Acknowledgements

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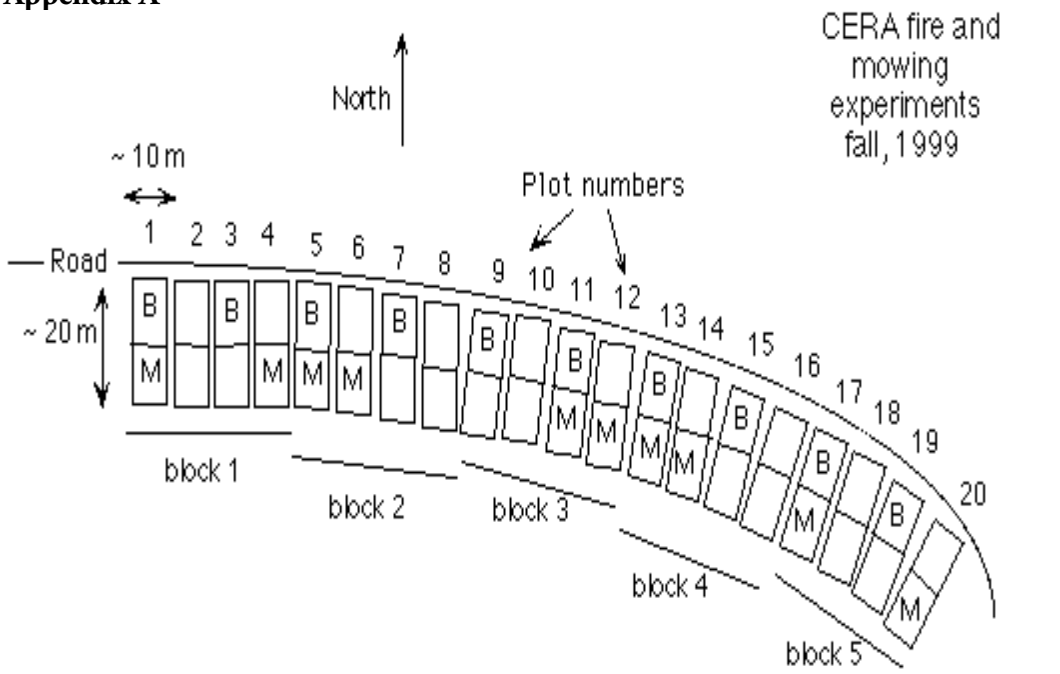
Appendix A



One-factor experiment (1997)

Odd-numbered plots ("B") have been burned every spring since 1997.
Even-numbered plots have been left unburned since then.

Two-factor experiment (1999)

Southern halves of plots (subplots) labeled "M" were mowed in late June, 1999.
Each block of four subplots contains burning and mowing treatments in all combinations.