St. Olaf College

Local Ecology Research Papers

Comparing the productivity of prairies with varying recent burn times

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2020

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Comparing the Productivity of Prairies with Varying Recent Burn Times

Field Ecology 371

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November 17, 2020

Abstract

Many research studies have been done on the effects of burning prairies and their productivity. The burns result in clearing out dead plant material and prevent the growth of trees and shrubs. The biodiversity composition of the prairie changes after a burn and must regrow. In this study, we sought to see different proportions of forbs compared to grasses in each prairie examined. We chose three prairies in the St. Olaf College Natural Lands that were burned a varying number of years ago. The prairies were burned in 2016, 2017 and 2018. The productivity of the prairie was evaluated by comparing soil and above-ground biomass samples. The highest percentage of forbs was found in the prairie that was burned in 2017. The site by the pond, burned in 2018, had intermediate levels of forbs and grasses and the highest average percent moisture and percent organic matter. The lowest percent of forbs was found in the 2016 burn site that had lower levels of soil moisture and organic matter. The variations shown in this study indicate that the St. Olaf Natural Lands will continue to see biodiversity in the organisms that inhabit the prairies.

Key Words: prairies, forbs, grasses, prairie burns, biodiversity

Introduction

Prairies play a critical role in the makeup of Minnesota ecosystems. Tallgrass prairies can provide habitat for many species of insects and birds (Environmental Quality Board 1998). They also offer a diverse group of plant species, such as grasses and forbs, that some grazing animals feed on. These plants are able to exploit nutrients and water efficiently despite the scarcity of water. Because of their deep root systems, prairie plants are used to control soil erosion. Despite the benefits that this ecosystem provides, there is still an extreme loss from Minnesota's original prairie. In 1847, it was recorded that Minnesota had eighteen million acres of prairie and now a little over one percent of that native prairie remains (Environmental Quality Board 1998). The health of these remaining prairies relies on frequent fires in order to prevent buildup of dead plant material and growth of trees and shrubs. Prairie burning leads to patches of burned and unburned land but this provides diversity of habitat. The practice of burning prairies came from the knowledge of Native Americans and provides greater productivity of the prairie specifically, getting rid of plant detritus and maintaining lower levels of soil moisture.. When burns happen in late-spring, there is a subsequent increase in warm-season grasses and the growth of forbs decreases. Also, there appears to be a change in the nitrogen availability post-burn (Tester 1996). The increase in nitrogen availability may affect the invasion of certain plants. Research into the differences among restored prairies could provide insight into what species are found in prairies at different successional stages.

The objectives of this research were to collect more data on the contents of the 1993 prairie, the spring 2003 prairie, the 2004 prairie. We also sought to compare the biomass composition of the prairies at different stages of regrowth and the soil qualities from various sites. The soil qualities examined were the percentage of moisture, bulk density and percentage of organic matter.

Methods

This research was conducted in three different prairies within the St. Olaf College Natural Lands. The 2003 prairie specifically north of North Eaves pond, referred to as “loop”, was last burned in 2016. The 2004 prairie south of prairie loop, referred to as “bench”, was last burned in 2017. The 1993 prairie that is north of Big Pond, referred to as “pond”, was last burned in 2018. Each site was transected by two 40 meter transect lines from a random point adjacent to the trail (Figure 1). In each transect, three biomass samples were taken by using a 50x50 cm square frame. There were 6 plots in each prairie and 18 plots overall. Some of the prairie biomass samples were collected on October 17, 2020 and the others including the soil samples were collected on October 31, 2020. The second round of prairie biomass was collected after the first major snowfall of the year and after it melted.

Collecting Prairie Biomass

Loppers were used to cut the grasses down to about 10 centimeters above the ground, to ensure that past year's growth is not included in our measurement. The labelled bags of biomass were placed in the drying oven at 65ºC for 48 hours. Following the drying, the biomass was sorted into forbs and grasses and weighed. Then the percentages of forbs and grasses in each sample were calculated by utilizing the total weight of the biomass collected at a plot. The data were analyzed using one-way analysis of variance tests based on the site.

Collecting Soil Samples

In each transect, there were 2 soil samples taken for a total of 12 samples. The samples were taken at the site that was 1 meter from the trail and the site that was 40 meters from the trail. A soil corer was used to extract a constant volume of soil at each plot. The soil was brought back to the lab in plastic bags and placed in a soil tin and weighed. Then the soil was placed in the drying oven at 105ºC for 48 hours. After drying, the tins were weighed and calculated the percent moisture lost from the soil. Percent moisture was found by subtracting the dry weight from the wet weight and dividing by the dry weight of the soil and multiplying by 100 to get a percent. Another measurement that was calculated was the bulk density. Every soil sample was taken to the same point on the soil corer so we were able to calculate the volume (=area x height). Next, we needed to calculate the soil's organic matter and so we used the method outlined in the laboratory manual written by Brower, Zar and von Ende (1998).The dry weight was calculated and then the soil was put through a 2mm sieve. Somewhere between 5 and 7g of sieved soil was then placed in a crucible that went in the muffle furnace. The samples were in the furnace for 4 hours at 550ºC. Following that process, the samples were weighed and the dry weight was used to calculate the percent of organic matter. This was the weight prior to the muffle furnace subtracted by the weight after and that value was divided by weight before the muffle furnace.

Data Analysis

After calculating all values, statistical analysis compared biomass and soil characteristics to see if there were differences between the sites. A variety of one-way analysis of variance (ANOVA) tests were run using the R commander module in R statistical software.

Results

Analysis of prairie biomass

The first test examined the results that were found from the prairie biomass collections in each site using one-way analysis of variance (ANOVA). We discovered that the percentage of grasses and forbs collected from each site was statistically significant (p= 4.36E-6). The highest proportion of forbs (76.903) in a site was found at the bench (2004 restoration) and the highest proportion of grasses (94.28) was at the loop (2003 restoration).

Analysis of soil samples

As previously mentioned we calculated the percentage of moisture, bulk density and percentage of organic matter in each soil sample. A one-way ANOVA was run to compare the percentage of moisture based on the site of the sample. The test showed no significance ($p=0.233$) between the percentage of moisture content and the sites (Table 1). The bench (2004 restoration) and the pond (1993 restoration) site had similar percentages of moisture around 33%. Another quality of the soil was the bulk density. The bulk density and site one-way ANOVA did not indicate any significant differences between the bulk densities at the various sites ($p=0.354$). However, interestingly, we ran a one-way ANOVA comparing the bulk density and the plot, which indicated the distance away from the trail, and found significant results ($p=0.0446$). The bulk density calculations were lower at sites that were farther away from the trail (Table 2). Lastly, we compared the percentage of organic matter in each soil sample with respect to the site from which they were collected. The highest average percentage of organic matter (5.58) was found at the pond (1993 restoration) site. There was a significant difference between the percentages of organic matter at each site ($p=0.0434$). There was no significance between the percent organic matter and the distance of the plot from the trail.

Discussion

Our Findings

The results indicated that there were varying compositions of biomass across the sites that were burned at different times. However, the results did not follow the trend that we expected to see pertaining to the most recent burn history. We expected to see a relationship between the years since previous burn and the proportion of forbs found at the site. I expected that the prairies that were burned longer ago would have the highest percentage of forbs and recently burned sites would have high percentages of grasses. However, this is not what we found. There was no clear trend between the time since last burn and the composition of the biomass. The most recent burn site (pond/2018) had 69% grasses and 32% forbs. The second most recent burn (bench/2017) had 23% grasses and 77% forbs breakdown. The site with the longest time since last burn (loop/2016) had majority (94%) grasses and only 6% forbs. Since there was no connection between prairie composition and burn time, we must speculate other possibilities for this outcome.

As previously mentioned, the bulk density was lower at the plots that were farther from the trail. The plots closer to the trail had a higher bulk density because of the disturbances caused by humans on the trails. Another pattern that was recognized showed that the percentage of organic matter was higher in the older prairie. Together these findings indicate that burn time and the age since restoration will impact the growth and biodiversity of a prairie.

Research found in literature

One aspect of consideration is the history of each of the sites before restoration. Two of the sites were restored within a year of each other and the third site was 10 years older than that. Prior to restoration, these sites were used for agriculture and so the current composition may be related to the past crops sown in that site. In addition, a study conducted by Briggs and Knapp (1995) found that there was a negative correlation between the forb net primary productivity (NPP) and grass NPP. Their study looked at the effects of meteorological patterns on the NPP of prairies. Briggs and Knapp speculated that the difference in grass NPP and forbs NPP came from recent drought events. They noticed that with a decrease in soil moisture there was also a reduction in grass NPP and conversely, forbs responded positively to the reduction in competition (Briggs and Knapp 1995). The study found that drier soil occurred after burns and thus some forbs were able to slightly outcompete grasses and there was variation in the plants among each plot. However, the Minnesota Department of Natural Resources' information about prairies discusses that forbs are often found in wetter plots of prairie because they need more moisture to flourish (Environmental Quality Board 1998). Our results aligned closest with the DNR's prediction because the wetter two plots had moderate to high percentages of forb biomass. I believe that more research should be placed on the role of the soil contents on the prairie plants. Our soil data was possibly incorrect because our samples were collected following lots of snow melting and so the moisture content in our study may not indicate the average moisture of the soil at each site.

A separate aspect that could contribute to the difference in the biomass composition is the season that the prairie burn occurred. In a study conducted by Towne and Craine (2014), it was recorded that various seasonal burns can be closely related to higher biomass yields of certain species. For example, the study discovered that early spring burns favored the growth of cool-season grasses and forbs (Towne and Craine 2014). But, prairies burned in the spring also rely heavily on precipitation during a narrower window of time than the prairies burned in the autumn. The plots we studied were all burned in the spring but they each were burned in different years and so their productivity relied heavily on the precipitation that fell in the season following their burn. The loop prairie, which was last burned in the spring of 2016, may have a different composition of forbs and grasses because of the precipitation levels of the season following the burn.

Another objective pertaining to the study was to discover more about the species that were growing in the part of the 2003 (loop) restoration site that was burned in 2016. As indicated by the prairie biomass, we notice that this site was particularly heavy with grass biomass. From solely observation, it seemed as if the 2003 site was less dense with biomass than the other two recorded. The compositional change could be attributed to the positioning of the plot compared to the others. The site is along the edge of the prairies of the St. Olaf Natural lands and so the added disturbances could cause a different trend in biomass than other parts of the natural lands.

Further Research

Within my research this semester there were some limitations but I think that these shortcomings can be brought into further research. I believe that one thing that could be modified was the way in which I sorted through the forbs and grasses. Due to unforeseen circumstances, I was unable to identify and separate my prairie biomass before it underwent drying in the oven and thus some of the plants were difficult to identify. I think that it would be very interesting to gather more biomass from the prairies and then sort the various plants prior to the drying process. An additional step could be to separate them into different species from the larger two categories of forbs and grasses. It would be intriguing to evaluate the diversity of the prairies and learn more about what kind of plants are growing out there. In addition to the further classifications of plants, I believe it would also be helpful to run tests on the soil samples to determine more about the nutrients in the soil. Learning more about the nutrients could provide insight into why certain species are growing in the natural lands.

Conclusions

The study depicted in this paper did not find overwhelming evidence leading to clear trends, however, there is potential. The study showed that there is a difference between the plant compositions of prairies burned at different times and that soil characteristics may have as much or more influence on plant composition than time of last burn. As mentioned before, biodiversity is an important aspect of prairies as they serve as habitats to small mammals, rodents, insects, birds and others. The St. Olaf Natural Lands will continue to see more growth in the biodiversity of the plants found in the prairies because of regularly scheduled burns and a variety of soil properties. Diverse habitats allow for a wider array of educational opportunities as well providing benefits to the other organisms in the prairie ecosystem.

Acknowledgments

I would like to thank Professor Kathy Shea for her patience and her numerous hours of help and guidance as I developed this project. In addition, I want to thank my friends who served as data collection assistants: Grace Peacore, Solveig Gordon and Summer Reid.

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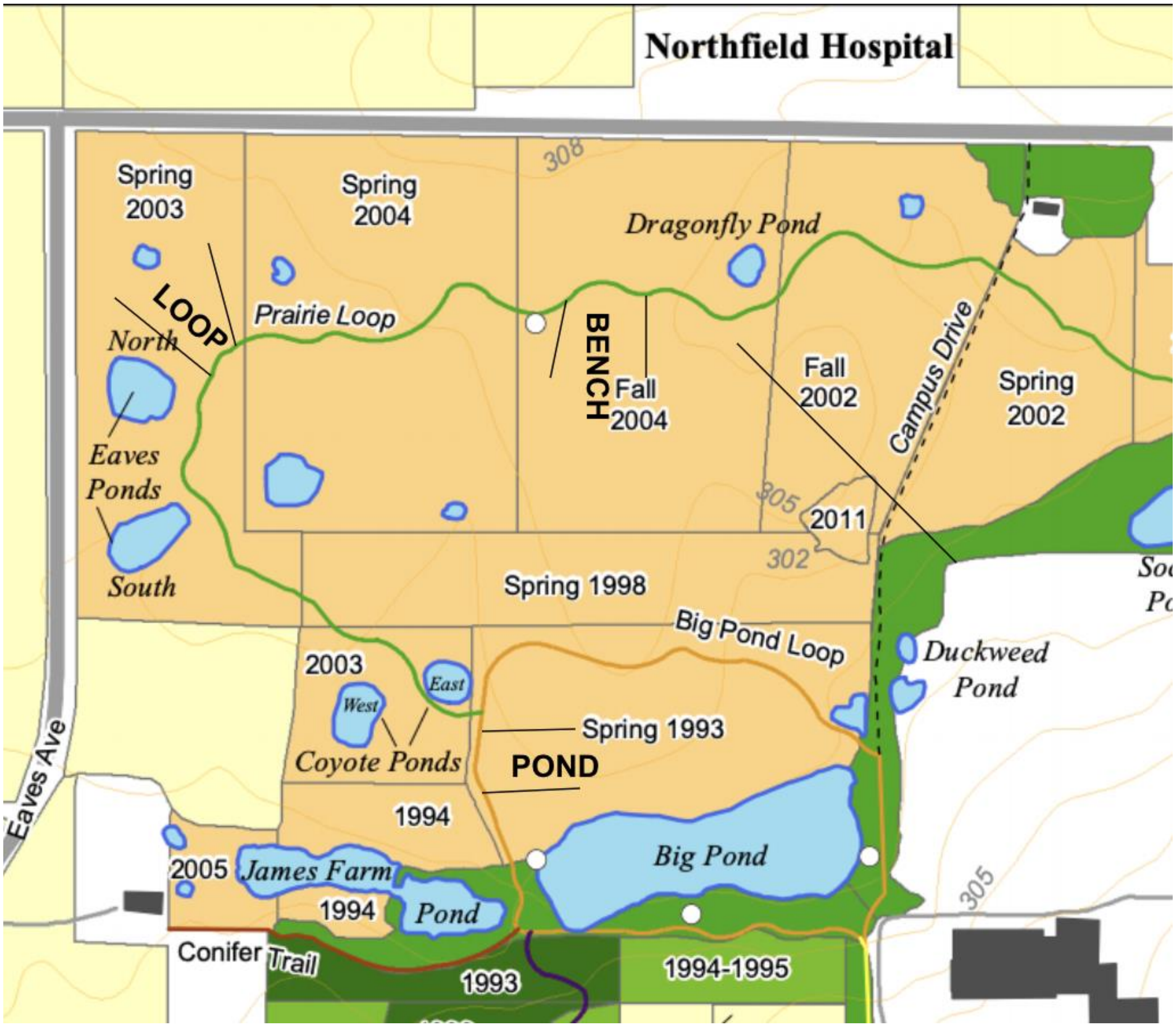

Figure 1: Map of various sites utilized in St. Olaf Natural Lands

Each of the three sites used are indicated on the map by the reference name. In each site, there are two 40 meter transect lines on either side of the label of the site.

Table 1: Comparing the variation of means in soil qualities as a function of the sampling site: This table shows the means of different calculations pertaining to the soil. The p values, f-values and number of samples will be included below to understand the relationship between the characteristics and the site. Percentage of moisture and site: p-value=0.233, f-value=1.723, df=2 and n=4. Bulk density and site: p-value=0.354, f-value=1.167, df=2 and n=4. Organic matter was significant with a p-value=0.0434, f-value=4.536, df=2 and n=4.

	Pond	Bench	Loop
Moisture (%)	34.93	34.11	19.43
Bulk Density (g/cm^3)	1.31	1.23	1.42
Organic Matter (%)	5.58	4.21	2.42

Table 2: Comparing variations of means in soil qualities as a function of the distance from the trail (A is 1 m from trail and C is 40 m from trail): This table contains similar information to Table 1 but instead, compares with the location of the plot within the site. Percentage of moisture was not significant: p-value=0.135, f-value=2.648, df=1 and n=6. Bulk density was found to be significant with p-value of 0.0446, f-value=5.266, df=1 and n=6. Finally, the percentage of organic matter was not found to be significant: p-value=0.701, f-value=0.156, df=1,n=6.

Plot	A	C
Moisture (%)	35.68	23.3
Bulk Density (g/cm^3)	1.22	1.42
Organic Matter (%)	4.29	3.84

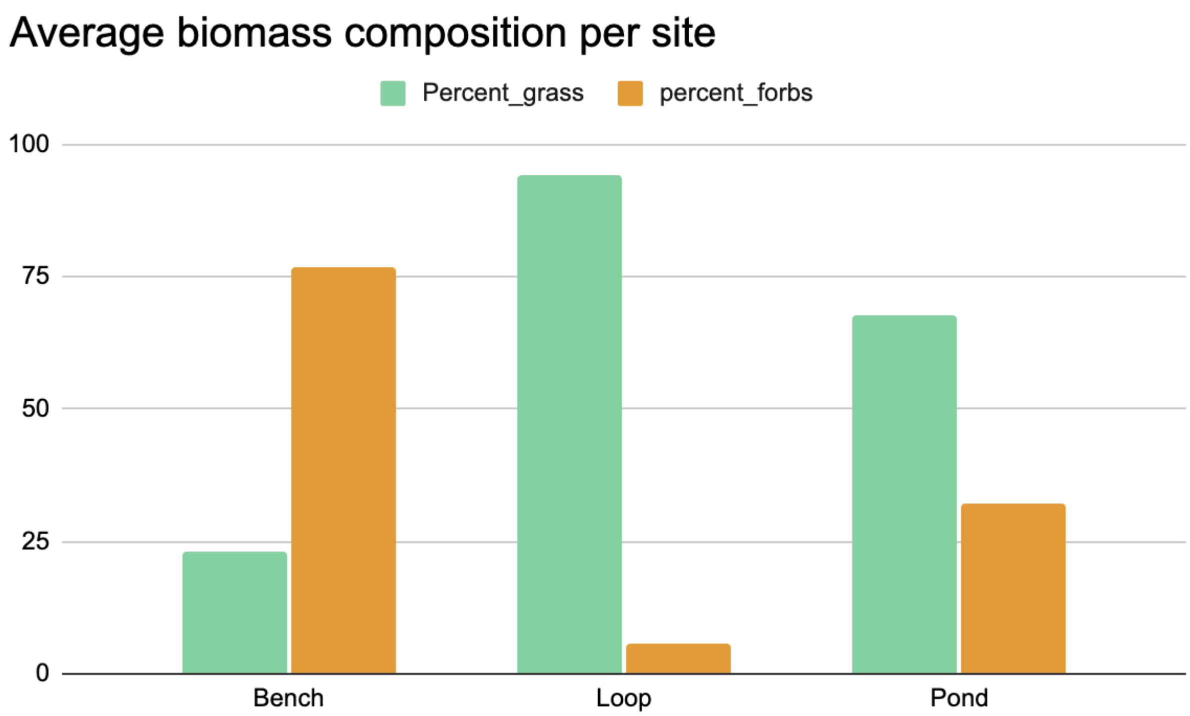

Figure 2: Comparison of the average percentage of grass and forb biomass as a function of site.

The x-axis represents the different sites and the y-axis displays the percentage. The highest percentage of grass was found at the loop site and the highest percentage of forbs was found at the bench site. The ANOVA test indicated significance in the organic breakdown at each site location (p= 4.36E-6).