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The effect of annual burning and mowing on soil fungal richness and abundance

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Abstract

Burning and mowing are management techniques frequently used for prairie restoration, and it is therefore important to understand their effects. This study explores the effects of burning and mowing on the abundance and species richness of soil fungi. Fungi form an important component of prairie communities by both decomposing dead organic matter and enhancing plants' ability to intake nutrients. We collected and cultured 5 cm soil cores from 20 burned and mowed plots at the Conard Environmental Research Area in central Iowa, a reconstructed prairie. We then counted the number of colonies and number of morphospecies on each plate to assess species richness and abundance. We found no significant difference in either variable due to burning or mowing, though the trends support recent studies showing an increase in fungal abundance in burned plots and a decrease in mowed plots.

Introduction

Fire is frequently used as a management technique in restored and remnant prairies due to the role it has played in their evolution. In addition, mowing is often used to remove litter without any of the secondary burn effects, such as changes due to heat or ash (Riechman, 1987). Mowing can also replicate the effects of grazing, in which a decrease in top growth leads to an overall reduction in root growth (Ehrenreich and Aikman, 1963). Thus it is critical to understand the effects of periodic fire and mowing on the biological communities of the prairie.

The value of soil fungi in the prairie community is due to their numerous roles, most notably as mycorrhizal symbiots. The dominant prairie grasses have a mutualistic relationship with mycorrhiza in which the fungi attach themselves to the plants' root hairs. The plant donates carbon to the fungus, and in exchange, the fungus increases the plant's ability to intake and transport soil nutrients including phosphorus, which can be scarce in prairie environments (Wilson and Hartnett, 1997). This relationship is crucial because these grasses would not grow normally in the absence of fungi (Anderson et al., 1994). (Smith et al., 1999). Additionally, fungi play a more complex role as decomposers, as discussed by Harte and Kinzig (1993). Finally, species-specific fungal pathogens may interact with host plants and their competitors to influence growth (Holah and Alexander 1999).

Fungi in all of these roles may be affected by the management practices discussed above, but there is a great deal of disagreement over what effects occur. Eom et al. (1999) found that annual spring burning increases fungal abundance while decreasing species richness. On the contrary, a study by Badia and Marti (2003) indicated that heating soils in an imitation of fire effects significantly decreased fungal abundance. While some studies found no significant differences due to mowing treatments (Eom et al. 1999), other research indicates that there may be more changes in fungivore communities due to mowing than burning (Larimer, personal communication). We expected to find an increase in fungal abundance in burned plots and in unmowed plots as well as a decrease in diversity in burned plots. These hypotheses were in accordance with Eom et al. (1999) and Larimer (unpublished manuscript, 2004), since their studies took place in environments similar to ours.

Methods

We collected soil samples on the established burn/mow plots at the Conard Environmental Research Area (CERA) in late October, 2004. There are a total of twenty plots which are divided into five blocks (Figure 1). Every block has a different combination of burning and mowing treatments which include the following: burn/mow, no burn/mow, no burn/no mow, burn/no mow. The burned plots have been burned annually in the spring since 1997, while the mowed plots have been mowed in the early summer in June, 1999-2003 (CERA website, 2004). Since plots were not mowed in the growing season previous to this study, mow effects reflect long-term impacts of mowing.

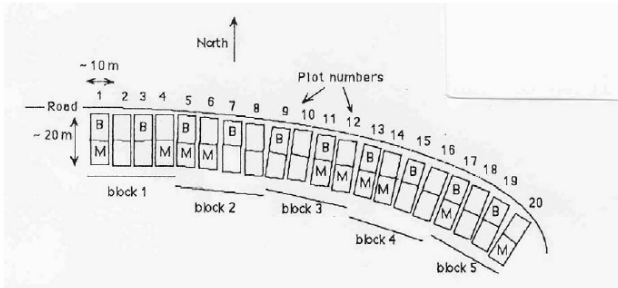

Figure 1: Experimental Burn/Mow plots and CERA

In each plot, we used a soil core collector to extract two 5cm cores from randomly chosen points. We then stored the two samples together in a refrigerator for five days before diluting and plating them. For each plot's dilution we mixed the two cores together thoroughly and set up a dilution series. We added ten grams of the soil mix to 100ml of sterile water, which was subsequently diluted to .01g/ml, .001g/ml, .0001g/ml, and .00001g/ml. By analyzing trial samples from burned and unburned plots, we found that the .01g/ml solution grew the most fungi; therefore, we decided to use this dilution when plating our samples.

.5ml of each diluted solution was cultured on three plates composed of potato dextrose agar treated with 200μg/ml chloramphenicol to inhibit the growth of bacteria. After 48 hours of incubation at 25°C, we counted both the total number of identifiable colonies on each plate and the number of different morphospecies present. Because we did not have the resources to identify different fungal species, we identified morphospecies, defining them by colony size and shape, color, edge morphology, and texture. We analyzed our data using a two-way ANOVA with an interaction term.

Results

All plates were successful in growing fungal colonies with the exception of the three plates with the solution from plot 18. We ran another experiment on all of the plots in block 5:17-20 in which we used the same soil samples. All of these plates grew more fungi than in the original experiment. We concluded that the lack of fungi on the plot 18 plates was due to experimental error rather than variations in the soil; therefore we have omitted the data from these plates from our analysis.

ANOVA revealed no significant treatment, block or interaction effects, either in number of species or number of colonies (Figures 2 and 3).

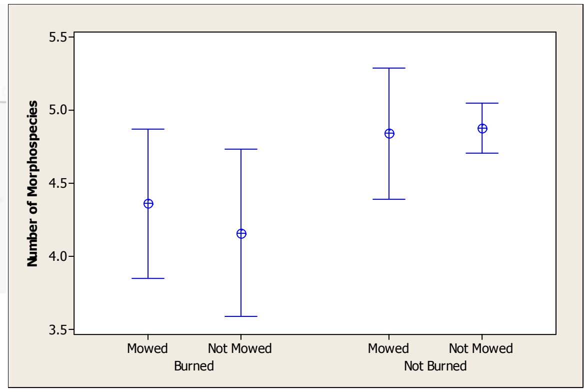

Figure 2. Interval Plot of Number of Morphospecies versus Burn/Mow Treatments. Bars are one standard error from the mean.

The number of colonies in unmowed-unburned plots had the highest coverage since plots burned or mowed had lower means. Burned plots had slightly lower means for morphospecies richness.

Discussion

Because our data did not indicate significant differences between treatments, we cannot draw any definitive conclusions. However, if we compare the general trends in the data to existing literature we find that our results agree with multiple studies conducted in the past. Eom et al. (1999) found that burning decreased species richness; their study also found that certain species of mycorrhizal fungi have a strong relationship with specific species of C4 grasses. Since other studies (Towne & Kemp, 2003) have indicated that the dominance of C4 grasses is increased with burning, it is possible that certain types of fungi become more common or dominant as well, simply because they are linked to these grasses. Unfortunately our conclusions

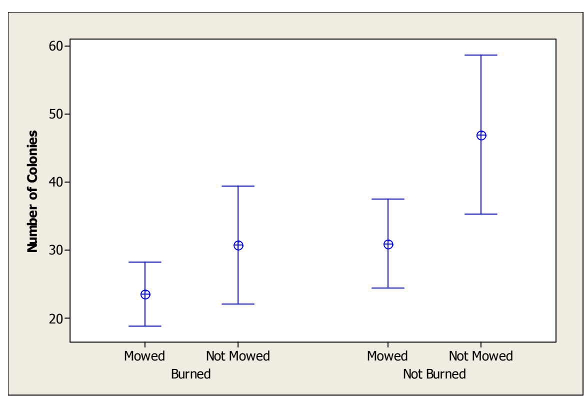

Figure 3. Interval Plot of Number of Colonies versus Burn/Mow Treatments. Bars are one standard error from the mean.

may be confounded by the multiple roles of fungi. For example, there are few studies on the effects of burning on decomposers in the prairie ecosystem, so we are unable to fully understand the observed trends.

We also observed fewer fungal colonies in burned plots. A study by Badia and Marti (2003) found that heating soils to imitate burning significantly decreased the colony forming units of fungi, while adding plant ash had no effect. Therefore it is probable that this difference is due to the higher soil temperatures rather than the chemical effects of burning.

In most studies it appears that mowing does not have a significant effect; however Larimer, (unpublished manuscript, 2004) in another study at CERA, found that fungivores were significantly more common in unmowed plots, suggesting a similar abundance in fungi. One possible reason may be that plants which are frequently grazed or mowed can reduce the amount of carbon they donate to mycorrhizal symbiots (Eom et al., 1999). This reduced benefit could cause lower levels of fungal colonization.

Even if there are no significant differences in fungal richness or abundance due to burning and mowing, there may still be key differences in the fungal communities. We did not take into account which species were found in each treatment, so there may have been a difference in the composition of the fungal communities. For example, Azaz and Pekel (2002) found no significant difference in abundance between burned and unburned areas, but did find a difference in the taxa of each location. Further research at CERA might explore the species of fungi found in different treatments or the burn/mow effects on plants in relation to fungal communities.

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