Characterizing the Age Distribution of an Oak Savanna at Fermi National Accelerator Laboratory

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ABSTRACT

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The preservation of plant and animal species is extremely important in maintaining a balanced and healthy ecosystem. Fermilab's Ecological Land Management (ELM) Committee has undertaken several ecosystem restoration projects in order to preserve habitats and restore biodiversity of a wide array of species. One such project is the oak savanna restoration and preservation located by the bison field. The purpose of this study is to characterize the savanna to ensure that we can continue to restore and preserve it. Firstly, we found out the population distribution of the trees inside the savanna by manually identifying each tree. Secondly, we calculated the age of each tree by measuring its circumference. Lastly, we calculated the canopy cover because of its significance in affecting diversity in the understory. We calculated the canopy cover of the trees in the savanna by using a spherical densiometer. Data was collected along three transects, which were 50 meters apart and spanned the width of the fenced savanna area. The canopy cover in the bison savanna was an estimated 28.56%, well within the healthy canopy cover range of 10-50%. The age distribution of the trees in the savanna should ideally be equitable and dominated by oak species between 80 and 250 years old, but the results of the study show that the savanna houses mostly older trees that will likely die within the next 100 years and not enough young trees to sustain the ecosystem afterwards. Tree plantings must continue in order for the savanna to reach a balance between new trees, thriving trees, and dying trees. Land managers at Fermilab have already started to balance out this distribution by transplanting oaks in the savanna to inter-canopy gaps. This practice is helping the savanna, ensuring that it sustains itself and that canopy cover stays balanced. The next step in research of the bison savanna is to characterize the species of the understory. This will give the ELM Committee an idea of how to manage what grows there and what can be done to further restore the understory of the savanna.

INTRODUCTION

Oak savannas are one of the rarest ecosystems in North America. The Midwest, at the time of European settlement, housed an estimated 11-13 million hectares of savanna [1]. However, recent studies show that only 0.02% is still intact [2]. Savannas are known as ecotones, or the transitional land between different plant communities, specifically between a prairie and woodland [3]. Due to the scattered overstory trees in a savanna, the canopy cover affects how much light and rain gets in, which greatly increases the diversity in the area [4]. Between savanna, scrub, and forest habitats, savannas have the highest conservation index values [5]. It is important to preserve this ecosystem because it provides a habitat and breeding ground for a number of animals, many of which come into savannas solely for the purpose of mating [6]. Also, one of the main purposes of restoring an ecosystem is the recovery of lost biodiversity [7]. The restoration of oak savannas is a high priority in Illinois because it would reintroduce the richness of rare species [8].

Prior to European settlement in the United States, savannas were maintained by disturbances such as fire, grazing, and drought [2]. These disturbances allowed fire-tolerant trees to flourish and the woody undergrowth to give way to a more herbaceous floor. Peterson and Reich argue that the "long-term persistence of savanna sites requires that a dynamic balance be maintained between mortality and ingrowth, such that neither trees nor grasses become locally extinct" [9].

After European settlement, fire frequency was greatly reduced and grazing practices were also changed. The land had also been lost to agriculture and other human expansion and development [2]. The changes in disturbances negatively affected the health of the savannas, as they became overgrown with dense, woody understories. The absence of the disturbances fueled the growth of exotic grasses, limiting light availability for the native species which suppressed their growth, reproduction, and establishment [10].

Due to negligence, many savannas today are overgrown with a woody understory, which is not conducive to a healthy savanna. An ideal savanna would have a fairly open canopy of fire-intolerant trees (about 10-50% coverage) and a dense herbaceous understory [2]. The amount of canopy coverage is crucial to the savanna community because it controls how much light and rain reach the savanna floor. The variation in light and rain distribution leads to more variation in understory species, creating a diverse area that is characteristic of a healthy savanna [4].

The bison savanna, located in central Fermilab, was the site used for this study. It is adjacent to the bison pasture and totals 10 hectares. The savanna is home to various birds and other wildlife including Great Horned Owls, Red-tailed Hawks, and Eastern Bluebirds [11]. The main species in the bison savanna are the bur oak (*Quercus macrocarpa*), white oak (*Quercus alba*), and shagbark hickory (*Carya ovata*), along with many bur/white oak hybrids. According to USDA Forest Service, the average lifespan of the bur oak is between 200 and 400 years [11]. The average lifespan of a white oak is between 400 and 500 years. A healthy oak savanna should ideally have many oaks between 80 to 250 years old [12].

The savanna at Fermilab has not been burned for approximately 100 years, which results in an uncontrolled growth of the understory. To counter that, the area was left open for the Bison to graze in. However, this meant that very few new trees were able to grow from seeds. With renewed focus on restoring and preserving the savanna, the Ecological Land Management (ELM) Committee at Fermilab has fenced off the area to stop bison grazing, transplanted approximately 30 new trees [13], and mow around the new trees in order to control the understory.

The purpose of this study is to ensure that these corrective measures taken five years ago are helping restore and preserve the savanna. Our objective was to determine the distribution of the species, their ages, and the general age structure of the trees in the savanna. We did this by characterizing each tree. We also determined the average canopy cover of the bison savanna, an extremely important characteristic of a savanna. Finding the population distribution, age structure, and canopy cover will allow the ELM Committee at Fermilab to determine what further steps need to be taken to preserve the savanna ecosystem. The ELM Committee's long-term goal is to create a more even age distribution among the oak population.

MATERIALS AND METHODS

We conducted research in the bison savanna on Fermi National Accelerator Laboratory's property. In the approximately 10-hectare area, each tree was first identified by species using the Forest Trees of Illinois handbook [13]. Leaves and bark were two main identifying features of the trees. The GPS location of the tree was taken and stored in the ArcPad program, provided by the Roads and Grounds at Fermilab. The program allowed us to pinpoint each tree in the savanna on a satellite image and visually showed the distribution of trees and their ages.

To get their relative ages, we measured the circumference at breast height, 4'5" above the base of a tree. When multiple trunks were encountered at breast height, each trunk was counted as a separate tree. The trunks were still measured at breast height and the measurement was recorded. Each tree species has an index number that, when multiplied by the diameter of the tree, would give us an approximate age.

Canopy cover was measured using a spherical densiometer. This tool reflected a mirror image of the above canopy, and using the built-in grid tool, we estimated a percent canopy cover. Google Earth was used to map out a total of three transects, approximately parallel to Road C and each 50 meters apart [14]. Along each transect, 30 points were randomly chosen using the RANDOM.ORG website [15]. At each point, an estimation of canopy cover would be made four times, one facing each direction, north, south, east, and west. The amount of open canopy at each direction would be taken and recorded.

RESULTS

Bur Oak (Q. macrocarpa)

Of the 62 bur oaks measured in the bison savanna, the majority are between 175 and 350 years old (61%). There is also a large proportion of young trees between 0 and 50 years old (39%), as we can see in Figure 1. This influx in young trees seems to create the illusion that the savanna is being sustained successfully, but in fact it was through planned transplanting of young trees and the mowing around them that they are surviving. According to the ELM Committee, more than 20 oak seedlings have been recently transplanted to begin to create a more even, healthy distribution of bur oaks. If it had not been for the recently transplanted trees, the savanna would mainly be housing only bur oaks between 175 and 350 years old.

***White Oak* (*Q. alba*)**

The white oak age distribution consists of nine trees that are primarily middle-aged and old. There were major gaps in numbers of trees between the ages of 0 and 100 and 175 to 225. No trees younger than 100 years were found. This implies that within 300 years, white oaks will no longer exist in the bison savanna.

Bur/White Oak Hybrids

Some trees that were found in the bison savanna had characteristics of both bur and white oak. There were a total of 16 bur/white oak hybrids, with an age gap from 25 to 150 years. Only three trees were less than 25 years old.

Shagbark Hickory (C. ovata)

A total of 33 shagbark hickory trees were found, 30 of which were between 175 and 325 years old. The data shows that no trees were found that are between 25 and 175 years old. Only 3 trees between the ages of 0 and 25 were found. Shagbark Hickory is not an invasive tree, so its presence in an oak savanna is normal.

Other Trees

No more than two of Box Elder, Sugar Maple, Yellow Birch, Pin Oak, American Elm, and Hawthorn were found in the Bison savanna. A total of five Honey Locusts were found.

Canopy Cover

The average canopy cover in the fenced in area of the bison savanna is approximately 28.56%.

DISCUSSION AND CONCLUSIONS

Our results show a similar curve in the age distribution of all tree species in the bison savanna at Fermilab. Older trees, between the ages of 200 and 300 years, are dominating the savanna, as seen in Figure 6. It also seems that younger trees are not regenerating at a quick enough rate to balance the age distribution. This lack of young trees coincides with the bison grazing practices in the savanna. Up until five years ago, bison had grazed the savanna for over 100 years. While this did control the growth of the understory, it also hindered the growth of new trees. The decision to halt bison grazing in the savanna was made in order to ensure that seedlings thrive with no other disturbance. Brudvig and Asbjornsen recommend that oak seedlings actually be transplanted to inter-canopy gaps so as to promote regeneration of species [17]. Land managers at Fermilab have already begun to transplant seedlings to the canopy gaps in the savanna to ensure sustainability. They have been mowing around these seedlings in order to control understory growth while at the same time preserving the health of the young trees. The influx of young trees due to transplantation of seeds and the discontinuation of grazing should allow the savanna to regenerate. It would be ideal to have an age distribution of trees that is equitable and has a balance between dying trees and thriving trees.

The amount of canopy cover is also an important factor in the health of a savanna. An ideal canopy cover in an oak savanna is 10-50%. A healthy canopy cover affects the understory to a large extent, as its variation leads to the variation in species in the understory. We found that the savanna had a canopy cover of 28.56%, well within the healthy canopy cover range of 10-50%. However, there are very large gaps in the savanna where there are no trees at all in comparison to some densely populated areas. For instance, Transect 1 had the lowest canopy cover of 14.39% because of a large area without trees. There were, however, many oak seedlings in the gap, which suggests that in the future, this open area will be filled in with sufficient canopy as well.

This study has explored some aspects of the savanna ecosystem (age structure, population distribution, canopy cover) to ensure that these corrective measures taken by the ELM Committee are helping restore and preserve the savanna. Currently, the age structure of the trees is not at an optimal curve, but the corrective measures are allowing seedlings to grow with will help the savanna reach a more normal age distribution. The canopy cover of the savanna is normal, but the numbers are deceiving because of large amounts of open areas throughout the savanna. Studying the understory will be an essential next step in the process of savanna conservation research. Invasive species such as the aggressive Canada thistle will need to be removed before it starts to harm the overall health of the savanna. If the variation in understory species is low, the canopy may need to be trimmed to create more variation in light and rain attainment. None of this can be decided until studies have been done on the understory. I also suggest conducting a study such as mine every five to ten years to study the age distribution of the savanna. While this process may take time and money, the preservation and restoration of an ecosystem as rare as the savanna is very essential.

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TABLES AND FIGURES

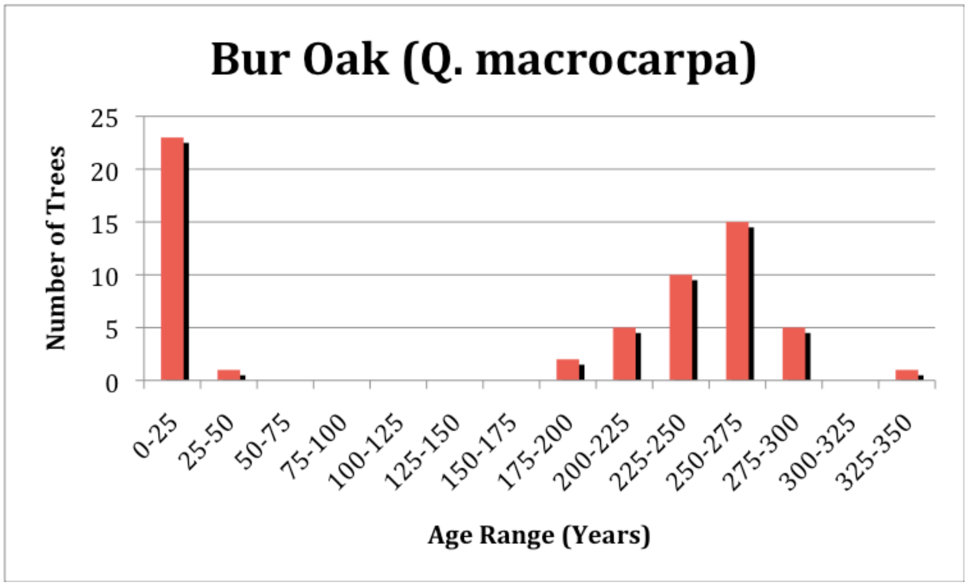

Figure 1: Age distribution of Bur Oak trees in the bison savanna at Fermilab.

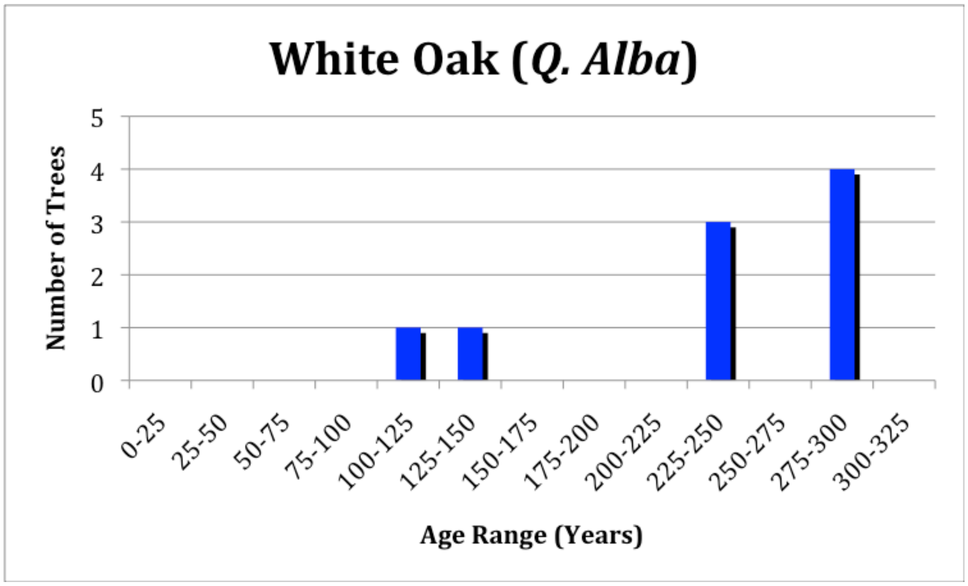

Figure 2: Age distribution of White Oak trees in the bison savanna at Fermilab.

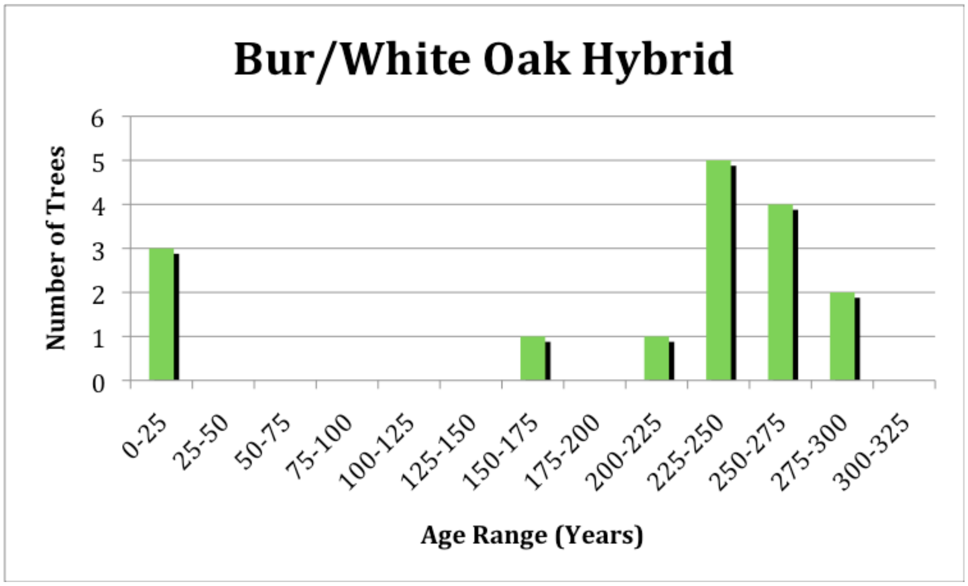

Figure 3: Distribution of Bur/White Oak hybrid trees in the bison savanna at Fermilab.

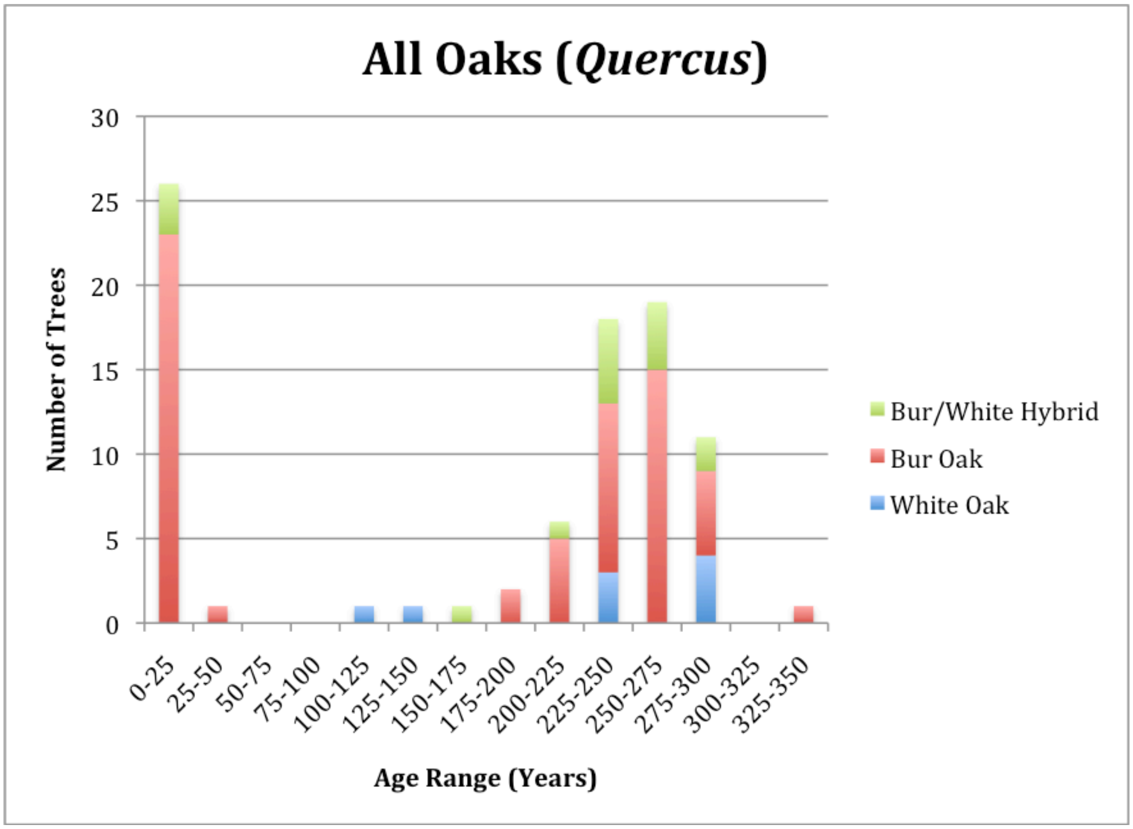

Figure 4: Age distribution of all Oak species in the bison savanna at Fermilab.

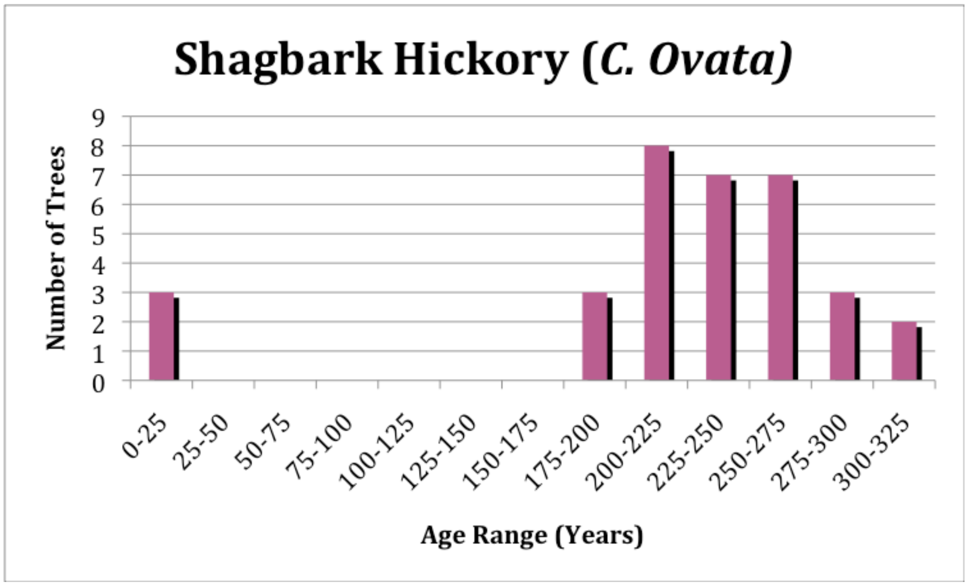

Figure 5: Age distribution of Shagbark Hickory trees in the bison savanna at Fermilab.

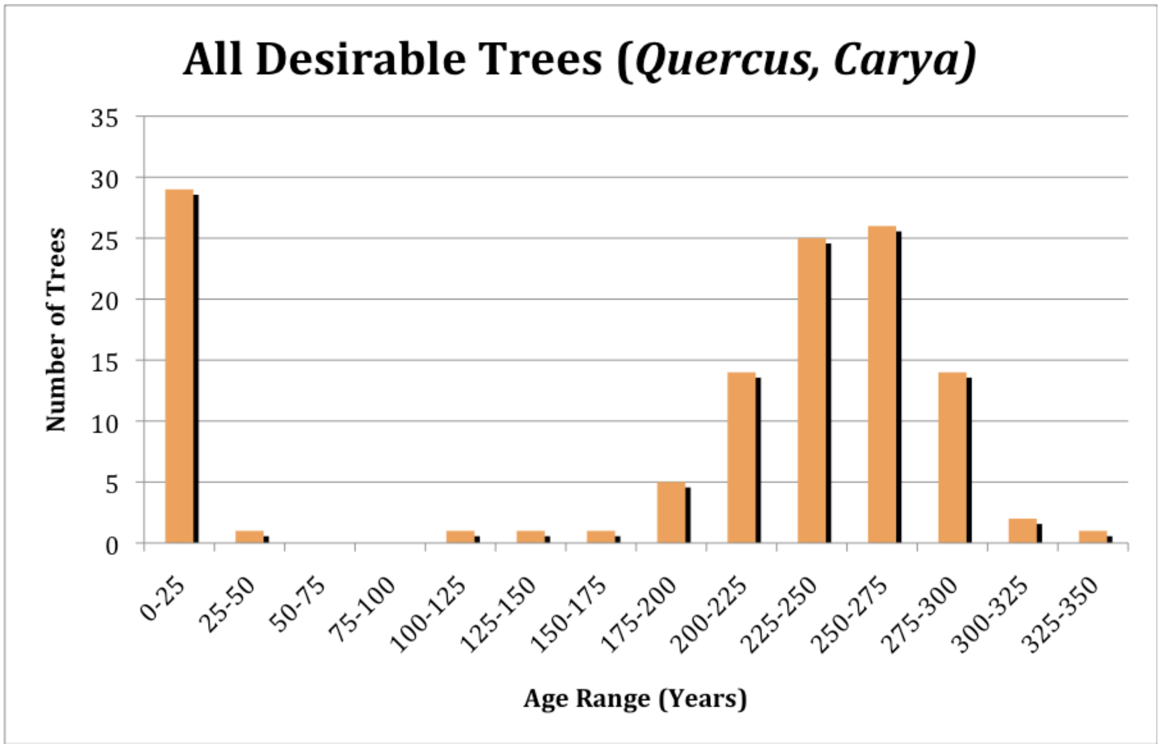

Figure 6: Age distribution of all desirable trees in the bison savanna at Fermilab.