Prairie Grass Restoration: A Three Year Plan

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An Undergraduate Thesis
Submitted in Partial Fulfillment for the Requirements of
Bachelor of Arts
in
Environmental Science: Conservation and Ecology

Carthage College
Kenosha, WI
May, 2017

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Abstract

With the rise in prairie grass restoration projects knowing the ideal growing conditions and grasses to plant in order for a successful restoration is very important. Prairie grass can have many benefits for the environment which is why many prairies were destroyed for farmland for their fertile soil. In the summer of 2016, a prairie restoration project was started but ultimately was not completed due to the site being taken over by Crabgrass. The site was treated with Roundup before the site was planted with Big bluestem grass. In order to find out why the Crabgrass grew on the site, a study was started at Carthage College to test some of the factors that could have attributed to the growth. The growth rate was first tested by growing Crabgrass, Big bluestem, and Buffalo grass and then mixing the grasses to observe which grass was able to outcompete each other. Next, treatment of the site was tested by treated Crabgrass plants with an herbicide treatment or burn treatment. Then, Buffalo or Big bluestem grass were planted and observed to see if the Big bluestem and Buffalo grass or Crabgrass would grow. It was found that Buffalo grass can reach a mature height more quickly than Big bluestem and Crabgrass which means that planting Buffalo grass will help ensure that prairie grass will grow on the prairie restoration site. It was also found that a burn treatment allowed for more planted grasses to grow instead of previous vegetation.

Introduction

Tallgrass prairie once covered 170 million acres of North America. (NPS, 2016) Most of the tallgrass prairies were plowed and destroyed with the invention of the plow by John Deere in 1837. (Drache, 2001) Now, less than 4% of tallgrass prairie land remains. Prairie grasses are capable of supporting a large biodiversity and have many benefits such as conserving soil, storing carbon, and serving as a highly populated wildlife habitat. (Sinnett, 2014) Having fields of prairie grasses rather than the traditional turf grasslands could lead to better soil and water conservation. With the increase in drought, conserving water is becoming more and more of a necessity. Tall grass prairies also require less maintenance than normal grasslands which could lead to the reduction of greenhouse gasses. This maintenance includes weeding, watering, fertilizing, and mowing. By restoring prairies less maintenance would need to be done in order to maintain the property.

Over the summer, a prairie grass restoration project was attempted on an acre of grass in the Village of Lena, Illinois at the Lena Burial Park. To accomplish this an acre of land was first treated with Roundup, an herbicide, to kill any existing vegetation on the site. Then, Pheasants Forever, a conservation group, planted the Big bluestem prairie grass seed mix into the acre of land. In the beginning, it seemed as if the restoration was a success with many different types of immature plants growing on the site. Eventually, it became clear that the intended prairie plants were being outcompeted by Crabgrass. Crabgrass, being a weed, was not ideal for the prairie and interesting because the herbicide, Roundup, was used before the prairie grass seed was planted which should have eliminated any unwanted plants from growing. At the end of the summer, almost the entire prairie site was taken over by the Crabgrass besides a few remaining prairie grasses. The goal of this paper is to figure out why this may have happened. Understanding why Crabgrass grew instead of the planted Big bluestem prairie grass seed mix will help future actions that are taken to restore prairies to become more successful.

Literature Review

Importance of Prairie Grass

In the 1800's, the prairie was seen as unlivable and considered a wasteland or "Great American Desert" due to the fact that there were little to no trees in the area. (Reichman, 1987) Another reason this area was considered unlivable was that there was little rainfall which meant little fresh water. In the 1900's, the steel plow was being used widely across the United States and eventually the fertile, rich soil of the prairie was discovered. This led to the destruction of prairie grass and its replacement with farmland. Prairie grass is a very unique and complex ecosystem that contains a diversity of different animals and plants, but what makes them so special are all the benefits that have been found that make them worth conserving and restoring.

Prairie grasses increase the quality of soil because of their deep roots. Depending on prairie grass species the root: shoot ratio of prairie grass has been found to be between 1.2 and 28.0. (Dwyer 1967) This means that if a plant has 1 inch of above ground growth there could be 1.2 to 28 inches below ground. Prairie grasses have such deep roots as an adaptation for little rainfall. As a result, the plant will grow deeper and deeper until a water source is found. These roots increase the soil quality because each year some roots die and decompose. This adds a large amount of organic matter to the soil, which is helpful when growing crops due to the high amount of nutrients such as carbon and nitrogen.

Soil erosion is the process of wearing away topsoil. (Ritter 2012) Soil erosion is also decreased by planting prairie grass due to the extensive root systems. Soil erosion can be caused by a lot of things which include excessive rainfall and high wind speeds. Slowing soil erosion due to air and water is important because it can cause a loss of available nutrients that plants use to grow. It can change the texture of the soil, which can cause the soil to not be able to hold water as well. (Ritter 2012) This can then cause the soils to be more susceptible to drought.

Prairie grass also provides habitat for a wide range of animals and insects. (Betz, 1996) Having a good diversity of animals is important to having a healthy ecosystem. By having a lot of plants and animals, the prairie will be able to support itself because it will be able to create its own ecosystem. Providing more habitat for animals and insects will, in turn, bring more species to the area that may not have been present in the past. This increase in biodiversity is extremely beneficial to an ecosystem.

Another benefit to prairie regions is the low maintenance they provide, and a reduction in mowing costs. Less mowing means less gas is used, which is helpful in two significant ways. Companies save money on gasoline costs, and possibly maintenance costs with lower lawn care requirements. Additionally, the decreased use of gas leads to less harmful greenhouse gasses being released into the environment. Most of the maintenance that comes with planting a prairie is burning it every couple years to reduce invasive species growth which can be used as a community education point and training for the local fire department.

Prairie grass can be very aesthetically pleasing, making a great landscaping tool. Prairie is known to be very colorful and exciting to look at because of the variety of plants, including wildflowers and grasses. These wildflowers and grasses attract animals and insects to them. These insects can be both attractive and beneficial for pollination, such as butterflies and honeybees. Prairies also draw animals to an area, including deer and birds. (Betz,1996)

With prairie grass having all of these amazing and beneficial effects planting it in an area of unused field seems obvious. The project originally was approved by the village board to help with the flooding that occurred but they were impressed with all of the other benefits that would come along with the prairie restoration.

Background on Studied Grasses

There are many different types of prairie grasses, falling into the classification of either tall grass prairies or short grass prairies. As their name implies, tall grass prairies can reach very tall heights, and of course, short grass prairies are very short in height. This study includes one of each of these classifications of prairie grasses, a tall variety, and a short variety.

Poa pratensus, otherwise known as Kentucky bluegrass is a very common grass, typically used for parks and home lawns. It is a sod forming grass which can grow about four to six inches above the ground, with roots reaching three to five inches below the surface. (USDANRCS 2002)

Andropogon gerardi otherwise known as Big bluestem grass is a native prairie grass to tallgrass prairies of North America. Big bluestem grass is one of the Big Four native grass species that characterize tallgrass prairies in North America. It is a warm season perennial that can grow four to eight feet tall. (USDANRCS 2002) It requires little water and full sun exposure to properly grow. It is a drought tolerant when it is fully established because it has extremely deep roots that reach to approximately ten feet below the ground. This is the grass that was planted at the site this past summer which did not grow. In a study on native species establishment, it was found that Big bluestem has a germination rate of about 30% which means if one hundred seeds were planted, only thirty of those seeds would grow. (Hillhouse, 2011) This germination rate is extremely low and could have contributed to the site being overtaken by Crabgrass. Big bluestem is important to this study because it is the main grass that was planted on the prairie restoration site over the summer.

Bouteloua dactyloides, otherwise known as Buffalo grass, is a native prairie grass found in shortgrass prairies. Buffalo grass is a warm season perennial that can grow four to six inches tall. (USDANRCS, 2002) It requires little water and full sun exposure to properly grow. It is drought tolerant when it is fully established because it also has extremely deep roots, reaching approximately eight feet below the surface. In the same study as above, a similar grass to Buffalo grass called Bouteloua curtipendula was found to have a germination rate of 70%, which means if one hundred seeds were planted, seventy of those seeds would grow. (Hillhouse, 2011) Buffalo grass is important to this study because it is able to grow more quickly than the Big bluestem grass. This gives it the potential to outcompete any other vegetation that may grow in the area. This germination rate is ideal because fewer seeds should need to be planted in order to guarantee that the seeds will take.

Digitaria, or Crabgrass, is part of the grass family of perennial lawn plants that are considered pests or weeds. They thrive in lawns that are thin, under fertilized, and poorly drained. The grass germinates in the early summer and can outcompete turf grass. When the plants die, they leave large gaps in the lawn that are then areas in which Crabgrass will likely grow. Crabgrass is best taken care of with biological control instead of herbicide. This is because Crabgrass grows due to bad lawn conditions that allow for it to grow. Biological control is when another plant is introduced to outcompete the unwanted plant. (UMASS, 2016) Crabgrass is what overtook the Big bluestem this summer and grew instead. It is hypothesized that this occurred because the Big bluestem was not able to establish itself before the Crabgrass so the Crabgrass outcompeted it. Also, the site was treated with an herbicide before it was planted which made the site of unfavorable conditions, so it was an excellent area for Crabgrass to grow, and it did.

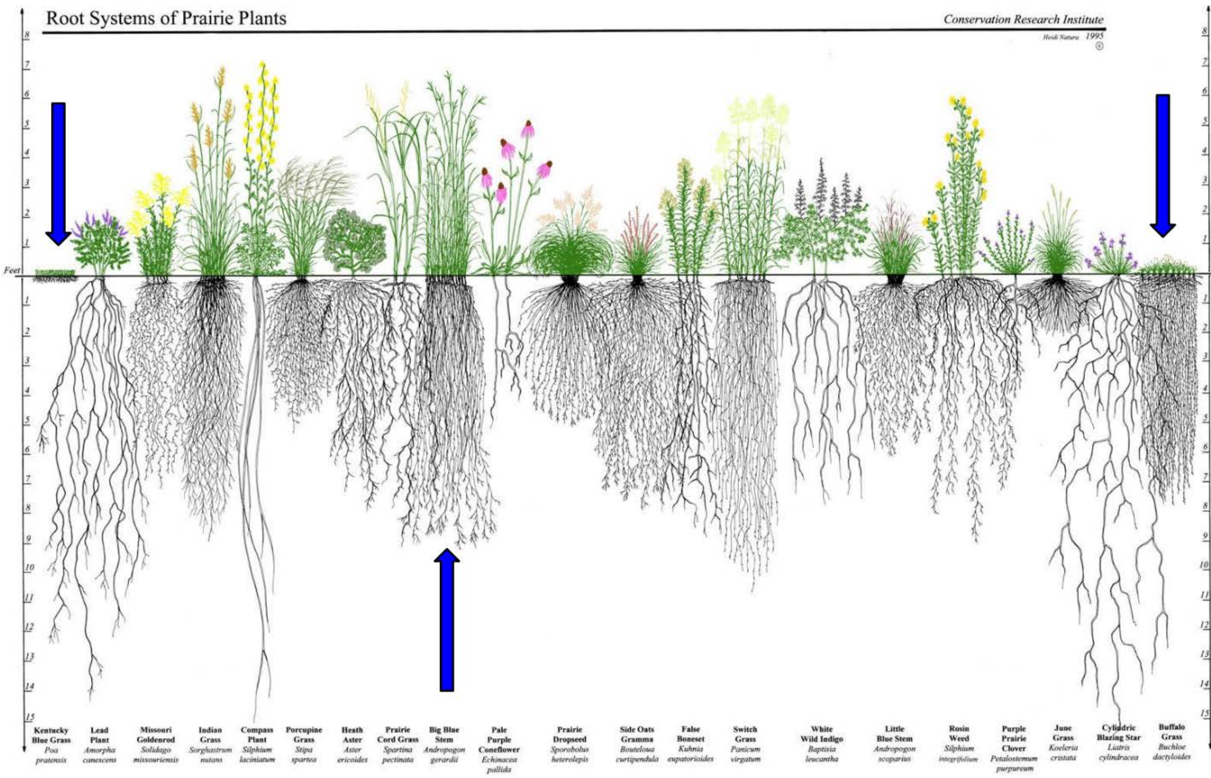

Figure 1: The blue arrows show the different grasses talked about. From left to right Kentucky Blue grass, Big bluestem grass, and Buffalo grass. (USDA, 2016)

Figure 2: This is a picture of Crabgrass root systems. (UMD 2010)

Grass Management

Management of grasses is something that almost everyone has done in their life. This could include a range of management techniques such as mowing or spraying an herbicide on unwanted grass. Two grass management techniques that will be studied are herbicide treatment and control burn treatment. These techniques will be used as a pretreatment to decide which is better at eliminating unwanted grasses at a site in which one wishes to grow prairie grass.

The burning of prairie has many roles in the ecology and management of a prairie. One of the benefits is to stop the growth of trees and shrubs. Prairie grass is able to survive the burning, while trees and shrubs cannot. This is because prairie grass has basal meristems, which means that the growing points of the grass are underneath the soil. Trees and shrubs have apical meristems that have growing points at the tips of shoots. This adaptation allows for the prairie grass to thrive after a burn and the trees and shrubs to die. (Betz,1996) Another important factor of burning is that it burns away any dead vegetation. If there is a thick layer of dead plant matter this will reduce the light availability for new shoots and hold nutrients. Burning prairie to reduce the dead plant matter is also beneficial because it will cut down on a number of wildfires that could occur due to a buildup of dead plant matter. This is the new treatment that will be tested because the first site was treated with an herbicide which made the site good for Crabgrass growth, and burning the site should help control the growth of unwanted vegetation.

One of the world's most popular herbicides is called Roundup. It uses a chemical called glyphosate that was discovered by John E. Franz in 1971. Roundup is also non-selective which means that it will kill almost any plants, including desirable plants. Glyphosate is quickly absorbed by the plant's leaves and then moved throughout the plant. The glyphosate cannot be broken down by the plant and blocks protein synthesis, which eventually leads to plant death due to a lack of nutrients and dehydration. (Martinson, 2005) However, Roundup is a friendly herbicide because it does not affect mammals, birds, fish or insects. This is a huge benefit of Roundup because it allows for the herbicide to be sprayed without the worry of harming other things besides plants.

The only issue is that there is now nothing growing in the area that the herbicide has been used which is favorable for some plants to then grow.

Purpose of Study

The purpose of this study is to find out why the first attempt at growing prairie grass did not succeed and to come up with a better plan of action for the next three years to put in place starting in 2017. This study will also help future restoration projects to be much simpler and smarter. In this study, grasses will be grown in a greenhouse environment to test different growing conditions. It will also help other scientists to know what mistakes were originally made, to avoid making them again, and consequently succeed in the future. If a pot of Buffalo and Crabgrass is planted and Buffalo grass is the primary growth, then Buffalo grass is a good prairie restoration grass. This would be because crabgrass grows very quickly which is why it considered a weed. So, if buffalo grass is able to also grow quickly it may be able to grow quick enough to establish itself before the crabgrass has a chance. If burning a pot of Crabgrass allows for Big bluestem and Buffalo grass to grow, and treating with herbicide does not allow for Big bluestem and Buffalo grass to grow, then burning is a better treatment for prairie restoration sites. So, if the pots that are treated with the burn treatment have less crabgrass growing in them in the end of the experiment then that means that the burn is better at getting rid of and preventing future crabgrass growth.

Hypotheses

My first hypothesis is that the site that was chosen for prairie restoration was not adequate for the growth of prairie grass.

My second hypothesis is that since the Buffalo grass has a mature height shorter than the mature height of Big bluestem it will be able to outcompete the Crabgrass when grown together.

My third hypothesis is that the burn treatment will have more desirable grass, prairie grass, growing after the treatment of the site than non-desirable grass, Crabgrass.

My fourth hypothesis is that the herbicide treatment that was done actually created a perfect environment for Crabgrass to grow and flourish.

Methods

Site Description

The site lies in on a slight decline with few trees in Northwestern Illinois. The site is in The Village of Lena, Illinois in an unused field of grass owned by the Lena Burial Park (Figure 3). The total site covers one acre and is surrounded by two more acres of unused land. The site will not be used by the burial park for the foreseeable future because of other available space. There are also over five hundred unused spaces that will be used before this land. The site now has an acre of some prairie vegetation growing on the edges of the site but the main portion of the site has become overtaken by Crabgrass which was not planted. (Figure 4)

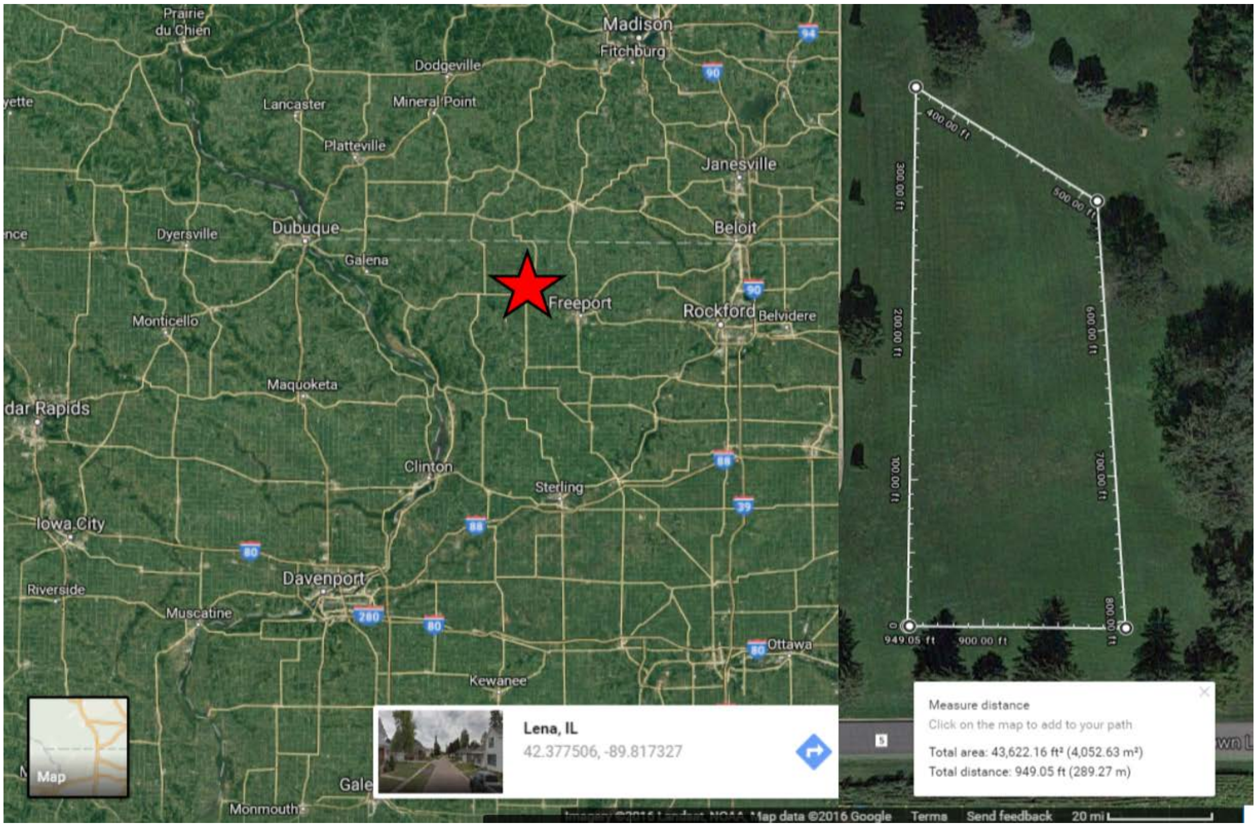

Figure 3: Lena, IL Prairie grass site with the top of the picture as North

Figure 4: Prairie grass site after the first attempt of restoration facing North

Overall Approach

In this study, many factors could have caused the growth of Crabgrass instead of the prairie grass which include but are not limited to soil texture, growth rate, and pretreatment of the site. Although these are not all of the factors that could have caused the prairie to fail these are what in the scope of this study. By studying these factors hopefully, a clearer answer will arise of what happened in the original project. Soil texture will be looked into by analyzing online soil surveys of the area and comparing this textures to ideal soil textures for prairie growth. The growth rate will be tested by growing Big bluestem, Buffalo, and Crabgrass in the greenhouse at Carthage College. Finally, the pretreatment will be examined by growing Crabgrass in the same greenhouse and applying a burn and herbicide treatment and then the planted with either Buffalo or Big bluestem grass.

Soil Analysis

The United States Department of Agriculture is a government agency that collected data on the United States' landscape, natural resources, and hazards that threaten them along with a variety of other services. (USDA, 2016) Based on the USDA soil analysis, two soil textures were identified in the study area. The Western half of the study area, about 63% of the area, was identified as an atterberry silt loam. The eastern half of the study area, about 37% of the area, was identified as Greenbush silt loam (Figure 5).

Atterberry silt loam is primarily composed of sand and silt with a small amount of clay. The soil is very deep and somewhat poorly drained. The native vegetation for this soil was a mix of prairie grass and hardwood trees. The soil has a mean annual soil temperature of 45 to 54 degrees Fahrenheit and a mean annual precipitation of 30 to 40 inches.

Greenbush silt loam also is primarily sand and silt with a small amount of clay. The soil is very deep and well drained. The native vegetation was prairie grasses and woodlands of widely spaced oak and hickory trees. The soil has a mean annual soil temperature of 47 to 57 degrees Fahrenheit and a mean annual precipitation of 33 to 48 inches.

The Soil Map may not be valid at the scale that was used to gather this data. This is because the area that zoomed into in the map was at a smaller scale than the soil surveys were done at. When looking at the larger area around the study site the area is still a combination of the two soil textures found when zoomed beyond the intended scale so even though this warning was displayed the data was still accepted.

Stephenson County, Illinois (IL177)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
61A	Atterberry silt loam, 0 to 2 percent slopes	0.6	62.6%
675B	Greenbush silt loam, 2 to 5 percent slopes	0.4	37.4%
Totals for Area of Interest		**1.0**	**100.0%**

Figure 5: USDA Soil Survey of Prairie Grass Site

Greenhouse Study: Constants

Each plant was grown in a 10-inch pot in the Carthage Greenhouse. The pots were filled to about ½ inch away from the top of the pot with Hidden Trails Potting Soil. Fifty seeds were planted at a depth of ½ inch and then covered with more potting soil until all the seeds were covered. The plants were watered daily for one week and then watered every other day unless otherwise noted. The plants were planted on January 16, 2017, and data was collected from then until March 13, 2017, for a total of eight weeks.

Greenhouse Study: Growth Rate

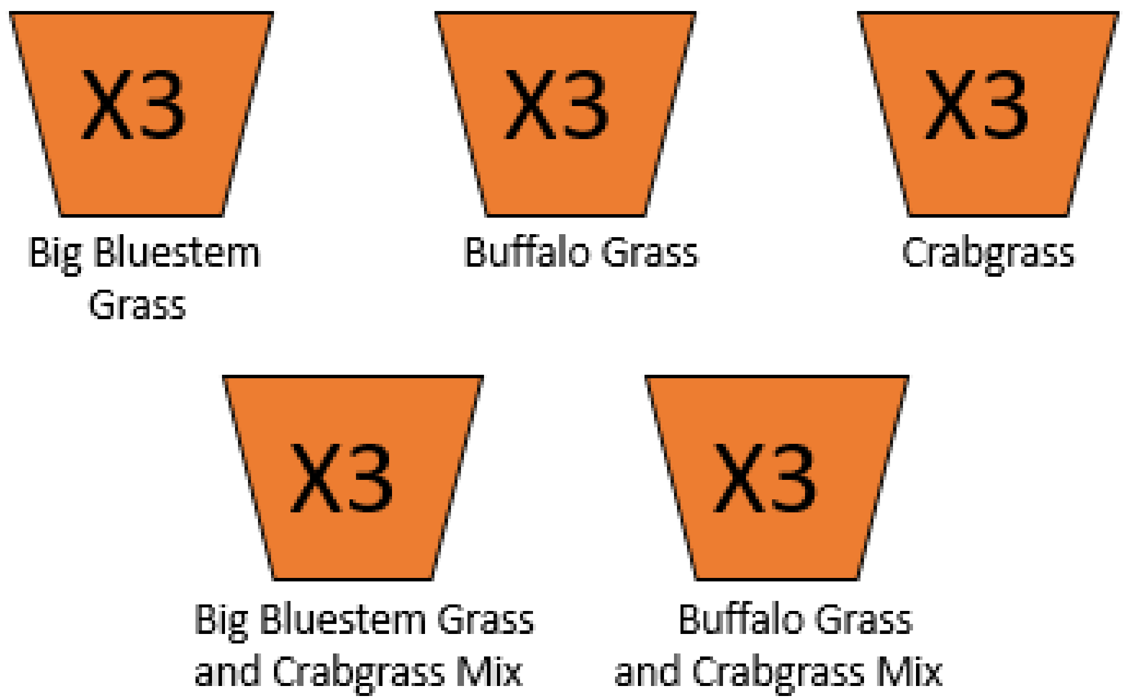

Figure 6: This illustration shows what was planted in each pot and how many pots.

To test this one pot was planted with Big bluestem grass, one with Buffalo grass, one with Crabgrass, one with a Crabgrass and Big bluestem grass mixture, and one with a Crabgrass and Buffalo grass mixture. (Figure 6) Each of the mixtures had twenty-five of each seed for a total of fifty seeds. Any foreign plants that grew in the pots were hand pulled to ensure that any no desirable plants would interfere with growth. The pots were measured weekly to record any growth that occurred. The plant growth for each plant was found by taking ten measurements from different places on the plant and then taking an average. The height was measured from the top of the soil to the tip of the grass blade. There were three potted patches of grass for each species of grass.

Greenhouse Study: Pretreatment

Each pot was first grown with Crabgrass and then applied with either the burn or herbicide treatment after three weeks. Three pots were treated with a very small control burn by using a butane torch and then planted with fifty seeds of Big bluestem grass. This was then repeated with fifty seeds of Buffalo grass. The next three pots were treated with herbicide then planted with fifty seeds of Big bluestem grass. This was also repeated with fifty seeds of Buffalo grass. (Figure 7) Before any seeds were planted the soil of both pre-treatments was not touched for three days to allow for the herbicide to absorb. The same was done to the burn treatments even though there was no agent to be absorbed so that the seeds would be planted at the same time. For both the burn and herbicide treatments, a small amount of potting soil was spread on top of the seeds. This was to ensure the seeds were covered and would not be scorched by the sun. After the treatment, the plants were watered daily for one week and then every other day for the remaining growing period. Any foreign plants that grew in the pots were hand pulled to ensure that any no desirable plants would interfere with growth. The pots were measured weekly to record any growth that occurred. The height was measured from the top of the soil to the tip of the grass blade. There were thirteen pots total with six of each treatment having three of Big bluestem grass and three of Buffalo grass and one control.

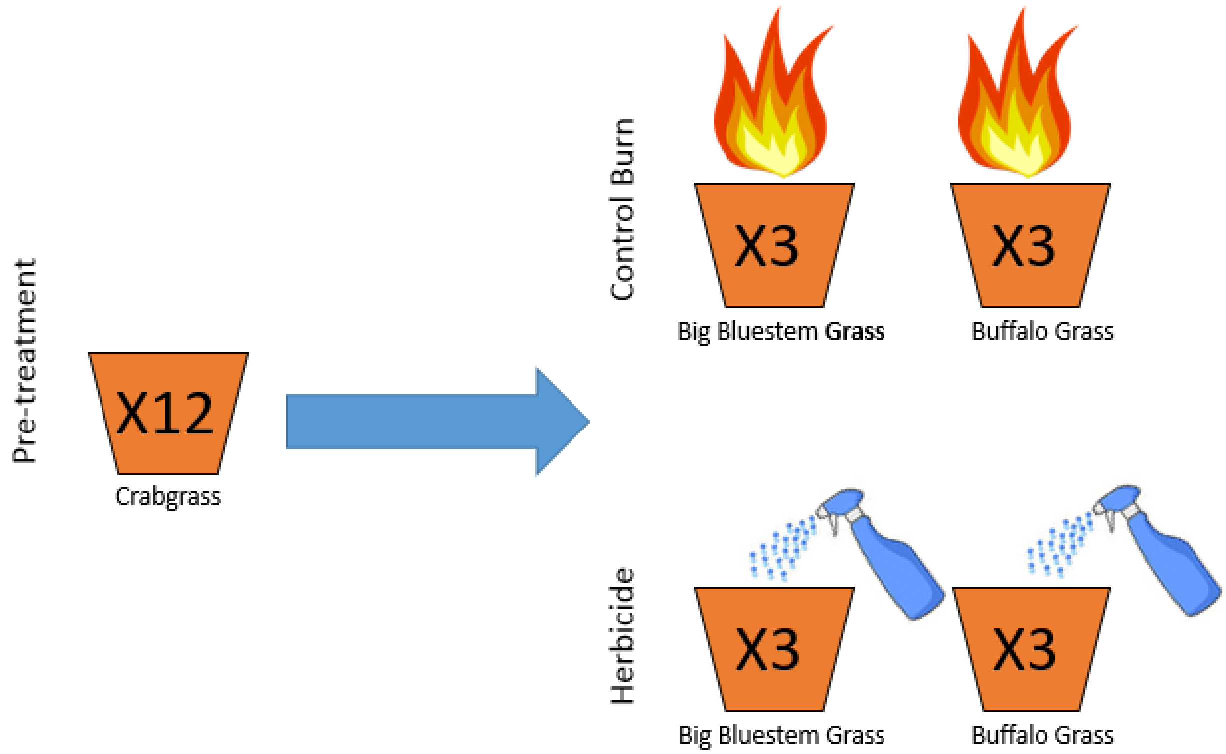

Figure 7: This illustration shows what the process that was done for this greenhouse study including the amount of plants and what treatments were used on each.

Data Analysis

Each of the two datasets obtained from the two variables tested were examined in Microsoft Excel. In this program, the significance of the data found was calculated using ANOVAs that first compared to see if the three plants grew relatively the same. The ANOVAs were also used to compare pots that were planted with a mixture of seeds to see if the mixture grew more similarly to one of the plants. For the pre-treatment experiment, the first three weeks of growth of the controls was used to compare to the current growth of the pots because there only was three weeks of growth. This was done to further prove what was growing in the pots with seed mixtures rather than just visual identification.

Results

The heights from ten measurements that were taken weekly found in the first greenhouse experiment were averaged and added to graphs. The three lines represent a different plant grown at the same conditions. The big bluestem averages all stay very similarly and at the end of 7 weeks are at around 15 cm. (Figure 8) The buffalo averages all follow a very similar line and plateau around 10 cm. (Figure 9) The crabgrass averages had two similar plants and one that grew a little faster. They ended around 24 cm. (Figure 10) The big bluestem and crabgrass mixture averages all stayed fairly the same and ended at 26 cm. (Figure 11) The buffalo and crabgrass mixture averages also grew similarly and ended at 25cm. (Figure 12)

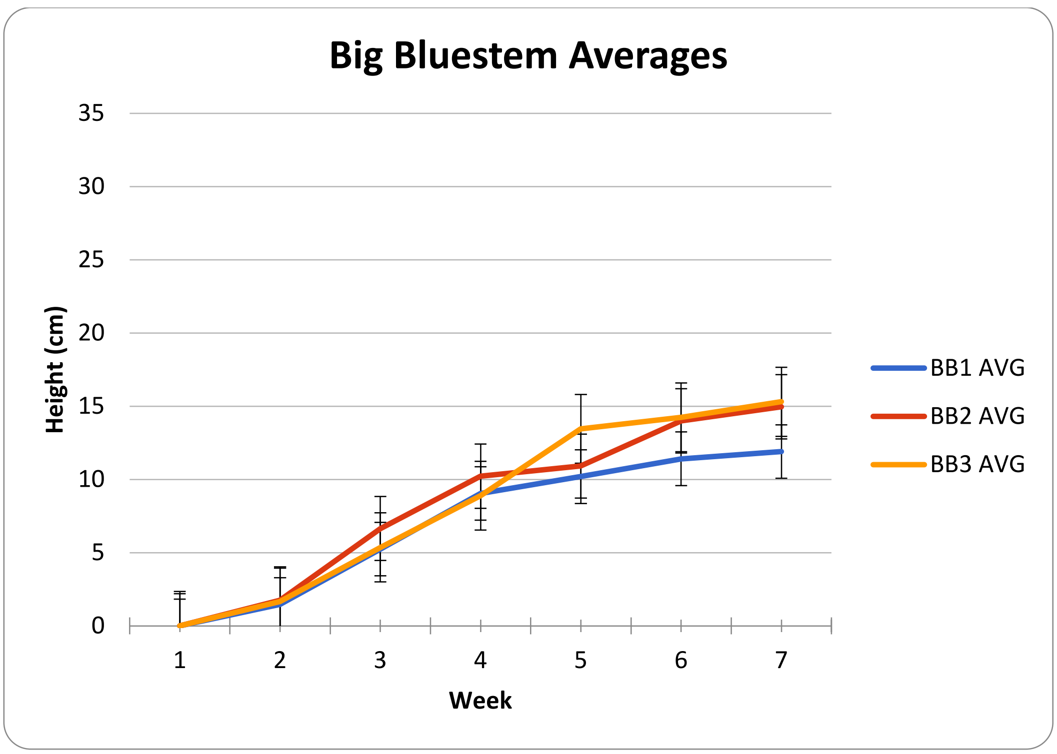

Figure 8: The three Big bluestem grass plants that were grown under normal conditions. Each line represents a potted plant that was grown. Each point is the average of ten measurements.

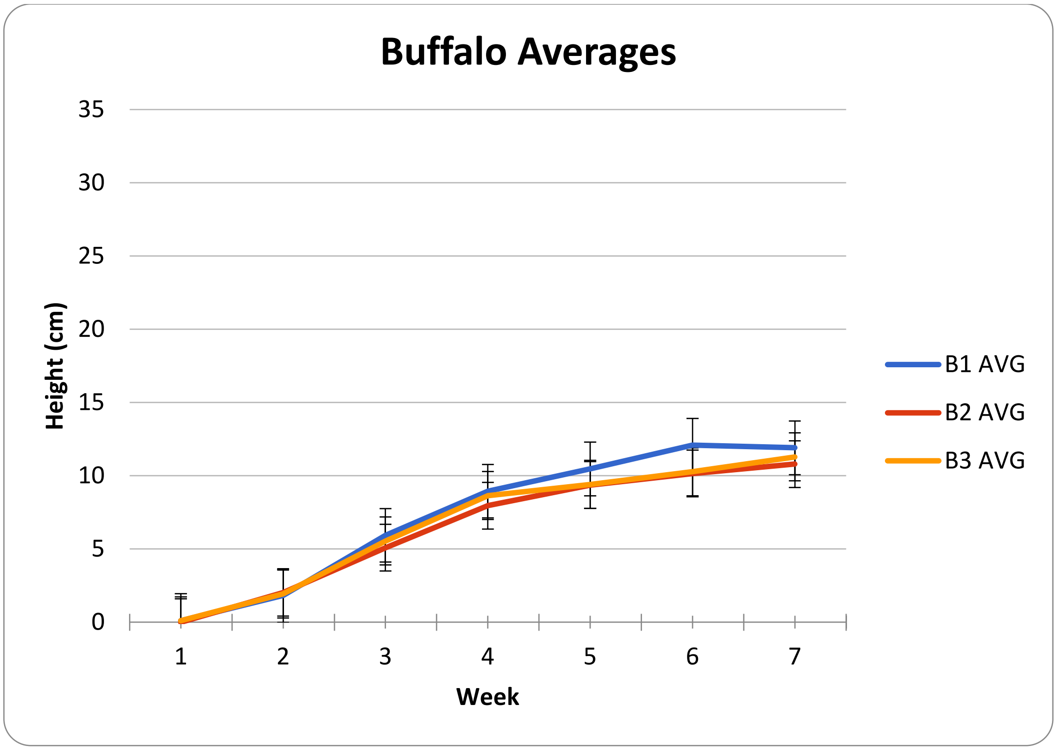

Figure 9: The three Buffalo grass plants that were grown under normal conditions. Each line represents a potted plant that was grown. Each point is the average of ten measurements.

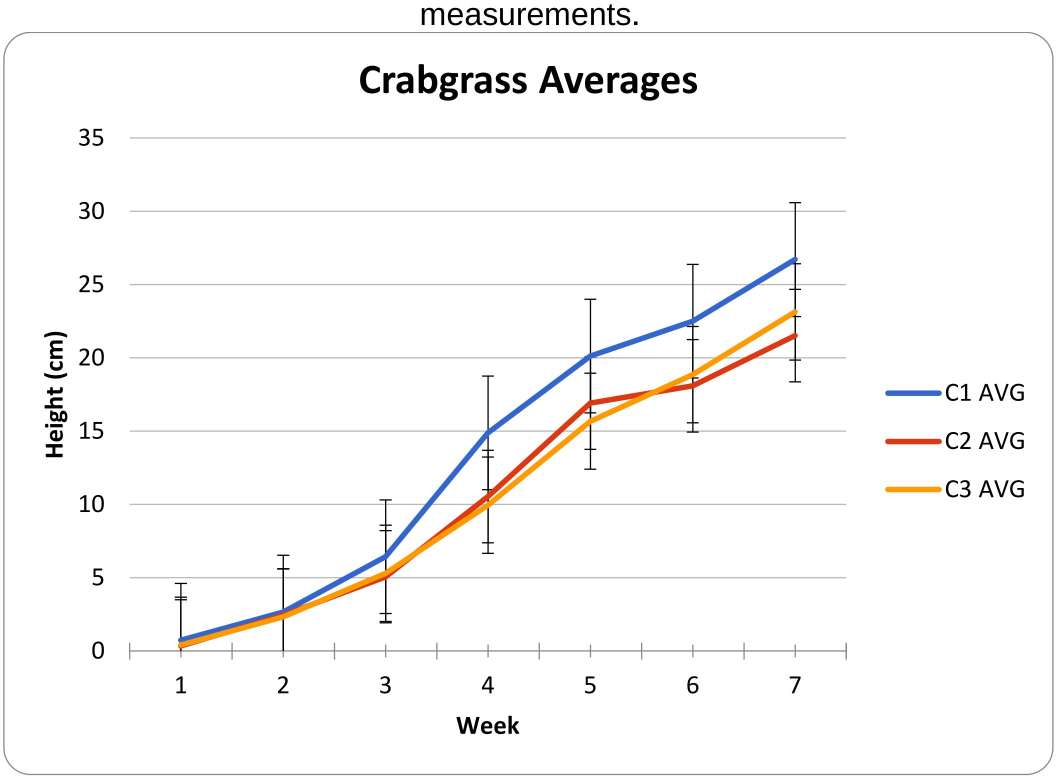

Figure 10: The three Crabgrass plants that were grown under normal conditions. Each line represents a potted plant that was grown. Each point is the average of ten measurements.

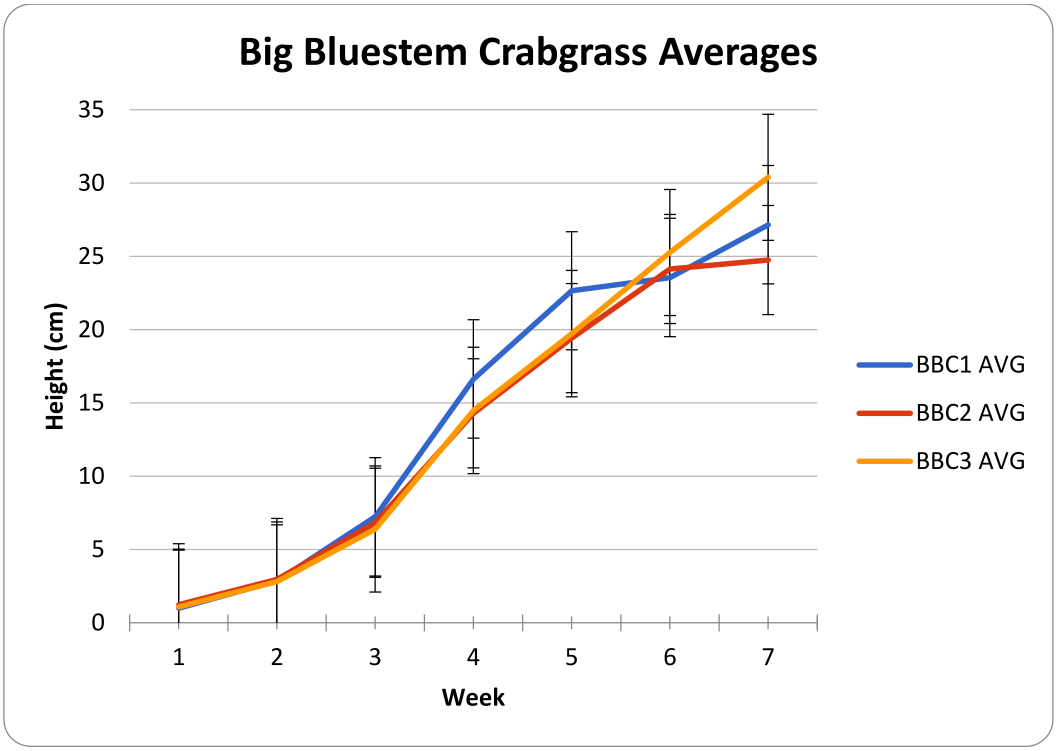

Figure 11: The three Big bluestem and Crabgrass mixtures that were grown under normal conditions. Each line represents a potted plant that was grown. Each point is the average of ten measurements.

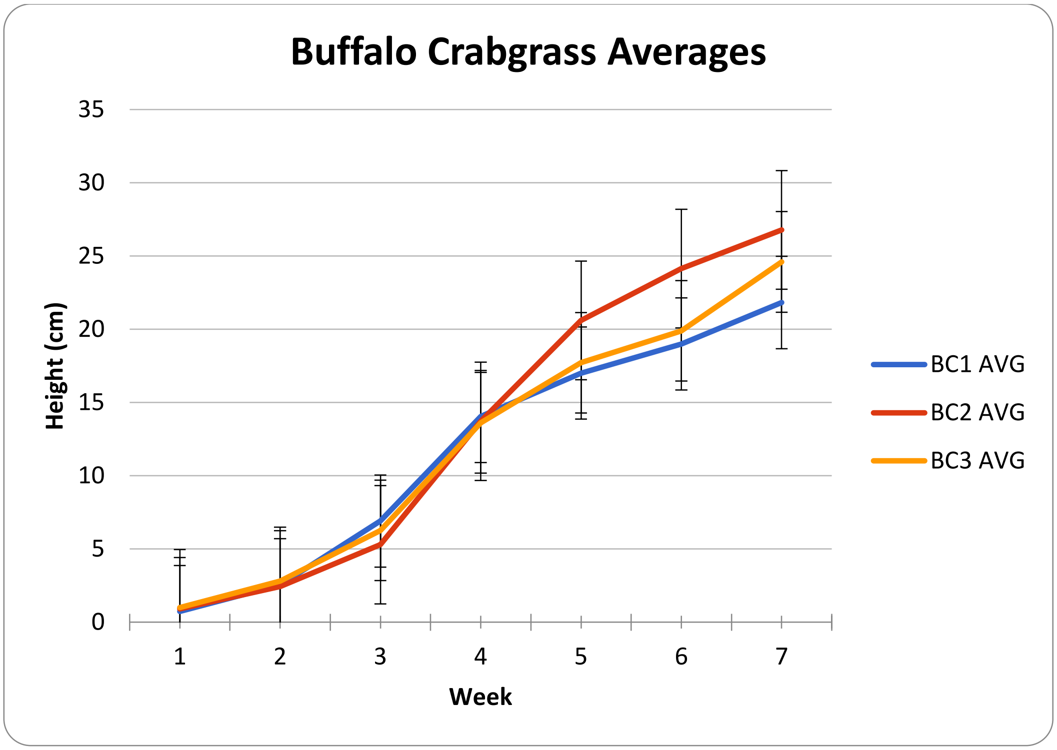

Figure 12: The three Buffalo and Crabgrass mixtures that were grown under normal conditions. Each line represents a potted plant that was grown. Each point is the average of ten measurements.

ANOVAs were run on each of the individual plants and the mixtures to test the difference between the pots. ANOVAs were also run comparing the controls to the mixtures. The independent variable was if the plants were mixed seed. The dependent variable is the height of the plants. A significance level of 0.05 was used to decide if the data was significant or not. The p-values of the controls were not with in this level. In the mixtures, none had significant p-values. Also, when compared to crabgrass big bluestem had a p-value of 0.96 and Buffalo had a p-value of 0.98. (Table 1)

ANOVAs		
Type	Plant	P-values
Controls	Big Bluestem	0.875
	Buffalo	0.937
	Crabgrass	0.819
Mixtures	Big Bluestem and Crabgrass	0.979
	Big Bluestem and Crabgrass compared to Big Bluestem	0.370
	Big Bluestem and Crabgrass compared to Crabgrass	0.960
	Buffalo and Crabgrass	0.943
	Buffalo and Crabgrass compared to Buffalo	0.299
	Buffalo and Crabgrass compared to Buffalo	0.987

Table 1: ANOVAs were run on each of the plants to test for similarity or difference. (Appendix A)

The heights that were found in the first greenhouse experiment were averaged and added to graphs. The graphs are in pairs with the pre-treatment first and then the after treatment. Figures 13, 15, 17, and 19 show the growth of the crabgrass for four weeks and all look similar. Week four the height returns to zero because this is when the pre-treatment was applied. Figures 14, 16, 18, and 20 show the growth of the pots after the prairie grass was planted.

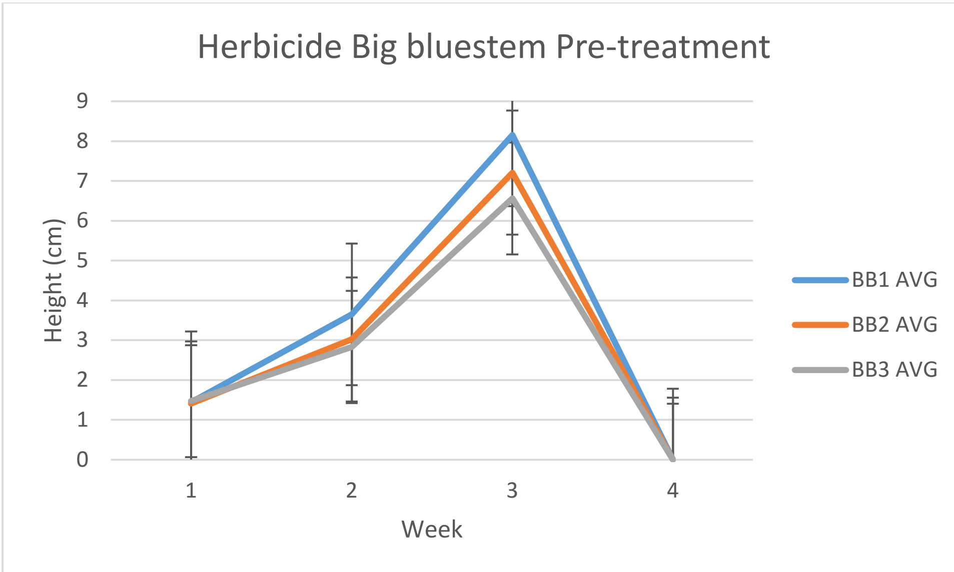

Figure 13: The first four weeks of Crabgrass growth before herbicide treatment and Big bluestem was planted. Each line represents a potted plant that was grown. Each point is the average of ten measurements.

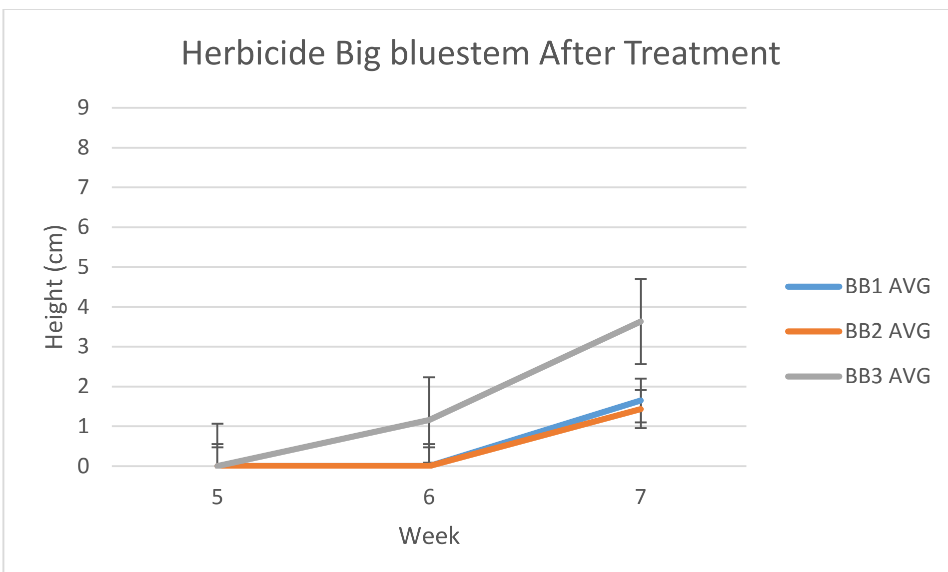

Figure 14: The next three weeks after herbicide treatment and the Big bluestem was planted. Each line represents a potted plant that was grown. Each point is the average of ten measurements.

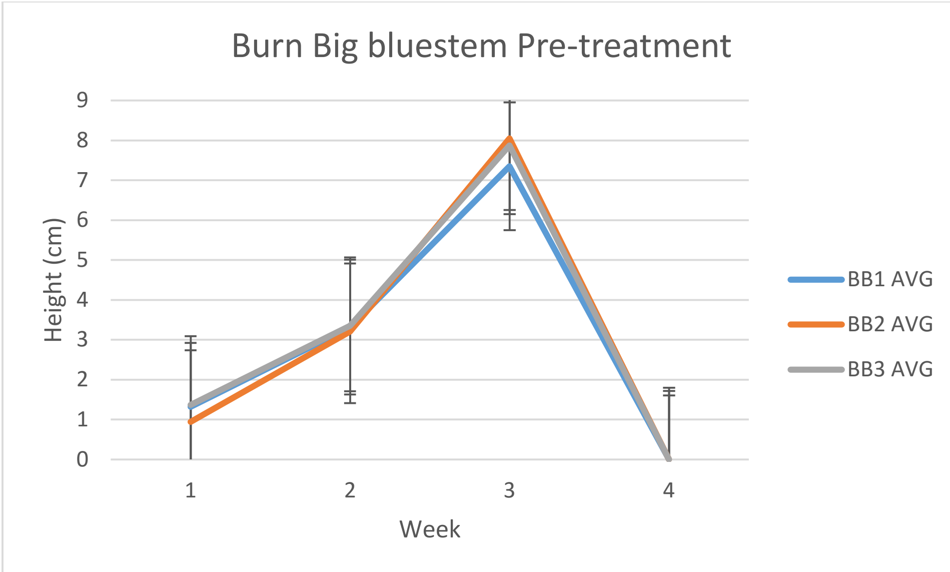

Figure 15: The first four weeks of Crabgrass growth before burn treatment and Big bluestem was planted. Each line represents a potted plant that was grown. Each point is the average of ten measurements.

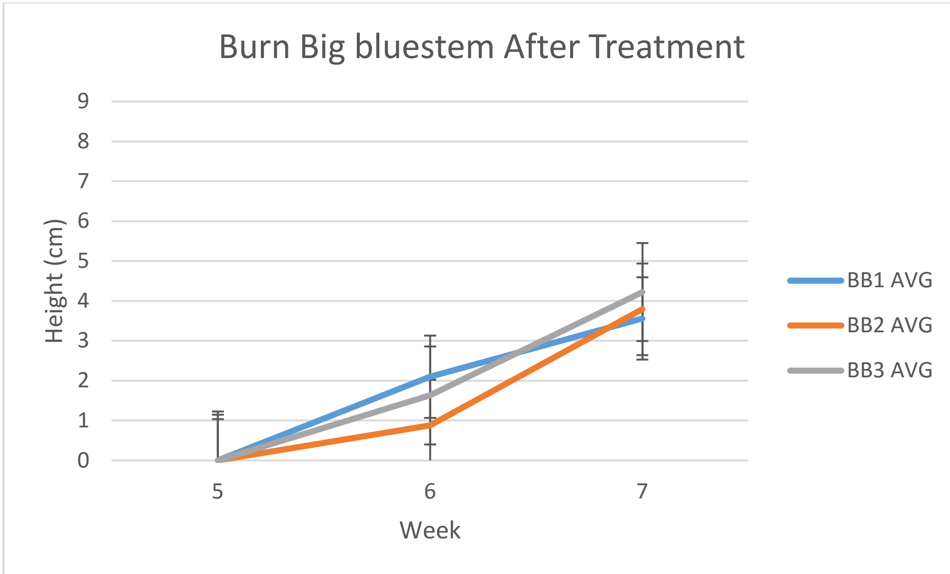

Figure 16: The next three weeks after burn treatment and the Big bluestem was planted. Each line represents a potted plant that was grown. Each point is the average of ten measurements.

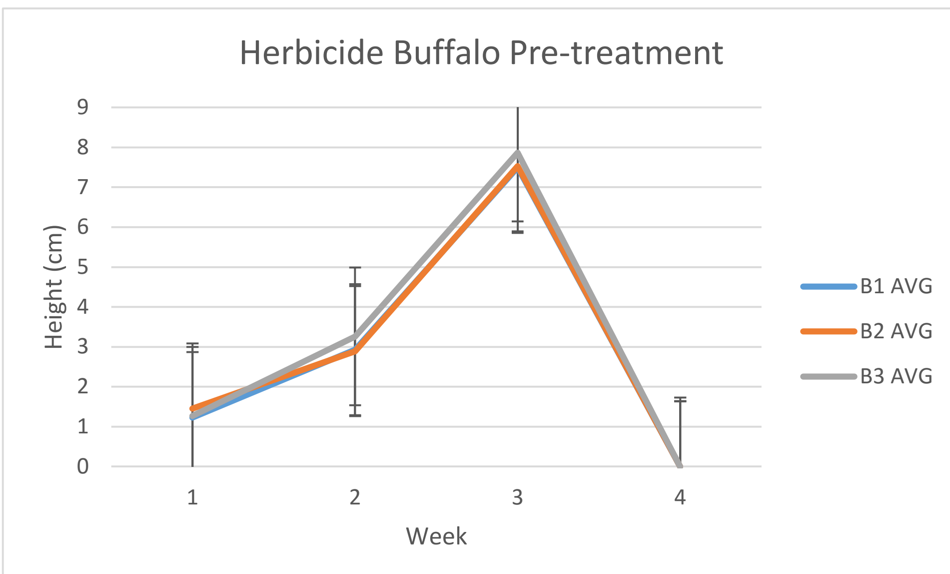

Figure 17: The first four weeks of Crabgrass growth before herbicide treatment and Buffalo grass was planted. Each line represents a potted plant that was grown. Each point is the average of ten measurements.

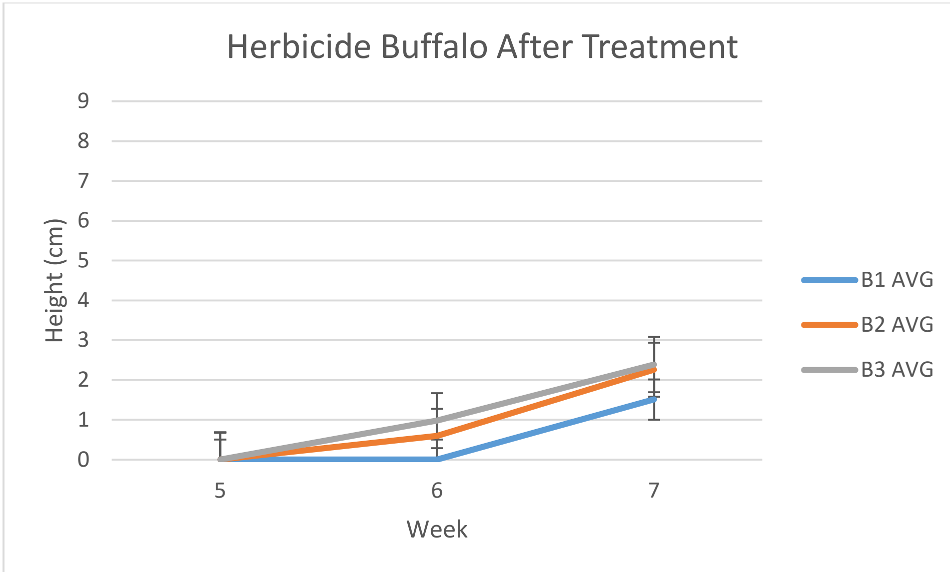

Figure 18: The next three weeks after herbicide treatment and the Buffalo grass was planted. Each line represents a potted plant that was grown. Each point is the average of ten measurements.

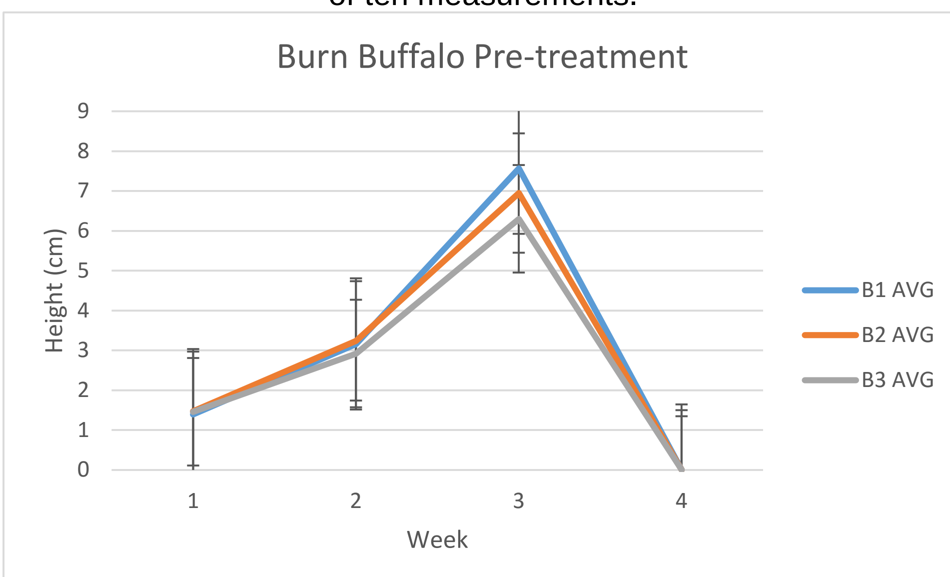

Figure 19: The first four weeks of Crabgrass growth before burn treatment and Buffalo grass was planted. Each line represents a potted plant that was grown. Each point is the average of ten measurements.

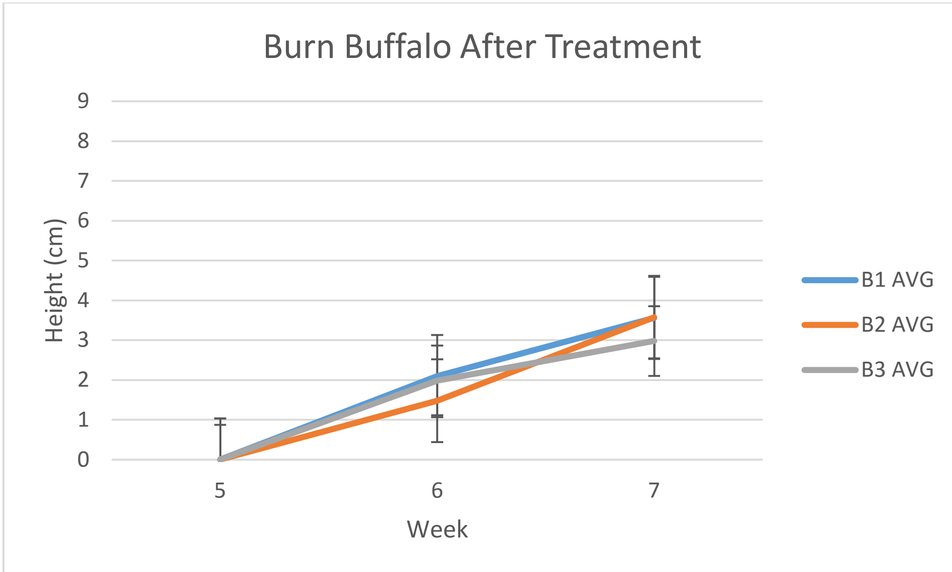

Figure 20: The next three weeks after burn treatment and the Buffalo grass was planted. Each line represents a potted plant that was grown. Each point is the average of ten measurements.

ANOVAs were run on each of the plants alone and then compared to the first three weeks of the controls in the first greenhouse experiment. The independent variable is the pre-treatment used. The dependent variable is the height of the plants. Table 2 shows the p-values of the herbicide no of which were significant. Table 3 the plants all have p-values that are not close to the 0.05 significance level with 0.966, 0.992, and 0.942 which was specifically for the burn pre-treatment and then planted with big bluestem. Also, the burn treatment then planted with buffalo had p-values that were not close to the significance levels with 0.984, 0.989, and 0.921.

ANOVAs		
Type - Herbicide	Plant	P-values
Big Bluestem	Big Bluestem	0.531
	Compared to Big Bluestem	0.744
	Compared to Crabgrass	0.461
Buffalo	Buffalo	0.780
	Compared to Buffalo	0.716
	Compared to Crabgrass	0.468

Table 2: The comparison of p-values between big bluestem and buffalo grass that were treated with herbicide. (Appendix A)

ANOVAs		
Type - Burn	Plant	P-values
Big Bluestem	Big Bluestem	0.966
	Compared to Big Bluestem	0.992
	Compared to Crabgrass	0.942
Buffalo	Buffalo	0.984
	Compared to Buffalo	0.989
	Compared to Crabgrass	0.921

Table 3: The comparison of p-values between big bluestem and buffalo grass that were treated with burn. (Appendix A)

Discussion

Soil Analysis

The soil analysis shows that it is primarily sand which is preferable for prairie grass to grow. It also shows that the soil temperature is about 50 degrees which prairie can grow in. Lastly, the soil analysis shows that the native vegetation for the area is prairie grass and hardwood trees. This is important because that means at one point this area most likely had prairie grass growing on it so the conditions should be favorable for prairie grass growth. The website did indicate that the data that was provided may not be accurate because of the scale that was used. This should not have affected the data too much so this result will still be expected. Knowing that the soil texture should not have affected the prairie restoration project allows for more focus to be placed on the other factors that could have attributed to the Crabgrass growth.

Since the soils at the prairie restoration site should have been adequate for growing prairie grass other factors must be at work that caused the Crabgrass to grow in. After some research was done it was determined that there were two main factors that could have caused the Crabgrass to grow, pretreatment and type of prairie grass grown. These variables were then tested in the greenhouse study in two different experiments. An error that could have occurred in this section is that the data may not be accurate to what is at the site currently and so a test should be done before concluding that the soil is adequate for the growth of prairie grass. This test could include soil texture, soil moisture, depth of the soil, and percent organic matter. Also, more issues with the site could be considered such as compaction of the soil and nutrient presence.

Greenhouse Studies

The first three graphs (Figures 8,9,10) show the averages of the three pots of grass grown over seven weeks. These tests are used as controls in the future experiments but also act as their own experiment. At the end of the seven weeks was pretty obvious that the Crabgrass grew the most just through visual observations and the data just further backs up those observations. However, when the graphs are interpreted it can be seen that the Big bluestem and Crabgrass plants are still growing while it seems that the Buffalo grass plants plateau and slow at around ten centimeters. This is important because it means the Buffalo grass was either at mature height or very close to mature height at around five weeks. The only issue is that the Crabgrass at this same time was over five centimeters taller than the Buffalo grass meaning that if planted in the same pot the Crabgrass would be the primary growth in the pot. The Big bluestem averages around this time showed a range of heights from ten to 14 centimeters. This means the same as above that it is likely that the primary growth if they were planted in the same pot would be the Crabgrass. This idea was tested and will be expounded upon later. The ANOVA tests helped determine if the plants grew similarly which is represented by a p-value of 1. If they were less similar the p-value was closer to 0 or reject null hypothesis. A significance level of 0.05 was used to determine if the plants grew statistically significant or not. The ANOVA tests (Table 1) for these plants showed that they all grew somewhat similarly with all of them having p-values over 0.8. The value of 0.8 was acceptable because the heights were being measured in centimeters and some difference in height was expected. These sample groups were then used as a way to test if a set of mixtures were growing more similarly to one plant or another in the other experiments.

The next two graphs (Figures 11,12) show the averages of the two pots of mixed grass grown over seven weeks. At the end of the seven weeks visually it was obvious that Crabgrass had grown in both mixtures and neither Big bluestem or Buffalo grass were growing. This is what was expected after evaluating the data from growing the plants on their own. The ANOVAs for these mixtures showed over a 0.9 for both meaning that the three pots of each grew very similarly. (Tables 1) Then ANOVAs comparing the mixture results and control results were done to further confirm that Crabgrass was indeed growing in the pots. First, the Big bluestem and Crabgrass mixture was compared to the Big bluestem control which yielded a 0.37 p-value meaning that the plants were not very similar and fail to reject null hypothesis. (Table 1)

Then, the Big bluestem and Crabgrass mixture was compared to the Crabgrass control which yielded a p-value of the 0.96 meaning that the six plants all grew very similarly. (Table 1) Next, the Buffalo and Crabgrass mixture was compared to the Buffalo control which yielded a 0.29 p-value meaning that the plants were not very similar. (Table 1) Finally, the Buffalo and Crabgrass mixture was compared to the Crabgrass control which yielded a p-value of 0.98 meaning that the six plants all grew very similarly. (Table 1) Even though these p-values that show values that are close to 0.3 it cannot be concluded that they were statistically different than what grew in the pots. This means that statistically we cannot prove what grew in the pot. To conclude, the Crabgrass, as expected, could outcompete both prairie grasses so, another factor must have caused the Crabgrass to grow instead of the prairie grass at the prairie restoration site.

For the second experiment, the Crabgrass all the plants grew very well for the first four weeks and then the treatment was applied which then caused the heights to return to zero. The first treatment, represented by Figures 13,14,17,18, was the herbicide treatment with then the Big bluestem and Buffalo grass to planted. After three weeks it was difficult to identify what was growing because the plants were still very small so statistical analysis was used to further identify them. When the ANOVA was run on the herbicide Big bluestem there was only a p-value of 0.53 which means the plants were not very similar. (Table 2) These three plants were then compared to the first three weeks of growth of Big bluestem and Crabgrass. When an ANOVA was run to compare to Big bluestem the p-value was 0.74 which means the plants were fairly similar to these first three weeks of growth. (Table 2) When an ANOVA was run to compare to Crabgrass the p-value was 0.46 which means they were not very similar. (Table 2) When the ANOVA was run on the herbicide Buffalo there was a p-value of 0.78 which means they were fairly similar. (Table 2) When an ANOVA was run to compare to Buffalo controls there was a p-value of 0.71 meaning they were fairly similar. (Table 2) When an ANOVA was run to compare to Crabgrass controls there was a p-value of 0.46 which means they were not very similar. (Table 2) For the herbicide treatments there is a fair chance that the desirable grass was growing in the pots but since the p-value was not higher it is hard to confirm this. When the ANOVA was run on the burn Big bluestem there was a p-value of 0.96 meaning these plants grew very similarly and when these numbers are compared to the controls we can be confident that there is a relationship. (Table 3) When the burn Big bluestem was compared to the Big bluestem control in an ANOVA there was a p-value of 0.99 meaning that they almost grew exactly the same. (Table 3) When the burn Big bluestem was compared to the Crabgrass control in an ANOVA there was a p-value of 0.94 meaning that they grew very similarly. (Table 3) When the ANOVA was run on the burn Buffalo there was a p-value of 0.98 meaning these plants grew very similarly and when these numbers are compared to the controls we can be confident that there is a relationship. (Table 3) When the burn Buffalo was compared to the Buffalo control in an ANOVA there was a p-value of 0.98 meaning that they almost grew exactly the same. (Table 3) When the burn Buffalo was compared to the Crabgrass control in an ANOVA there was a p-value of 0.92 meaning that they grew very similarly. (Table 3) Since both of these numbers grew relatively the same it is hard to conclude exactly what is growing in these pots at the moment and more research is needed. Also since for many of the ANOVAs a p-value that was not in the significance range was not achieved most of this data is not statistically proven.

Throughout this experiment, there was a chance that errors could have occurred. Human error could have occurred at any stage of this experiment through the measurements, watering unevenly, or incorrect data entry. Another error that could have occurred is that there were issues in the greenhouse. Even though the greenhouse computer controlled every inch of the greenhouse doesn’t grow the exact same. It was observed that plants closer to the greenhouse wall did not grow as well as the plants closer to the center of the greenhouse. This error could be minimized by increasing the number of replicates that are done for each variable so as long as all of the same variables are not along the center or the back wall the average of the plants will not be disrupted. Also, to make it even more accurate an average of the three pots could have been taken to make the data even more accurate and less influenced by random factors. Lastly, to better represent the site that this was being tested for a sandy loam soil could have been used instead of the potting soil used.

Future Plan and Recommendations for Other Projects

Year one (2017) the prairie site will be burned with the help of the Lena Fire Department to ensure that the burn does not get out of control. A burn will be done because of the results that were seen in the burn vs herbicide experiment that showed that burning allows for replanted seed to have a better chance of survival than using an herbicide. Even though it was difficult to determine for sure what growing in the pots. The burn will be done in quarter acre sections by mowing firebreaks to help again with controlling the burn. The burn will occur in late March early April. The prairie will be replanted with a mix that is mainly Buffalo grass seed since that was the grass that was quicker to mature and able to outcompete Crabgrass as seen in the experiments. The seed will be watered depending on rainfall.

Year two (2018) the prairie site will be seeded with Big bluestem grass seed because this is the original seed that was desired to be grown. This will be done in mid-March after any ice and snow have melted. No burn or herbicide treatments will be applied to the prairie site.

Year three (2019) the prairie site will again be seeded with Big bluestem grass seed to attempt and overtake the prairie site. This will again take place in mid-March after any ice and snow have melted. No burn or herbicide treatments will be applied to the prairie site. Firebreaks will also be mowed into the site that will be used as paths throughout the prairie which will be maintained until the next controlled burn.

For other projects that may wish to restore a prairie that are looking for direction the best idea for beginning the project would be to look into burning the site before planting Buffalo grass in Late-March or April. This would hopefully get the project started in the right direction. However, this project does have some limitations in that more data and replicates need to be done to confirm what is currently known.

Conclusion

The first hypothesis was proven incorrect after the data was analyzed from the USGS that showed the soil texture and history of the area were adequate for growing prairie grass currently and in the past. The second hypothesis somewhat true because the Buffalo grass did reach mature height while the Big bluestem did not reach mature height. The only issue was that the Buffalo grass was still not able to outcompete the Crabgrass. The third hypothesis did not have enough data to fully conclude if the burn or herbicide treatment was better but from the data that is currently collected it seems that the burn does indeed work better. The fourth hypothesis also did not have enough data to fully conclude if the herbicide treatment creates an environment that Crabgrass can grow and flourish in or not but from the data that is currently collected it seems it could be true based on the p-values of around 0.7 and 0.4 which could easy switch with a few more weeks of data and being able to actually identify the grass. If these p-values were in the significance level of 0.05 more conclusions could have been drawn.

This study not only will help the village of Lena complete their prairie restoration project other communities that either have a prairie restoration project that need guidance or want to start a prairie restoration project can look to this study. Although this study encompasses some of the factors there are more that could have been looked into. One is the amount of water given to the prairie. It is possible that the prairie was not watered enough and since Crabgrass can survive harsher conditions it was able to survive the amount of water that was available. Another study that could be done is a nutrient study of the study area to ensure that there was not an excess or insufficient nutrients for prairie growth but there was for Crabgrass growth. The soil survey showed that the area has the correct soil texture and even possibly had prairie growing there before most prairies were converted into farmland. Overall, it was found that Buffalo grass grows to a mature height quicker than Big bluestem and can outcompete Crabgrass and burning a prairie ensures that Crabgrass will not regrow in the area. This new information will now be applied to the prairie restoration project that is occurring in Lena, IL and hopefully will benefit any others looking to do a similar project.

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Appendix A

Big Bluestem						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
BB1 AVG	7	49.25	7.035555556	23.40972716		
BB2 AVG	7	58.5	8.357142857	33.61755714		
BB3 AVG	7	58.91	8.415714286	38.75849524		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	8.5280107	2	4.26400535	0.133548175	0.875844225	3.554557146
Within Groups	574.7146772	18	31.92859318			
Total	583.2426879	20				

Table 1: The ANOVA for the Big bluestem grass plants with the P-value highlighted.

Buffalo						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
B1 AVG	7	51.28	7.325714286	23.42772857		
B2 AVG	7	45.39	6.484285714	17.7479619		
B3 AVG	7	47.2	6.742857143	18.76369048		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.600695238	2	1.300347619	0.065083136	0.937209027	3.554557146
Within Groups	359.6362857	18	19.97979365			
Total	362.236981	20				

Table 2: The ANOVA for the Buffalo grass plants with the P-value highlighted.

Crabgrass						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
C1 AVG	7	94.05	13.43571429	105.3466619		
C2 AVG	7	74.92	10.70285714	69.61269048		
C3 AVG	7	75.66	10.80857143	75.32108095		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	33.55698095	2	16.77849048	0.201116287	0.81963012	3.554557146
Within Groups	1501.6826	18	83.42681111			
Total	1535.239581	20				

Table 3: The ANOVA for the Crabgrass plants with the P-value highlighted.

Big Bluestem Crab						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
BBC1 AVG	7	101.1	14.44285714	114.0752905		
BBC2 AVG	7	93.67	13.38142857	96.89481429		
BBC3 AVG	7	100.2	14.31357143	129.651206		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4.695216667	2	2.347608333	0.020676407	0.979559113	3.554557146
Within Groups	2043.727864	18	113.5404369			
Total	2048.423081	20				

Table 4: The ANOVA for the Big bluestem and Crabgrass mixtures with the P-value highlighted.

Big Bluestem Crab Compared to Big Blue Control						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
BBC1 AVG	7	101.1	14.44285714	114.0752905		
BBC2 AVG	7	93.67	13.38142857	96.89481429		
BBC3 AVG	7	100.195	14.31357143	129.651206		
BB1 AVG	7	49.24888889	7.035555556	23.40972716		
BB2 AVG	7	58.5	8.357142857	33.61755714		
BB3 AVG	7	58.91	8.415714286	38.75849524		
ANOVA						
ource of Variatio	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	405.1865166	5	81.03730332	1.114151971	0.370216622	2.477168673
Within Groups	2618.442542	36	72.73451504			
Total	3023.629058	41				

Table 5: The ANOVA for the Big bluestem and Crabgrass mixtures compared to the Big bluestem controls with the P-value highlighted.

Big Bluestem Crab Compared to Crabgrass Control						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
BBC1 AVG	7	101.1	14.44285714	114.0752905		
BBC2 AVG	7	93.67	13.38142857	96.89481429		
BBC3 AVG	7	100.195	14.31357143	129.651206		
C1 AVG	7	94.05	13.43571429	105.3466619		
C2 AVG	7	74.92	10.70285714	69.61269048		
C3 AVG	7	75.66	10.80857143	75.32108095		
ANOVA						
ource of Variatio	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	98.57629821	5	19.71525964	0.200188202	0.960302351	2.477168673
Within Groups	3545.410464	36	98.48362401			
Total	3643.986763	41				

Table 6: The ANOVA for the Big bluestem and Crabgrass mixtures compared to the Crabgrass controls with the P-value highlighted.

Buffalo Crab						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
BC1 AVG	7	82.08	11.72571429	69.4380619		
BC2 AVG	7	93.92	13.41714286	114.6827238		
BC3 AVG	7	85.9	12.27142857	82.39138095		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	10.43325714	2	5.216628571	0.058721093	0.943149608	3.554557146
Within Groups	1599.073	18	88.83738889			
Total	1609.506257	20				

Table 7: The ANOVA for the Buffalo and Crabgrass mixtures with the P-value highlighted.

Buffalo Crab Compared to Buffalo Control						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
BC1 AVG	7	82.08	11.72571429	69.4380619		
BC2 AVG	7	93.92	13.41714286	114.6827238		
BC3 AVG	7	85.9	12.27142857	82.39138095		
B1 AVG	7	51.28	7.325714286	23.42772857		
B2 AVG	7	45.39	6.484285714	17.7479619		
B3 AVG	7	47.2	6.742857143	18.76369048		
ANOVA						
ource of Variatio	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	344.7263548	5	68.94527095	1.267176182	0.299248809	2.477168673
Within Groups	1958.709286	36	54.40859127			
Total	2303.43564	41				

Table 8: The ANOVA for the Buffalo and Crabgrass mixtures compared to the Buffalo controls with the P-value highlighted.

Buffalo Crab Compared to Crabgrass Control						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
BC1 AVG	7	82.08	11.72571429	69.4380619		
BC2 AVG	7	93.92	13.41714286	114.6827238		
BC3 AVG	7	85.9	12.27142857	82.39138095		
C1 AVG	7	94.05	13.43571429	105.3466619		
C2 AVG	7	74.92	10.70285714	69.61269048		
C3 AVG	7	75.66	10.80857143	75.32108095		
ANOVA						
ource of Variatioi	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	51.09149762	5	10.21829952	0.118635207	0.987426519	2.477168673
Within Groups	3100.7556	36	86.1321			
Total	3151.847098	41				

Table 9: The ANOVA for the Buffalo and Crabgrass mixtures compared to the Crabgrass controls with the P-value highlighted.

Herb Big Blue						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
HBB1 AVG	3	1.65	0.55	0.9075		
HBB2 AVG	3	1.43	0.476666667	0.681633333		
HBB3 AVG	3	4.79	1.596666667	3.437233333		
ANOVA						
ource of Variatioi	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.355288889	2	1.177644444	0.702880145	0.531795673	5.14325285
Within Groups	10.05273333	6	1.675455556			
Total	12.40802222	8				

Table 10: The ANOVA for the Big bluestem after the herbicide treatment with the P-value highlighted.

Herb Big Blue Compared to Big Blue Control						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
HBB1 AVG	3	1.65	0.55	0.9075		
HBB2 AVG	3	1.43	0.476666667	0.681633333		
HBB3 AVG	3	4.79	1.596666667	3.437233333		
BB1 AVG	3	6.71	2.236666667	7.305233333		
BB2 AVG	3	8.41	2.803333333	11.87203333		
BB3 AVG	3	7.03	2.343333333	7.522433333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	14.22817778	5	2.845635556	0.538163571	0.744130053	3.105875239
Within Groups	63.45213333	12	5.287677778			
Total	77.68031111	17				

Table 11: The ANOVA for the Big bluestem after the herbicide treatment compared to the Big bluestem controls with the P-value highlighted.

Herb Big Blue Compared to Crabgrass Control						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
HBB1 AVG	3	1.65	0.55	0.9075		
HBB2 AVG	3	1.43	0.476666667	0.681633333		
HBB3 AVG	3	4.79	1.596666667	3.437233333		
C1 AVG	3	9.82	3.273333333	8.404633333		
C2 AVG	3	7.85	2.616666667	5.616633333		
C3 AVG	3	8.03	2.676666667	6.092633333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	20.80771667	5	4.161543333	0.993197898	0.461681611	3.105875239
Within Groups	50.28053333	12	4.190044444			
Total	71.08825	17				

Table 12: The ANOVA for the Big bluestem after the herbicide treatment compared to the Crabgrass controls with the P-value highlighted.

Burn Big Blue						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
BBB1 AVG	3	5.66	1.886666667	3.202533333		
BBB2 AVG	3	4.67	1.556666667	3.934433333		
BBB3 AVG	3	5.85	1.95	4.5289		
ANOVA						
ource of Variatio	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.267622222	2	0.133811111	0.034410931	0.966363641	5.14325285
Within Groups	23.33173333	6	3.888622222			
Total	23.59935556	8				

Table 13: The ANOVA for the Big bluestem after the burn treatment with the P-value highlighted.

Burn Big Blue Compared to Big Blue Control						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
BBB1 AVG	3	5.66	1.886666667	3.202533333		
BBB2 AVG	3	4.67	1.556666667	3.934433333		
BBB3 AVG	3	5.85	1.95	4.5289		
BB1 AVG	3	6.71	2.236666667	7.305233333		
BB2 AVG	3	8.41	2.803333333	11.87203333		
BB3 AVG	3	7.03	2.343333333	7.522433333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.791761111	5	0.558352222	0.087320835	0.992838361	3.105875239
Within Groups	76.73113333	12	6.394261111			
Total	79.52289444	17				

Table 14: The ANOVA for the Big bluestem after the burn treatment compared to the Big bluestem controls with the P-value highlighted.

Burn Big Blue Compared to Crabgrass Control						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
BBB1 AVG	3	5.66	1.886666667	3.202533333		
BBB2 AVG	3	4.67	1.556666667	3.934433333		
BBB3 AVG	3	5.85	1.95	4.5289		
C1 AVG	3	9.82	3.273333333	8.404633333		
C2 AVG	3	7.85	2.616666667	5.616633333		
C3 AVG	3	8.03	2.676666667	6.092633333		
						S
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	6.093466667	5	1.218693333	0.230088536	0.942074502	3.105875239
Within Groups	63.55953333	12	5.296627778			
Total	69.653	17				

Table 15: The ANOVA for the Big bluestem after the burn treatment compared to the Crabgrass controls with the P-value highlighted.

Herb Buffalo						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
HB1 AVG	3	1.51	0.503333333	0.760033333		
HB2 AVG	3	2.86	0.953333333	1.370533333		
HB3 AVG	3	3.37	1.123333333	1.443433333		
ANOVA						
ource of Variatio	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.6158	2	0.3079	0.258449916	0.780423995	5.14325285
Within Groups	7.148	6	1.191333333			
Total	7.7638	8				

Table 16: The ANOVA for the Buffalo grass after the herbicide treatment with the P-value highlighted.

Herb Buffalo Compared to Buffalo Control						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
HB1 AVG	3	1.51	0.503333333	0.760033333		
HB2 AVG	3	2.86	0.953333333	1.370533333		
HB3 AVG	3	3.37	1.123333333	1.443433333		
B1 AVG	3	7.86	2.62	8.9481		
B2 AVG	3	7.11	2.37	6.5689		
B3 AVG	3	7.58	2.526666667	7.692633333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	12.89689444	5	2.579378889	0.577825762	0.716563688	3.105875239
Within Groups	53.56726667	12	4.463938889			
Total	66.46416111	17				

Table 17: The ANOVA for the Buffalo grass after the herbicide treatment compared to the Buffalo controls with the P-value highlighted.

Herb Buffalo Compared to Crabgrass Control						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
HB1 AVG	3	1.51	0.503333333	0.760033333		
HB2 AVG	3	2.86	0.953333333	1.370533333		
HB3 AVG	3	3.37	1.123333333	1.443433333		
C1 AVG	3	9.82	3.273333333	8.404633333		
C2 AVG	3	7.85	2.616666667	5.616633333		
C3 AVG	3	8.03	2.676666667	6.092633333		
						S
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	19.32671111	5	3.865342222	0.979067513	0.468996672	3.105875239
Within Groups	47.3758	12	3.947983333			
Total	66.70251111	17				

Table 18: The ANOVA for the Buffalo grass after the herbicide treatment compared to the Crabgrass controls with the P-value highlighted.

Burn Buffalo						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
BB1 AVG	3	5.66	1.886666667	3.202533333		
BB2 AVG	3	5.06	1.686666667	3.236133333		
BB3 AVG	3	4.97	1.656666667	2.303433333		
ANOVA						
ource of Variatio	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.0938	2	0.0469	0.016094531	0.984076626	5.14325285
Within Groups	17.4842	6	2.914033333			
Total	17.578	8				

Table 19: The ANOVA for the Buffalo grass after the burn treatment with the P-value highlighted.

Burn Buffalo Compared to Buffalo Control						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
BB1 AVG	3	5.66	1.886666667	3.202533333		
BB2 AVG	3	5.06	1.686666667	3.236133333		
BB3 AVG	3	4.97	1.656666667	2.303433333		
B1 AVG	3	7.86	2.62	8.9481		
B2 AVG	3	7.11	2.37	6.5689		
B3 AVG	3	7.58	2.526666667	7.692633333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.803977778	5	0.560795556	0.105308006	0.989044961	3.105875239
Within Groups	63.90346667	12	5.325288889			
Total	66.70744444	17				

Table 20: The ANOVA for the Buffalo grass after the burn treatment compared to the Buffalo controls with the P-value highlighted.

Burn Buffalo Compared to Crabgrass Control						
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
BB1 AVG	3	5.66	1.886666667	3.202533333		
BB2 AVG	3	5.06	1.686666667	3.236133333		
BB3 AVG	3	4.97	1.656666667	2.303433333		
C1 AVG	3	9.82	3.273333333	8.404633333		
C2 AVG	3	7.85	2.616666667	5.616633333		
C3 AVG	3	8.03	2.676666667	6.092633333		
						S
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	6.451294444	5	1.290258889	0.268282275	0.921864422	3.105875239
Within Groups	57.712	12	4.809333333			
Total	64.16329444	17				

Table 21: The ANOVA for the Buffalo grass after the burn treatment compared to the Crabgrass controls with the P-value highlighted.