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Local Ecology Research Papers

Conifer Tree Growth Patterns in the St. Olaf College Restoration Lands

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Abstract

The St. Olaf College natural lands include several areas of natural habitat restoration and within this area is a section of conifers. The goal of this restoration area is to replicate the tree composition of the forests found in northern Minnesota. The focus of this study is on a group of trees that were planted in 1993. Using maps from the Biology Department I measured the diameter of all the tagged trees and counted the number of mature female cones on each tree for the jack pine, red pine, white pine, and white spruce species. These data were analyzed to determine which species has the greatest amount of growth and which species produces the most mature female cones. I found that red pine and white pine had the greatest average diameter and that red pine had the greatest mature female cone production. Cone production on red pine and white pine trees increased as the diameter of the tree grew in size. The purpose of this study was to determine which species has been most successful in recreating the conifer forest habitat on the restoration sites, and which species has the greatest potential for continued growth and reproduction.

Introduction

In the past century there has been an increased interest in preserving the environment and reversing the destruction to the natural habitats that were disturbed decades ago. Humans have altered a major portion of the Earth's surface in order to harvest natural resources and to create communities and housing. Restoration allows for the reconstruction and reproduction of those natural habitats that were once present. Another goal of restoration is to allow for natural plants and animals to exist without extensive management. Restored areas should be able to survive as they naturally did centuries ago.

This study is focused on the coniferous forest of the St. Olaf College natural lands. Coniferous forests have been found in several parts of the state of Minnesota, mostly in the area near and around the Great Lakes. Most of the natural coniferous forest

is now found in the northeastern part of the state. Within the St. Olaf natural lands coniferous plot the dominant species include: jack pine, red pine, white pine, and white spruce. In many coniferous forests succession is caused mainly by disturbances such as windstorms, drought, fire, insects, mammals, plant diseases, and human disturbance (Heinselman, 1996). If the forest remains undisturbed older trees will die off and be replaced by younger trees creating a forest of trees of all ages. Forests that occur in nature include a variety of tree species at different ages (Dovciak et. al, 2001). Restoration increases the succession that results in such natural forests.

The natural lands at St. Olaf College include several different habitats that have been restored, including a coniferous forest. Within the several hundreds of acres of natural lands at St. Olaf the planners have tried to create a diversity of natural Minnesotan ecosystems, some that are natural to the area, while others like the coniferous forest was not natural to the Northfield area at the time of settlement by the pioneers. The purpose for the diversification of the ecosystems was partly motivated by the opportunity that students would have to study and research all of the habitats found in Minnesota.

Previous studies on the conifer section have been done in the past couple of years. This project is a continuation of these studies to monitor the success of the growth and reproduction of the forest. The study of the conifers at St. Olaf has continued to have similar goals including: recording heights, diameters, and location of the conifers; measure cone production and reproduction; and determine the growth for individual species.

The objectives of this study are to determine the growth rate and amount of cone production for each of the conifer species in the St. Olaf restoration area. In addition, I would like to determine if there is a relationship between the tree trunk diameter and the amount of cones produced for each species.

Methods

There are two different sites within the conifer section including the site planted in 1993 and the site planted in 1999. Previously growth measurements were made on the 1993 site in 1995, 1997, 1999, and 2004; and the 1999 site was measured in 2000 and 2004. The height, diameter, and number of female cones were recorded in 2003 and cones were counted again in 2004.

Growth

I used maps that have plotted all of the trees that were originally planted and tagged which made it possible to take measurements on each of the individual trees. The diameters of the trees were measured at breast height (approximately 1.5m). Since all the trees had diameters that were large enough a diameter tape was used to collect all of these data.

Reproduction

Only mature female cones will be counted on each tree individually. Mature cones are at least two years old and are still present on the tree. Because jack pines never loose their female cones, I only counted those that still had pigment and were on the outer-most portion of the branches.

Analysis

All statistical analysis was done using STATA and included one-way ANOVA to test variance for mean diameter measurements and the mean cone production between species (2003). Regression tests were also used for each species to find any relation between cone production and growth of diameter.

Results

In concurrence with a previous study (Cooper, 2004) I found that jack pines have the greatest average number of mature female cones and have the greatest mean trunk diameter (Table 1). All of the pine species had fairly similar mean trunk diameters, but the white pine and white spruce showed similarities in the average number of mature female cones (0.74 and 0.87 respectively). White spruce had the smallest mean trunk diameter at 8.5 cm.

There was a significant difference between species in the average trunk diameter (Table 2). Jack pine had the greatest mean diameter (16.27 cm) and had the largest difference in mean diameter with white spruce. This one-way ANOVA test had significantly high variance in variables as well as high kurtosis, but after doing a Kruskal-Wallis test the results were consistent in that there was still a significant difference in mean diameter between species.

There was also a significant difference between species in the average cone production per individual tree (Table 3). Jack pine was found to have the greatest cone production with an average of 22.97 cones per tree. Since white pine and white spruce

had similar lesser cone production, these species have the greatest difference in cone production with the jack pine. Again with the analysis of variance there was significant variance in variables and extremely high skewness and kurtosis. A Kruskal-Wallis and transformation tests showed that the significance between species was in fact the same for the original one-way ANOVA results.

Red pine and white pine showed a significant increase in cone production as the trunk diameter increased (Figure 1 and 2). Red pine had the strongest relationship (R-squared = 0.17) and white pine only showed this relationship after a single outlier was removed. Jack pine and white spruce showed no relationship in the linear regression between cone production and trunk diameter. Jack pine in fact appeared to have a negative relationship where the number of cones produced decreases as the trunk diameter increases (Figure 3). The relationship between cone production and diameter in white spruce was outweighed by the number of trees that lacked cones and had larger diameters (Figure 4).

Discussion

Individual Species

Jack pines are known as a pioneer species because they are very tolerant of different conditions, especially light. This would explain why jack pines have the greatest average trunk diameter and the greatest cone production. The difference between reproduction and the number of cones found would most likely be due to differences in reproduction ages of each species. Jack pine is also unique in that the tree

never looses the mature female cones that are produced which would make a difference with those trees that may have lost mature female cones due to the season, wind, or any other external effect. The overall growth and signs of reproduction, with the increase in trunk diameter and cone production, are similar results to those that have been found in previous studies.

Restoration

These four dominant species continue to show overall growth and reproduction, which are positive signs for the overall restoration of the northern Minnesota coniferous forest habitat. As the trees continue to grow they will continue to grow taller and increase their diameters. In order for the restoration to be completely successful is for the trees to continue to reproduce so that the forest can continue to form as a continual cyclical habitat that occurs in natural forests. It is important that the forest begin to produce a second generation so that as the trees get older, they may begin to die and may be more susceptible to destruction by natural events, such as wind.

The study of restoration ecology is fairly young and there are still many aspects that have not been fully explored. The goal of restoration ecology is to restore natural habitats that have been destroyed. St. Olaf College has several acres of restoration lands with several different habitats. Many of these sites have been very successful in restoring the natural lands that were present before the human impacts on the earth. The coniferous plots are different in that so far only trees have been planted and this forest is type of ecosystem that is non-native to the area.

Ecosystems are complex and include several different plant and animal species. The coniferous trees that have been planted at St. Olaf College are a very small portion of the habitat that is anticipated. Eventually under story plants will need to be introduced to complete the plant composition of the forest. These plants are essential for the completion of a successful restoration of the forest habitat. John D. Aber suggests that succession within recreated habitats may be affected by the disturbance that an area once experienced or in this case may be affected because of the difference in overall ecosystem structure (1987). If the under story plants were introduced there is potential that they will be affected by this succession disturbance or it may affect the growth of the tree species that are currently present.

Because this plot is a habitat that is not naturally occurring within the prairie that covers the southern portion of Minnesota, there are many factors that this site will have to overcome in order to complete a successful restoration. The animal composition will be difficult to recreate because the plot is a relatively small area. This coniferous forest is an island among the prairie lands of southern Minnesota making it difficult to recreate the animal composition that would be found in a coniferous forest in northern Minnesota. Since this restoration plot is relatively small it would be most difficult for larger mammals to be able to survive in this restored habitat.

Conclusion

The restoration of a northern coniferous forest at St. Olaf College has been successful to this point. The dominant trees have continued to show growth through the

increase in trunk diameter and have shown signs of reproduction with the presence of mature female cones. The restoration process should continue with the planting of under story plants. For future studies this plot should continue to be monitored to fully understand the succession of the restoration of a non-native habitat.

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Table 1. Summary of names, average number of cones per tree, and average diameter at breast height for the four most dominant conifer species in the 1993 coniferous restoration plot at St. Olaf College.

Common Name	Latin Name	Mean # of Cones	Mean DBH (cm)
jack pine	*Pinus banksiana* Lamb	22.98	16.27
red pine	*Pinus resinosa* Soland	18.48	15.29
white pine	*Pinus strobus* L.	0.74	14.42
white spruce	*Picea glauca* (Moench) Voss	0.87	8.50

Table 2. One-way analysis of variance comparing mean tree trunk diameter for dominant conifer species in the 1993 coniferous restoration plot at St. Olaf College.

summary of diameter (cm)			species	mean	std. dev.		
frequency			white pine	14.42	3.77	116	
red pine	15.29	2.88	42				
jack pine	16.27	3.19	40				
white spruce	8.502	1.98	39				
p-value	0.000						

Table 3. One-way analysis of variance comparing mean mature female cone production for dominant conifer species in the 1993 coniferous restoration plot at St. Olaf College.

summary of cone production			species	mean	std. dev.		
frequency			white pine	0.74	3.75	116	
red pine	18.47	17.98	42				
jack pine	22.97	24.11	40				
white spruce	0.87	3.48	39				
p-value	0.000						

Figure 1. Linear regression of tree truck diameter in relation to the number of mature female cones counted on red pine individuals in the 1993 coniferous restoration plot at St. Olaf College.

Figure 2. Linear regression of tree truck diameter in relation to the number of mature female cones counted on white pine individuals in the 1993 coniferous restoration plot at St. Olaf College.

Figure 3. Linear regression of tree truck diameter in relation to the number of mature female cones counted on jack pine individuals in the 1993 coniferous restoration plot at St. Olaf College.

Figure 4. Linear regression of tree truck diameter in relation to the number of mature female cones counted on white spruce individuals in the 1993 coniferous restoration plot at St. Olaf College.

Number of Mature Female Cones

Number of Mature Female Cones

Number of Mature Female Cones

Number of Mature Female Cones

# of Obs = 42
P-value = 0.0064
R squared = 0.17

# of Obs = 116
P-value = 0.0043
R squared = 0.07

# of Obs = 40
P-value = 0.0804
R squared = 0.05

# of Obs = 39
P-value = 0.6681
R squared = 0.005