# Analysis of Controlled Burns on the Biodiversity at Rush Oak Openings

Matthew Taylor, Student
Department of Biology, SUNY Geneseo
Geneseo, NY 14454

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**Abstract**

As a popular connotation, conservation is usually used for the preservation of exotic animals facing extinction. However, many people do not consider the immense value of protecting domestic ecosystems. Development of appropriate conservation plans that reinforce the healthy function of these ecosystems, rather than anthropocentrically based, should be the primary goal. The New York Department of Environment Conservation has persevered in its mission to adequately replicate the fire ecosystem at it's Rush Oak Openings site, where fires are an intricate part of the site's ecology. Since 2001, various controlled burns have taken place, and the extent of these fires have been mapped in ArcGIS. Using data collected this year, we can attempt to assess the health of this ecosystem and contrast it with the already compiled historical data in ArcGIS. Furthermore, we assessed the complexity and health of both the grassland tracts and forest plots by computing Simpson's E to obtain measures of relative species evenness which could be compared between the sampling areas. For grasslands, enough information was compiled to be able to construct a DCA, or Detrended Correspondence Analysis, where the relationships between the ecology of our indicator species for oak openings were examined. Various factors that could be potentially effect species evenness were also examined. although the mapping of species relationships may be informative, we conclude that we did not find any statistically significant data that allowed us to better understand the role of fire on the oak opening ecosystems.

## 1 Introduction

**Background Information** Rush Oak Openings (or Rush Oaks) is a conservation site that is maintained by the New York Department of Environment Conservation (DEC) in the town of Rush, NY. The total area is approximately 228 acres situated between two 'tracts,' the Quinn Tract and the Goff Tract. Rush Oaks was chosen as a conservation site by the DEC due to its unique environment, commonly known as an "oak savannah" or as an "oak opening." It has been suggested that these were very common ecosystems prior to European colonization. These unique landscapes were formed from glacial events hundreds of thousands of years ago that left very little litter that would allow for the growth of forests. However, this did support the growth of grass. (Rush Oaks Unit Management Plan, 1998) It has been suggested that these fire adapted systems rely on the role of fire disturbance to help mitigate the advance of invasive species. (Pg. 85, Lockwood et al., 2007) A series of common ecological tests, along with various locations were chosen to help us better understand this unique relationship.

Fire management on the Rush Oaks site has occurred since 2001, even thought the NYDEC held the land since as early as 1990. (Rush Oaks Unit Management Plan, 1998) Controlled burns usually took place on years that permitted safe burning, i.e. years where wind speed and direction was acceptable, and also years when the NYDEC had enough funding. Dr. Kernan, a Biogeographer at SUNY Geneseo, provided historical information necessary for this research to be conducted. Survey teams consisted of students from Conservation Biology (Bio 0338) and Field Biogeography (Geog 0331). Teams consisted of five individuals and contained students from both classes.

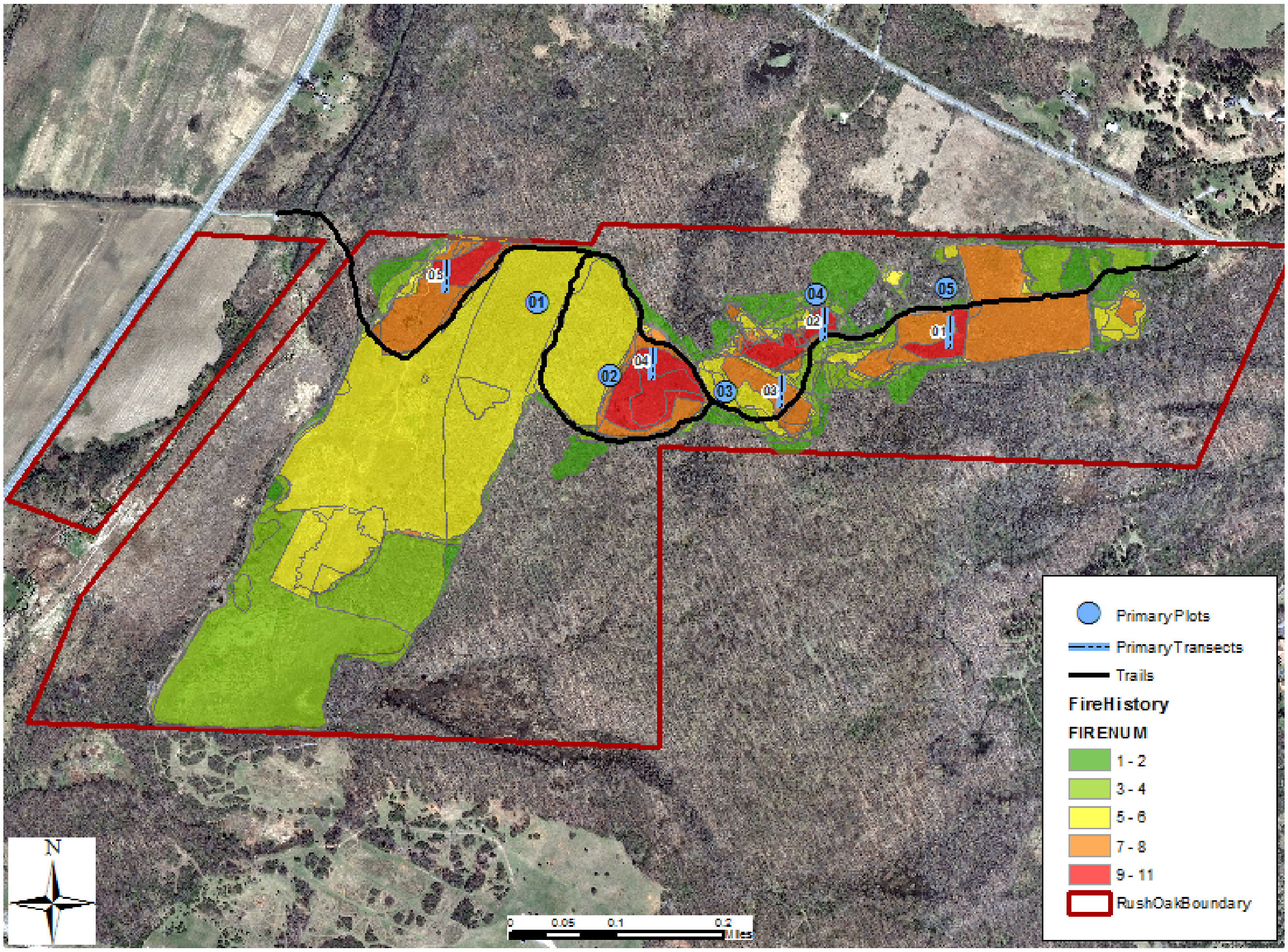



Figure 1: Site map for Rush Oak Openings. Boundary of NYDEC land is shown in red. Number of fires is indicated by the key at the bottom right and assigned a color on the map. Trail is shown in black, while grassland survey tracts are black with a blue highlight. Tract IDs are plotted next to the tracts. Blue circles are the forest sample plots. Plot IDs are plotted inside the circles. Map created using ArcGIS software.

Each team was responsible for one grasslands transect and one forest plot. Data was collected on September 15th and September 22nd of 2014.

**Purpose of the Study** The data collected at Rush Oak Openings provides valuable information for the role of fire disturbance in oak opening ecosystems that will have a major influence on how we, as conservation biologists, attempt to preserve the environment around us. Fire disturbance is thought to provide a valuable role in preventing invasive species from colonizing native environments. (Pg. 85, Lockwood et al., 2007) The ability to thereby quantify this then, is inherently valuable in assessing proper management techniques for not only oak opening systems but other ecosystems that are reliant on disturbance as a natural phenomena.

## 2 Methods

**Data Collection** A variety of tests were used to quantify the species diversity and composition of the landscape for analysis. Measurements in the grasslands were made along a 50m transect.

Every two meters a number of tests could have been performed. The first test that was performed was a Quadrat Frequency. A "T" was assembled with the top part of the "T" separated by four dividing lines. This created 5 sections, and the presence of a species in a specific amount of zones resulted in a score from 0 to 5. Surveyors measured the presence of various key species, e.g. Sorghastrum nutans and Monarda fistulosa, and the amount of the "T" that they occupied. The second test that was performed was a steppin test, where surveyors were required to drop a pin from a sufficient height and then record the amount of ground litter, i.e. leaves or other dried vegetation, that the pin "hit." This was repeated five times, and for each successful "hit" the score increased. Possible scores ranged from 0-5.

At the ten meter mark two tests were performed. The first was a robel pole measurement that required surveyors to assess the maximum height at which 50% of a 10cm section was obscured. For example, if the highest section that was 50% obscured by the vegetation, the surveyors recorded the measurement as "1.9m," or "190cm." The second test was to take a horizontal digital image that could be used to assess the vertical vegetation structure. A white backdrop was placed (centered) at the 10m marks and were approximately 2m behind the transect line. The photographer was positioned on the opposite side of the transect and was also approximately 2m in front of the transect line. The cameras were placed atop a meter high pole to standardize the height at which the photos were taken.

Figure 2: Vertical vegetation analysis after conversion to binary in imagej.

For any groups that came across woody debris, a canopy gap intercept method was used to document this occurrence. For transects where debris obstructed their ability to perform the tests above, they were simply marked as "NA" in the data and were not included in statistical tests.

For the forest plots, two transects measuring 25.24m in diameter (or rather 12.62m in radius) were laid down with the middle of the tape at the stake that represented the center of the plot. A second tape was laid perpendicular to the first to make four zones or quadrats. Downed woody debris were recorded for each plot and placed in categories relative to their size, e.g. fuel loads (100hr., etc.). A Daubenmire quadrat was then used to measure the amount of ground cover, i.e. seedlings. This test was performed every two meters along the second tap/transect.

Two measures of large woody growth were conducted, one to assess the canopy and the other to assess the understory. For the canopy data, every tree with a Diameter Breast Height (DBH) of $\geq$ 5cm was recorded along with their species. For the understory data, surveyors walked along one of the transects and recorded trees. to a half meter on either side of the transect, with a DBH of $\leq$ 5cm.

**Data Aggregation and Statistical Analyses** The data for all of the tests were then compiled in the ArcGIS program, where historical data was supplemented to the data collected on September 15th and 22nd, 2014. A site map was generated to allow readers to orientate themselves with the location of various transects and plots that will be referred to in the discussion. The data was then exported for statistical analysis using the program R and RStudio. Images that were taken in the field were imported into imagej where they were trimmed for consistency (all photos should have a height of approximately 2m and should not include any foreign objects), converted to binary (black and white), and then assessed to create a measure of percent vegetation cover.

Rather than calculate species diversity, species evenness was chosen as the primary metric for comparing and contrasting transects and plots. This is because species evenness, unlike diversity, allows us to understand the composition of the landscape than simple measures of diversity. Evenness was calculated using Simpson's E, as shown below:

(a)

$$E = \frac{1/\sum(n/N)^2}{d}$$

$d =$ number of species possible
$n =$ the total number of a single species
$N =$ the total number of all the species

A General Linear Model (GLM) was performed on data from the converted images (percent vegetation cover) and data from the robel pole measurements to analyze the relationship between these two factors. A boxplot was used to show the evenness relationship between the different tracts in the grasslands. A Detrended Correspondence Analysis (DCA), also known as a DECORANA, was performed to show the relationship between the various indicator species to better understand their ecological presence at Rush Oak Openings. A DCA differs from a Primary Component Analysis (PCA) in that the rescaling of points prevents distortion that in some situations complicate our understanding of the underlying relationships. (Holland, 2008)

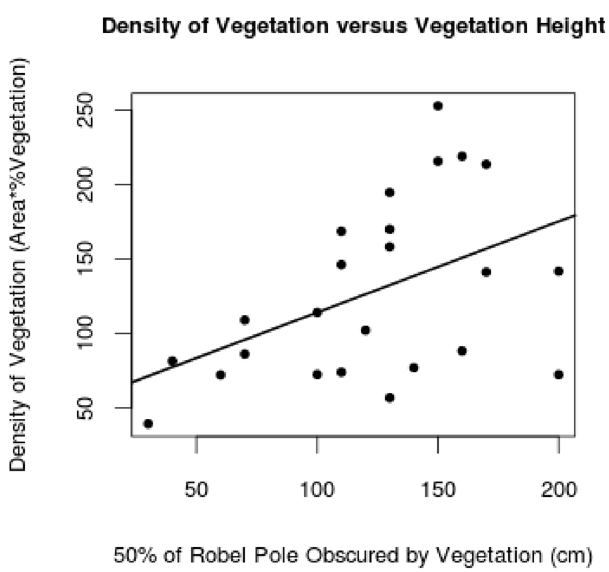



Figure 3: GLM of Density of Vegetation versus Robel Measure.

To assess the role of fire in the ecosystem, a number of plots were constructed to show the relationship between evenness and other factors; namely fire and litter. Correlations were performed on Figures 6.A and 6.B, while the remaining graphs were sorted by their appropriate scores and were plotted as bar graphs with 95% confidence intervals.

For the analysis of the forest plots two bar graphs with 95% confidence intervals were produced. These graphs looked at the varying species evenness of the plot sites and also the average DBH of trees. Analysis of canopy position was disregarded due to the fact that the data reported trees at multiple levels, and it was determined that this qualitative data should not be used if there were potential inaccuracies.

For measures that produced a population size of one (n=1), or a single sample of that instance was recorded, a 95% confidence interval was not plotted.

In order to perform the necessary tests, two R packages were required: plotrix for the 95% confidence intervals and vegan for the necessary DCA functions. R code available upon request.

# 3 Results

**Grassland Data** In order to examine the relationship that existed between vegetation density and vegetation height, a GLM was used. (Figure 3) It was found that there was a statistically significant relationship existed between the robel pole measurements and the vegetation density. ($p = 0.0225$)

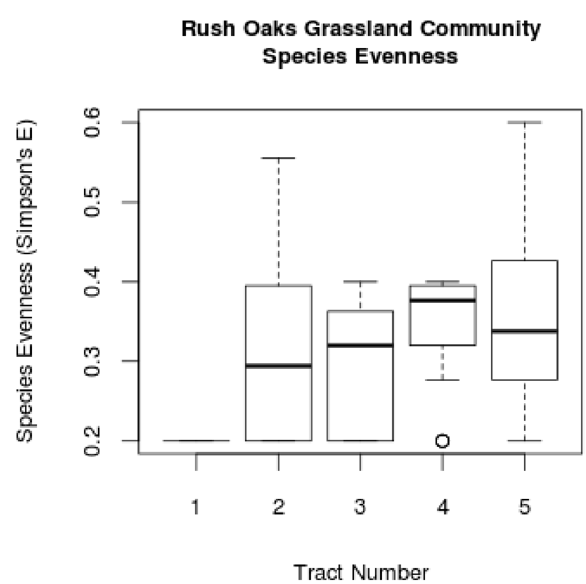



Figure 4: Species Evenness was calculated for every two meters on each transect resulting in a distribution of samples for each of the tracts. These distributions are graphed as boxplots.

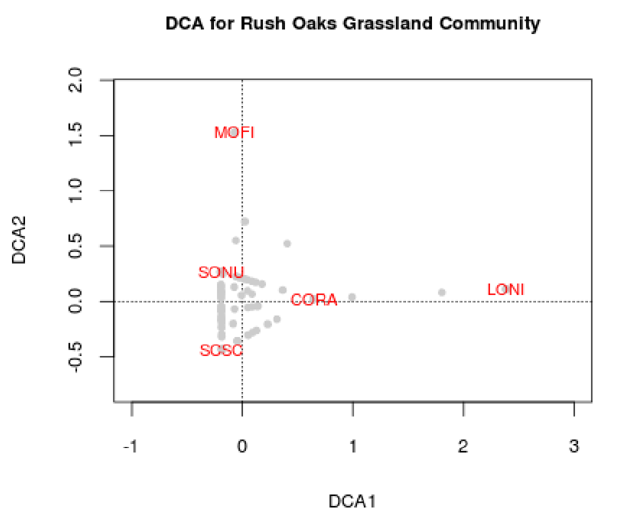



Figure 5: Results of the Detrended Correspondence Analysis, where the composition of plant distributions was assessed.

A quick plot of species evenness for the four transects was also produced. A boxplot was used to allow the reader to visualize the heterogeneity of the data. These data were not analyzed do to their non-parametric nature. Tract 1 appears to be extremely low because this plot was dominated by goldenrod (an invasive species that was not recorded).

To assess the relationship between different indicator species, a DCA was used. (Figure 5) The data obtained from the DCA allows us to see that three species; indiangrass, little bluestem, and dogwood were all fairly common in the oak openings community. Furthermore, it appears as though honeysuckle is equally as common between indiangrass and little bluestem, but interestingly is closer related to the presence of dogwood. Wild bergamot appeared to be related only to the presence of indiangrass. From the scaling, we might also imply that wild bergamot was also more abundant than honeysuckle for our specific samples.

In 6.A a correlation was performed to assess if there was a connection between species evenness and fire frequency. Due to the data being non-parametric, Kendall's Tau was used. It was found that there was no distinct correlation that existed between species evenness and fire frequency. ($p = 0.7651$)

In 6.B a correlation was performed to assess if there was a connection between the density of vegetation and fire frequency. Because the data was again found to be non-parametric, Kendall's Tau was used. It was found that there was no distinct correlation between the density of vegetation and fire frequency. ($p = 0.4199$)

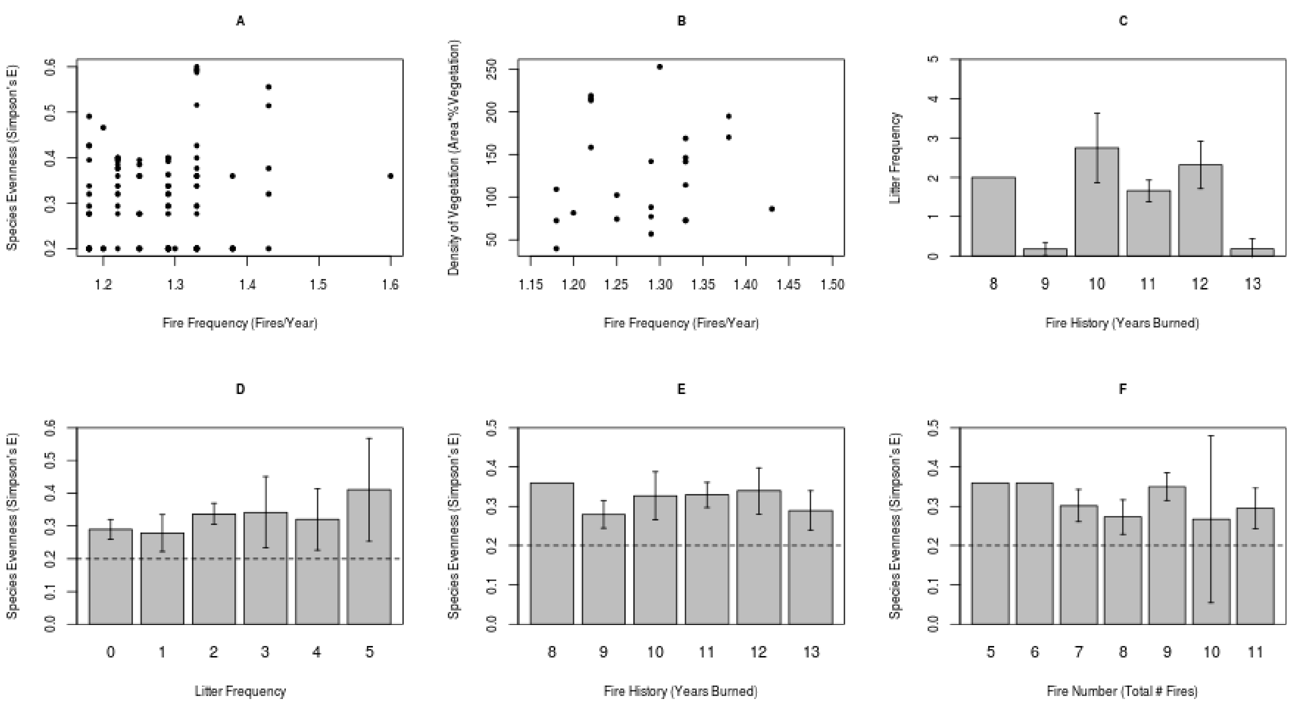
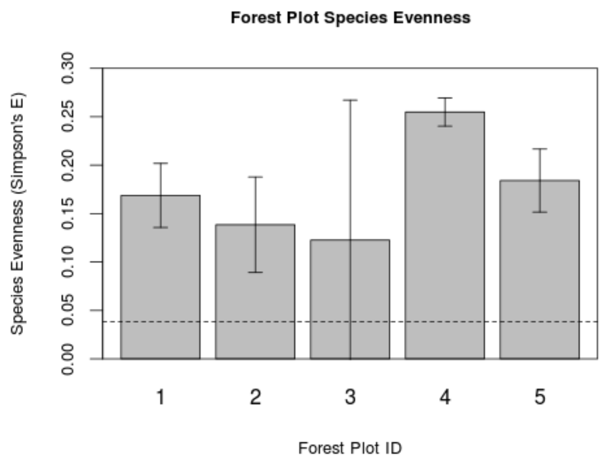



Figure 6: Plots of various measurements collected at Rush Oaks.

For 6.C through 6.F, no statistical tests were done do to the data being non-parametric. To properly statistically analyze the transects we would have required all of the various treatments, like the number of years burned, to have normally distributed species evenness values. For 6.D through 6.F, a dashed line was plotted at the precise minimum value that one could possibly receive if you were to calculate Simpson's E for those samples.



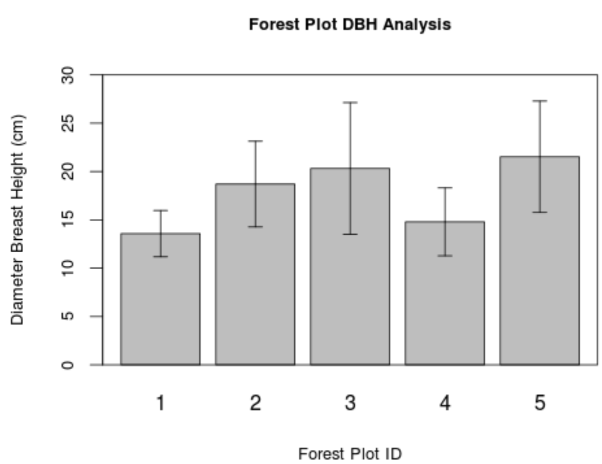




Figure 7: Measurements collected for forest plots at Rush Oaks. The top graph depicts the species evenness of each plot, and the bottom graph assesses the differences in DBH between plots. 95% confidence intervals included to better view the distribution. Dashed line in the top graph represents the minimum possible value.

**Forest Data** For forest plots, species evenness along with DBH were analyzed for any notable pattern between the five areas. Since the data was non-parametric, no statistical tests were performed. For the assessment of species evenness, a dashed line at the minimum was provided at the minimum value. (Figure 7)

For each of the forest plots, 95% confidence intervals were plotted to help visualize the distribution of the data.

# 4 Discussion

**Patterns of Biodiversity and Species Composition** From the results presented in Figure 4 and Figure 7, we can observe that the distribution of species is more even (or has a greater abundance of second and tertiary species in the environment) for grassland areas than it is for the forests in oak openings. This is likely related to the idea that it takes a larger amount of time for any significant change in the canopy species of a system. The age of the grasslands (as it was burned in the spring of this year [2014]) is significantly lower than the age of the forest (unknown). Furthermore, the intentionally induced fires likely play a role in the reduction of species, other than oaks and hickory, that are not particularly adapted to be able to survive fire disturbances.

However, Shaben and Myers, who worked with Garry oak savannas in the Pacific Northwest, found that the abundance of non-native species declined for areas with high amounts of invasives, while the abundance of invasive species increased. (Shaben and Myers, 2009) Since one of our transects represented an area with a high degree of invasives (transect 1), we are able to see this reduction in the abundance in indiangrass and the subsequent effect that it has on the composition of the ecosystem in that particular area. This may be extended to make a prediction about the high levels of variance of species evenness for each of the transects, where lower areas of biodiversity likely have a higher concentration of invasives. If we consider that the transects run from east to west (transect 1 is the easternmost, transect 5 is the westernmost), we can observe that the biodiversity increases as we continue westward (transect 5 will be discussed later). This might represent a trend regarding the "invasion path" of goldenrod in the Rush Oaks ecosystem.

When we examine the species evenness for the forest plots, we can observe that their measures are somewhat subpar. This, however, did not come as a surprise. These plots, if being maintained by fire, should likely be lower in their measure of species evenness due to the ability of oak and hickory to sustain in fire ecosystems. If we consider Figure 1 and Figure 7, we can observe that plot 4 had the highest amount of biodiversity while plots 2 and 3 had the lowest amount of biodiversity. We can observe that the amount of fires at plots 2 and 3 was higher than the amount of fires at plot 4. Therefore, we might insinuate that lower amounts of fires do not favor the typical oak opening tree species of oak and hickory. Plot 5 is interesting because it was never burned in the history of the site, at least by the NYDEC. We can observe the biodiversity is lower than plot 4, and more similar to plot 1 (which experienced a moderate amount of prescribed fire). When we examine the data, we found that this site had a high number of Quaking aspen, or Populus tremuloides. This likely represents the negative effect of not treating a site with prescribed fire and how it can alter the ecology of oak opening forests.

Measures of DBH (Figure 7) also provided interesting information. If we consider plots 1-4, we will notice that as the biodiversity decreases, the DBH increases for these plots. This may be because of two reasons, the first being a direct result of lowered competition and thus the recruitment of more resources (i.e. a population of oak or hickory that is not competing with fire-intolerant trees), or the density of the forest. For the data that we collected, plot one had the highest number of trees (N=71), plot two had the second most of trees (N=41), and plot three only had 13 trees (N=13). Because our plots were assessed in a given amount of space, we should expect that our results for DBH are likely a result of density. For reference, plot five had a similar number of trees (N=15) as plot three. The only plot that does not match this trend is plot four, whose tree population was similar to plot two (N=34), but had similar measures of DBH to plot one. It is probable that this is related to the high species evenness of the plot, where a large variety of trees are likely in competition for similar resources.

**Critque of Management Objectives and Strategies** It is particularly worrying that goldenrod has completely excluded indiangrass from some transects at Rush Oak Openings, namely the area of transect 1. Complete replacement of such a species, which the DCA (Figure 5) suggests may be important to the presence of wild bergamot, may have potentially large effects on the ecosystem at Rush Oaks. Mouillot et al. showed that rare species that are environment specific play potentially large roles in the ecosystem maintenance. (Mouillot et al., 2013) Future data collection will allow us to assess whether or not specific populations are growing or declining. In this case, we will be able to monitor the wild bergamot and be able to assess whether or not this potentially important species is being excluded due to the high abundance of goldenrod.

Furthermore, this is direct evidence that prescribed fire has not worked on reducing the number of invasive goldenrod and helped to maintain the native indiangrass. It has been concluded that prescribed fire in grassland communities varies widely in terms of intensity and burn time. (Engle, 1989) In the future, the NYDEC should develop a plan to assess the quality of prescribed fire. Either goldenrod has lifestyle properties that make it somewhat fire intolerant, or the quality of prescribed fires do not adequately promote the growth of our indicator species. The evidence for this may be related to the measured vegetation densities (Figure 2). Transect 1 has a high vegetation density, which just may be a characteristic of goldenrod, that may attribute to high enough temperatures (burn intensity as a function of vegetation density) that inhibit proper germination of indiangrass. Unfortunately, since we do not have any data for this, we cannot possibly determine an answer.

A major critique of the conservation plan for Rush Oak Openings would be the artificial seeding of little bluestem in the area where transect 5 is located. If we consider that the westernmost plots have lower abundances of invasives, artificial seeding may actually decrease the biodiversity of the area. (Figure 4) If prescribed fire is used to help maintain our indicator species, then it seems counter-intuitive to help plant against one of those species. Additionally, Little bluestem was abundant in other areas where artificial seeding was not taking place, so the practice appears to serve no intrinsic purpose.

**Limitations of the Study and Suggestions for Future Studies** The major drawback in the assessment of the ecology, and the ability to draw conclusions from our work, at Rush Oak Openings was mainly due to the quality of data collected. There are likely two reasons for this.

The first reason for poor data would be due to the fact that many of the transects cross multiple sections where the fire frequency changes. This makes assessment, and statistical analysis, particularly tricky. This was likely one of factors that led to heterogeneity in the data for each transect, which then had further consequences by distorting larger level characteristics at each of the areas.

The second reason would likely be due to the inexperience of the surveyors. In this case, students who likely have had none, if any, field experience. This was made more difficult due to the fact that data analysis occurred in the afternoon on a cloudy day (September 15th, 2014, approximately 4pm - 6pm), where this could have led to failures to correctly identify species.

This led to inabilities to assess the underlying processes of this unique ecosystem. A Kruskal-Wallis test was not used due to the fact that it would make more sense to assess differences between populations, especially considering that we are looking for effects of our "treatments," and not whether or not they are drawn from the same population. (Hampton, 2006) Furthermore, the heterogeneity of the data likely meant that the means where skewed and probably insignificant.

Future studies will have the benefit of having historical data about species composition at Rush Oaks. Data collection should also take place on a sunny weekend, where both grassland and forest data can be collected, and on-site review by organizers can audit the results from the surveyors. Inaccuracies can then be corrected.

## 5 Acknowledgements

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