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A field investigation on vegetation cover, density, and soil chemistry differences of Spring--and Fall--prescribed burnings

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A field investigation on vegetation cover, density, and soil chemistry differences of Spring- and Fall- prescribed burnings

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Abstract

Prescribed burning, a type of vegetation management tool, controls native plant and weed growth by eliminating entire plots of vegetation, in turn providing a better growing environment for the next generation while also keeping foreign vegetation at bay. Seasonal differences in temperature play an important role in controlling plant growth. Cooler temperatures, for example, that arrive come fall signal plants to reduce growth and energy usage, and as temperatures get warmer, plants are then signaled to grow again. Two different sites that underwent prescribed burning at different seasonal times, one on November 2016, and the other on March 2017, were studied. Both sites were observed for differences in % vegetation cover and density using twelve, 3-cm PVC tube-constructed quadrats. Further soil analysis from both burn sites was done to note differences in soil chemistry, including soil pH, potassium, and phosphorous concentrations in kg/ha. This study demonstrated higher % vegetation cover and density averages for the March burn site, but also highlighted minimal differences in soil chemistry between both sites. One recommendation for future experiments would be to plant identical vegetation into both sites and conduct a prescribed burn, with one site burned in the fall and the other in the spring. By doing so, differences in vegetation cover and soil characteristics would be more easily identifiable.

Keywords: *Prairie, Prescribed burning, Vegetation cover, Soil characteristics, Seasonal difference*

Introduction

Prescribed burning is considered one of the best management tools for continued invasive plant control, and is used for a variety of reasons. Initially, prescribed burning of plant vegetation was introduced in Europe to induce a controlled fire regime, which counteracted the then disappearance of biomass-consuming land management practices (Alcaniz et al. 2006). The primary benefit of burning was then noted to maintain the health of an existing area containing native plants by providing more nutrients, while also managing weeds and other growth (Matthews 2015). Likewise, in a study conducted on a Louisiana prairie that underwent prescribed burnings, averaged data of extractable calcium, magnesium, sodium, and phosphorus concentrations were significantly higher than if they were clipped or not burned at all (Jariel et al. 2004). One factor affecting the impact of prescribed burning on plant life is fire intensity. Low to moderate intensity fires promote rejuvenation of the dominant vegetation by eliminating an undesired increase of pH, and leading to more available nutrients. Fire intensity, moreover, may not have strong effects on plants during the dormant season because dormant seeds do not have to rely on outside minerals and nutrients, which can be lost through burning. Environmental factors that strongly control the fire intensity include moisture of the soil, air temperature and humidity, wind speed, and topography, which can all weaken the intensity of the fire and affect the combustion process (Certini 2005). Furthermore, natural heat treatments through burning could reduce seed dormancy in a way like artificial heat treatments: by breaking down the seed coat and increasing imbibition. Similar observations note that natural heat treatments become more effective in reducing the seed-coat dormancy of older seeds with weaker seed-coats than new seeds with hard seed-coats (Round et al. 1988).

Along with prescribed fires, seasonal changes have strong effects on plant growth. Cooler temperatures in fall will trigger a variety of plants to reduce growth and store energy, and as the temperature approaches freezing, growth stops and the plant could become dormant (Matthews 2014). Not only does cold temperatures affect a plant's development, but precipitation changes in spring and summer factor in as well. Studies have shown that extreme precipitation, which occurs mainly in spring and summer, decrease the above-ground production of plants in sites containing a moderate amount of moisture. Thus, if plants that are optimized for moderately moistened soil are introduced to an over-abundant amount of water, they tend to be negatively affected in growth (Zeppel et al. 2013).

Initial research on the association between prescribed burning and the effects of seasonal changes on plant growth has noted a relationship between plant development when burning is closer to spring, and soil chemistry in plants burned in both fall and spring. During the spring season, prescribed burning in lowland sites have been shown to produce significantly higher grass biomass than autumn and winter burnings (Gene Towne et al. 2003). A higher grass biomass could indicate higher vegetation count; thus, it is possible spring burning can produce more vegetation than autumn burnings. Not to mention, having optimal soil moisture can have a positive effect on seed germination and plant growth when xylem tissue is operable. As a vascular tissue of many plants, xylem tissue conducts most water and minerals, thus it provides better benefits when soil moisture is optimally abundant. According to a study of xylem water potential in perennial grasses in a North American fescue prairie, leaf xylem water potential and stomatal conductance were lower in plants the year after being burned in the fall in comparison to spring burning, with declines over the growing season. Soil moisture generally was greater in plots burned in the spring than those burned in fall (Grilz et al. 1994). Based on these facts, having a higher xylem water potential would lead to a more efficient transport system in the vegetation, connecting to better benefits of spring burning because the increase in both soil moisture and xylem water potential will create an optimized environment for more seeds to grow. In turn, as more seeds grow, population of the native plant will further increase. More so, immediately after a prescribed fire, research has shown that total Carbon, Nitrogen, Phosphorous, Potassium, and other essential plant nutrients significantly increased, highlighting the benefits for the next generation of vegetation (Alcaniz et al. 2006). In fact, prescribed burns on plant life has been correlated with increased soil inorganic Nitrogen availability throughout the growing season, which is associated with increased soil temperature and reduction in above-ground Nitrogen (Augustine et al. 2014). Thus, an investigation was conducted to test for differences in % vegetation cover, density, and soil chemistry between sites that underwent prescribed burning during the dormant season on November and March. We predicted that by burning plant vegetation closer to spring-time, the % cover and total density per m^2 will be higher than if it is burned closer to fall. Furthermore, we also hypothesized that through prescribed burning, nutrients along with soil chemistry in both fall and spring burnings will positively increase with little difference between each other.

Methods

Our experiment was conducted on the Russel R. Kirt prairie site on the College of DuPage campus, which occupies about 7 ha of land and has been burned every 1-2 years for the past 20-30 years. Two sites of interest were analyzed within this prairie. The first site was burned on November 12, 2016, while the second site was burned on March 3, 2017. Data was collected on the % cover and total density of varying plots in both sites on April 4th, 2017. Data collection was done by creating a 1-m^2 quadrat using 3-cm PVC tubes and meter sticks, which added to a total of 12 quadrats per site due to 6 groups creating 2 quadrats each. Each of these quadrats were randomly sampled at least 2 meters apart. Within each quadrat, % cover was calculated by estimating the percent of vegetation covering each quarter of a quadrat, which was then averaged together to create a total % cover for the entire quadrat. Similarly, plant density was ascertained by counting all newly emerged plants within quarters of a quadrat. Then, each value was summed to find the total density per 1-m^2 quadrat. Additionally, 2-3 soil samples from both November and March burn sites were collected and analyzed on the date of March 23, 2017. Using the LaMotte® soil macronutrient test kits, soil samples were mixed with acetic acid extract solution, in which extracts were analyzed for relative concentrations of Phosphorous, Nitrite, Nitrogen, and Potassium. Soil pH levels were tested directly mixing soil with a pH indicator and comparing to color charts.

To test for significance in % vegetation cover, density, and soil chemistry, a 2-sample Student's t-test assuming unequal variances was conducted. Significance was further determined at $\alpha = 0.05$.

Results

Observational data:

At the time of data collection for % cover and total density per m^2, the forecast was cloudy with a temperature of 11.7°C. The vegetation of the November burn site had a higher number of seed sprouts than the March burn site, but did appear smaller in height. The soil of the November burn site was littered with numerous dead twigs, wood pieces and small rocks, in addition to being moderately dry. On the other hand, the vegetation of the March burn was observed to have much more seed sprouts in addition to some appearing taller than those at the November burn site. The soil of the March burn site contained more moisture due its soft and adhesive characteristics. More so, the March burn site contained dead twigs, wood pieces and small rocks, but not as numerous or extensive as the November site.

In accordance to observed data, the mean average and standard deviation of the vegetation cover for the November burn site was 4.76 +/- 2.8935, while having a mean average and standard deviation of 68.67 +/- 36.104 for its density. More so, the mean average and standard deviation of the vegetation cover for the March burn site was calculated at 6.78 +/- 11.434, in addition to a mean average and standard deviation of calculated density at 279.83 +/- 167.648.

Table 1. Data from conducted t-test assuming unequal variances among the % vegetation cover for both November and March burn sites

	November burn % cover	***March burn % cover***
Mean	4.755416667	6.78125
Variance	8.472425947	30.88103693
Observations	12	12
Pooled Variance	19.67673144	
Hypothesized Mean Difference	0	
df	22	
t Stat	-1.118672234	
P(T<=t) two-tail	0.275346436	
t Critical two-tail	2.073873068	

Comparing the vegetation cover for the November and March burn sites (***Table. 1)***, I conclude that there was not a significant difference in the means between both groups (t= 1.119, df= 22, P= 0.275). In contrast, in terms of the densities of both November and March burn sites, there was a significant difference in the means between both groups (t= 4.266, df= 12, P= 0.0011)

Table 2. Soil Chemistry and pH of November and March burn sites in kg/ha

	November Average Values	*March Average values*
NO2	1.12	1.12
NO3	11.21	12.68
P	117.69	104.61
K	127.03	112.09
pH	7.167	7.5

Additionally, individual ions and pH were tested for significance from three soil samples of both November and March burn sites (***Table 2***). Results of the conducted 2-sample t-test led to the conclusion that there was no significant difference between the P concentrations in kg/ha of the two burn sites (t= 0.414, df= 3, P= 0.707).

Discussion

Primarily, data taken on the vegetation cover for both sites demonstrated that the November burn site yielded a reduced average value of 4.76, while the March burn site yielded a value of 6.78. Not only did the March burn site yield a higher value in its vegetation cover, but its data collected on quadrat density from all 12 quadrats yielded an average value of 279.83, while the November burn site yielded an average value of 68.67. These findings thus supported my first hypothesis by highlighting the increased value output for both % vegetation cover and densities from the March burn site in comparison to the November burn site. One factor attributing to the March burn site providing higher average values could be that the native plants are warm-season plants (C4 plants). These plants mainly grow in warmer temperatures, and since burning provides needed nutrients for the next generation of plants, prescribing a spring burn on warm-season plants would in theory provide seeds nutrients at the time when they will start growing. By doing so, nutrients would be fully utilized. If warm-season plants had undergone prescribed burning in cooler temperatures, as done on the November burn site, then by the time vegetation begins to grow, necessary nutrients provided from the burning might have been lost due to the time difference between regular plant growth and burning. Another factor that positively affected the March burn site more than the November burn site was that some native plants of the March burn site were dormant for a shorter time due to the prescribed burn. As stated before, fire treatments may break down the seed coat and reduce dormancy, such that these plants may have perceived the environment to be optimal to begin germination. Along with the fact these native plants were nearing the end of their dormancy, prescribing a burn during the spring season would allow native plants to shorten the length of the dormant stage.

Although both burn sites differed in % vegetation cover and density, there was no significant difference in soil chemistry, supporting my second hypothesis. In comparison, November and March sites were very similar, but both did slightly differ in some chemical compounds, as shown in **Table 2**. A factor keeping the soil chemistry of both sites similar could have been the decomposer diversity. If both sites contained similar decomposers that functioned at the same speed within their respective soil, then the November burn site should have had lower concentrations of all soil nutrients while the March burn site concentrations would be higher. Due to the November burn site being similar in most soil characteristics, its decomposers optimally would work slower as to not take away most soil nutrients necessary for vegetation to grow, in turn displaying similar soil characteristics as the March site at the time of data collection.

One recommendation for further exploration into the differences of prescribed spring- and fall- burning would be to plant the same vegetation into both sites, and then conducting the burn. By doing so, plant vegetation would act as the controlled variable, possibly allowing for better indications of soil chemistry changes and more prominent differences in plant height, % vegetation cover and density. Within this experiment, little knowledge was known about the different plant vegetation native to these sites, therefore by using known vegetation, differences would be more easily noticeable.

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