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Abstract
Herbivory from ungulate species has been shown to have an impact on the species composition of trees within forest ecosystems. In the central and eastern United States, white-tailed deer impact their respective forest ecosystems by browsing on trees. By building fenced exclosures, we can measure the impact that deer have on their ecosystems. Overall density changes, as well as density or diameter changes in individual species, indicate that herbivory has impacted the forest composition. In my study, I analyzed the impact that herbivory had on an area of the St. Olaf Natural Lands. By measuring and identifying trees in a deer exclosure area and an open area adjacent to it, I found no significant difference in densities or diameter between the two plots. These results do not follow the general trend shown by previous studies, but could be a result of the small study area or relatively short time since the exclosure was implemented. Continual studies of this specific area may produce more accurate long-term results and may indicate the time period needed between implementation and observable results.

Keywords: deer exclosures, density, diversity, forest composition, herbivory, Odocoileus virginianus*,* Quercus *spp., white-tailed deer*

Introduction

Forest composition and tree diversity are impacted and shaped by herbivory (Frelich and Lorimer 1985, McInnes et al. 1992, Gill 2000, Goetsch et al. 2011, Abrams and Johnson 2012, Garthe et al. 2014, Burney and Jacobs 2018). Selective browsing from ungulate species such as white-tailed deer (*Odocoileus virginianus*), bison (*Bison bison*), caribou (*Rangifer tarandus*), elk (*Cervus elaphus*), and moose (*Antilocapra americana*) puts selective pressures on tree species, and affects the survival and succession of certain tree species (Côté et al. 2004, Averill et al. 2018).

White-tailed deer populations, specifically, have increased dramatically due to reduced hunting pressures and an increase in the ability to forage due to land use changes (Côté et al. 2004). Previous research demonstrates that low densities of deer increase diversity of flora, but when deer become overabundant, floral diversity is limited, and becomes more homogenous (Averill et al. 2018). Deer prefer small trees and seedlings, which will eventually result in gaps in the canopy. Herbaceous understory plants are then favored and replace the original tree saplings

(Tanentzap et al. 2011). Certain tree species, such as hemlock (*Tsuga canadensis*), various oak species (*Quercus* spp.), and black cherry (*Prunus serotina*) are frequently browsed in their respective forest ecosystems (Frelich and Lorimer 1985, Côté et al. 2004, Leonardsson et al. 2015).

Creating fenced-in regions where deer are unable to browse allows researchers to study the impact that herbivory has on forest ecosystems. Results have shown that the pressures due to browsing have been recorded across all forest ecosystems. In Michigan, researchers found that white-tailed deer were the major cause of decline of hemlock (*Tsuga canadensis*) regeneration, and were facilitating a shift in dominance from hemlock to sugar maple (*Acer saccharum*) (Frelich and Lorimer 1985). Similarly, in Pennsylvania, studies on fenced deer exclosures showed that fenced plots had higher species diversity and increased seedling number (Abrams and Johnson 2012). Though a weak trend, exclosures to prevent deer browsing were found to aid in oak regeneration in Sweden (Leonardsson et al. 2015).

Serving as a keystone species, deer exert selective pressures on forest ecosystems that have impacts on more than just plant diversity (Côté et al. 2004, Averill et al. 2018). Deer populations often exceed what forest ecosystems can sustain, and the effects are potentially irreversible (Averill et al. 2018). Reduction in tree growth results in less protection from erosion and floods. Damage to agricultural and forested lands from deer browsing in the United States results in damages estimated at $750 million annually in 1997 (Côté et al. 2004).

Studying the direct impact of deer browsing in a specific region provides answers on how forest composition is impacted, and may provide insight into how to solve issues of overbrowsing (Leonardsson et al. 2015). Using a fenced-in area compared to one exposed to deer browsing, I analyzed the effect that herbivory had on the forest composition of the St. Olaf Natural Lands. The objectives of this study were to determine if 1) the diversity of tree species varies between areas exposed to deer browsing and those where deer exposure is restricted by fences, 2) herbivory impacts the density of tree species, and 3) herbivory impacts the diameter of mature trees.

Methods

Study Site:

My research took place in a region of restored hardwoods in the St. Olaf College Natural Lands. Acquired in 2005, the area lies along Highway 19 (Figure 1). Located within this plot of land are two 10 m by 10 m fenced-in plots, established in 2009. These exclosures were established in order to continually study the effect that herbivory has on the forest composition. In this study, I focused on the eastern exclosure that is closed off from deer browsing (henceforth referred to as "exclosure") and the 10 m by 10 m area east-adjacent to it, which is open for deer browsing (henceforth referred to as "open"). Visually, both areas look dense and are fairly shaded. At the time of study (through October), the areas did not have much underbrush, aside from saplings. There was a large amount of litter on the ground in all areas. The area is located at 44°27'31" N, 93°11'32" W and has a 308 m elevation. Previous research in this area was completed by two other St. Olaf students at various times during the exclosure's life (Rand 2009, Larson 2018).

Reference information was provided via an ArcGIS Story Maps project by a previous student (Kellogg n.d.).

Data Collection

In order to analyze the effect that herbivory has on species diversity and density of woody plants, I divided each of the plots into two sections, an east and west side, each 5m by 10m. Within each section, I identified and tallied all the seedlings (shorter than 0.5 m) and saplings (taller than 0.5 m but less than 2.5 cm DBH). I also identified and measured the diameter at breast height (DBH) of all mature trees. Mature trees in this instance are considered any woody plant greater than 2.5 cm in DBH. Mature trees were marked with tape to ensure they were not counted twice. Data were collected on various dates throughout the month of October.

Statistical Analysis

To analyze my data, I used Excel (Version 16.55), and R Commander (Version 3.3.1). Additionally, I completed the Shannon-Simpson Diversity Index to view any statistically significant variation in diversity between sites. Using Excel, I organized data and found totals for each species and tree height class. I completed both one-way and two-way ANOVA tests to determine significance between key variables such as density and diameter. I also analyzed the differences in density between two oak classifications, red and white. Due to the small-scale nature of this experiment and the potential for greater variation if it were expanded to a larger size, all densities will be reported based on the 10 m by 5 m plot size, not by hectares. Additionally, the study was a singular trial, so conversion to hectares would inaccurately represent the forest composition.

Results

Diversity

Overall, a total of 16 species and 649 individual woody plants were identified within the exclosed and open areas. 347 of these trees were in the exclosure, and 302 were in the open area. Poison ivy (*Toxicodendron radicans*), swamp oak (*Quercus bicolor*), red oak (*Q. rubra*), and white ash (*Fraxinus americana*) were the most abundant species (Table 1). I completed two Shannon-Simpson Diversity Indices, one including poison ivy and one excluding poison ivy, to identify if diversity differences were significant. The analysis using the Shannon-Simpson Diversity Index showed that all four plots that were sampled had fairly low diversity. The diversity differences were more consistent in the table excluding poison ivy. In that case, the eastern side of the exclosure was significantly different from every other subplot ($p < 0.05$). The western side of the exclosure was not significantly different from the open areas, which shows that this data is not consistent (Table 2, $p > 0.05$).

Density

I found that there was no significant difference in total density between the exclosure and open areas (Table 3, $p > 0.05$). There was a slight trend of the open area having a lower density, but overall, there was no significant difference in average density of the two sites. Similar results were shown in analysis of the densities of mature trees, saplings, and seedlings (Table 4, $p > 0.05$).

In analysis of densities by individual species, I found that red oak and swamp oak were the most dense mature species at 16.5 and 4.5 trees per 10 m x 10 m enclosed area, and 14 and 11.5 trees per open area. Densities between sites did not vary significantly ($p > 0.05$), but densities between species did ($p < 0.05$) (Table 5). Saplings showed more variation in species densities, with poison ivy having the highest density in both the exclosure and open areas (23.5 and 36 respectively). Swamp oak was the second densest (20 and 11.5 respectively), and white ash followed close behind (18.5 and 8 respectively). Densities between sites were not significant ($p > 0.05$) but densities between species were ($p < 0.05$) (Table 6). Seedling data followed the same trends as mature trees and saplings, with density between sites showing no significant variation ($p > 0.05$) and density between species showing significant variation ($p < 0.05$). The most dense species were poison ivy, white ash, and the invasive amur maple (Table 7).

<u>Oaks</u>

I divided oak trees into two categories: red oaks, which consists of red and pin oaks (*Q. palustris*), and white oaks, which consists of swamp and bur oaks (*Q. macrocarpa*). Aside from poison ivy, the oak genera as a whole was the most prominent in both areas. There was no significant variation in density of mature trees between the sites (Table 8, $p > 0.05$). Sapling densities showed similar trends, with no significant variation in density (Table 9, $p > 0.05$). Seedling densities showed the least significance (Table 10, $p = 1$).

<u>Diameter</u>

The mean DBH by species between the exclosed and open sites did not vary significantly ($p > 0.05$). In the exclosed site, basswood (*Tilia americana*) had the largest average diameter at 26.8

cm. Amur maple (*Acer ginnala*) had the second largest average diameter at 17.15 cm, followed by European white birch (*Betula pendula*) and quaking aspen (*Populus tremuloides*) at 10 cm each. In the open site, quaking aspen had the largest average diameter, at 18.9 cm, followed by white ash at 15.9 cm and buckthorn (*Rhamnus cathartica*) at 9.2 cm (Table 11).

Discussion

Diversity

Statistical analysis of my data showed that deer herbivory had a slight impact on diversity, specifically when excluding poison ivy from the analysis (Table 2). Though the diversity analysis showed the significant differences between plots, it is not consistent through the whole exclosure area, and cannot be conclusive evidence for herbivory causing a decrease in diversity. Previous studies show conflicting results. Deer have shown a preference for black cherry, oak species, and hemlock (Frelich and Lorimer 1985, Leonardsson et al. 2015, Burney and Jacobs 2018). Preferences for certain species result in a lower density of that species, resulting in potentially lower diversity levels. Additionally, herbivory is proven to promote invasions of non-native plants (Côté et al. 2004, Knight et al. 2009, Abrams and Johnson 2012, Burney and Jacobs 2018, Averill et al. 2018). While invasive plants are not directly introduced via deer, the significant reduction of native flora as a result of deer allows space for invasive species to take over (Averill et al. 2018). An example of this may be the mature buckthorn tree within the open area, being the only mature buckthorn within both plots.

Density

The differences in density between the exclosure and open area were not found to be significant (Tables 3, 4, 5, 6, 7, 8, 9, 10). Previous studies show that browsing impacts density by killing seedlings or reducing growth height. Heavy browsing on seedlings and saplings results in lower density stands. Fragmented landscapes and low-productivity habitats are more susceptible to browsing (Gill 2000, Côté et al. 2004). Density declines may then impact fauna, specifically invertebrates and birds (Côté et al. 2004).

Diameter

There was no significant difference in diameter for mature trees between the exclosure and open area (Table 11). Studies reporting basal area show that tree species sensitive to deer browsing decreased over a time span of 13 years (Tanentzap et al. 2011). Species that increased in abundance with the presence of deer increased in basal area. These species may be the non-natives that become more prevalent with the presence of deer. In this study buckthorn, which is invasive, had a larger diameter in the open area. However, it is difficult to conclude that diameter and total basal area of buckthorn increased due to browsing from deer because of the frequent management of buckthorn within the St. Olaf Natural Lands.

Previous Research at St. Olaf

Studies by two St. Olaf students were conducted in the same area as my research. Rand (2009) conducted her study a few months after the implementation of the deer exclosures. She measured density, species diversity, spatial distribution, and height of the tree species. Rand (2009) found no significant differences in tree density and diversity between exclosures and open areas, corroborating results from this current study. Larson (2018) studied diversity, density, and size (diameter) of the trees within and outside the exclosures. He found that density and size between the exposed and unexposed areas were not statistically significant, once again corroborating my data (Larson 2018).

Limitations and Future Study

The lack of significance in my data shows that there are limitations to my study. First, my research area was very small, covering a total area of 20 m by 10 m. Studying a larger exclosure site or multiple different exclosures may provide more information as to how herbivory impacts forest composition. Additionally, the exclosure I studied was implemented in August of 2009, allowing for only 12 years of growth without exposure to browsing. Future research conducted may reveal the timescale needed to see significant impacts. Finally, the data I collected is all subjective to my analysis. I may have identified species incorrectly or miscounted. Human error is possible in every study, but should be addressed just the same.

Conclusion

Over the 12 years that the deer exclosures have been present in the St. Olaf Natural Lands, we have not seen significant changes in the forest composition. Other studies have show how the differences between exclosures and areas exposed to deer browsing become more greater over time. Differences are expected to become greater as time passes and the St. Olaf exclosures have time to diversify. Composition in all forest ecosystems is continually impacted by white-tailed deer herbivory. ~~As white-tailed deer herbivory continues to impact forest ecosystems, we can expect changes in composition.~~ Recovery from severe browsing may take effort from land managers, but it is possible to restore forests and promote native plant growth regardless of the threat of browsing (Tanentzap et al. 2011). Deer, though considered "ecosystem engineers", need to be managed to prevent rapid change in the forests. Increased seeding to increase the number of seedlings and saplings can help maintain diversity and density of native species. Increasing hunting pressures will also help prevent deer overabundance (Côté et al. 2004). Continued research into the impacts of deer browsing for specific locations is essential for identifying and adapting solutions to the threat that herbivory poses on forest ecosystems.

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Figures and Tables

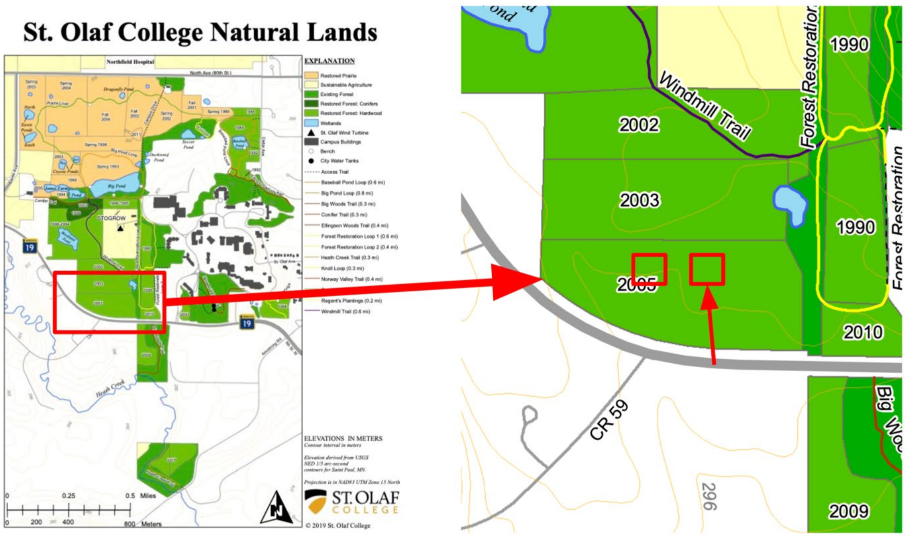

Figure 1. A map of the St. Olaf College Natural Lands representing the study area. The exclosures were located in the 2005 region, next to Highway 19. Research was conducted in the easternmost exclosure and the area directly adjacent to it.

Table 1. The total number of each species counted in the exclosure and open area. Each species is represented in number of seedlings, saplings, and mature trees, with the total value in red.

	Exclosure				Open			
Species	**Seedlings**	**Saplings**	**Mature**	**Total**	**Seedlings**	**Saplings**	**Mature**	**Total**
amur maple	31	0	2	**33**	24	2	0	**26**
basswood	1	3	1	**5**	3	0	0	**3**
bitternut hickory	0	1	0	**1**	0	0	0	**0**
buckthorn	10	5	0	**15**	16	1	1	**18**
bur oak	0	2	2	**4**	0	0	0	**0**
European white birch	2	4	1	**7**	2	0	0	**2**
green ash	0	1	0	**1**	0	0	0	**0**
ironwood	4	5	3	**12**	0	0	0	**0**
pin oak	0	4	5	**9**	0	0	10	**10**
poison ivy	56	47	0	**103**	20	72	0	**92**
quaking aspen	0	0	1	**1**	0	0	1	**1**
red oak	4	11	33	**48**	1	3	28	**32**
swamp oak	9	40	9	**58**	11	23	23	**57**
white ash	8	37	0	**45**	41	16	3	**60**
white pine	1	1	0	**2**	1	0	0	**1**
white spruce	3	0	0	**3**	0	0	0	**0**

Table 2. Shannon-Simpson Diversity Indices showing the diversity within each subplot. **2A** shows the diversity of the plots including poison ivy. In this instance, the Open (east) plot had the highest percentage of diversity. Comparisons of Ds values showed that Exclosure (east) was significantly different from Exclosure (west) and Open (east). Exclosure (west) was significantly different from the previously mentioned Exclosure (east) and Open (west). Open (east) was additionally significantly different from Open (west). **2B** shows the diversity of the plots excluding poison ivy. In this analysis, Exclosure (east) had the highest diversity. Exclosure (east) was significantly different from every other plot, but none of the other plots were significantly different from each other.

A.	**Exclosure (east)**	**Exclosure (west)**	**Open (east)**	**Open (west)**
Richness	14	10	10	8
Shannon (H')	0.78	0.77	0.79	0.66
Simpson (Ds)	0.71	0.8	0.81	0.72
Variance of Ds	0.001420	0.000147	0.000204	0.000583

B.	**Exclosure (east)**	**Exclosure (west)**	**Open (east)**	**Open (west)**
Richness	13	9	9	7
Shannon (H')	0.99	0.69	0.72	0.65
Simpson (Ds)	0.89	0.75	0.77	0.75
Variance of Ds	0.000298	0.000293	0.00054	0.000496

Table 3. A comparison of the average total tree density between exclosed and open sites. This analysis includes seedlings, saplings, and mature trees. The differences in densities were not found to be statistically significant (Df = 1, f-value = 0.917, p-value = 0.439).

Site	Mean	Standard Deviation	# of Plots
Exclosed	173.5	6.363961	2
Open	152.0	31.112698	2

Table 4. A comparison of the average total tree density between exclosed and open sites. Data are separated into size classes. Average density between exclosed and open sites were not statistically significant for any of the size classes ($p > 0.05$). **4A** represents average total density of mature trees (Df = 1, f-value = 0.182, p-value = 0.711). **4B** represents average total density of saplings (Df = 1, f-value = 1.221, p-value = 0.384). **4C** represents average total density of seedlings (Df = 1, f-value = 0.02, p-value = 0.901).

A.

Site	Mean	Standard Deviation	# of Plots
Exclosed	28.5	14.849242	2
Open	33.0	1.414214	2

B.

Site	Mean	Standard Deviation	# of Plots
Exclosed	80.5	17.67767	2
Open	58.5	21.92031	2

C.

Site	Mean	Standard Deviation	# of Plots
Exclosed	64.5	38.89087	2
Open	60.5	10.6066	2

Table 5. A comparison of the mean density of mature trees by species in both exclosed and open sites. Density between the different sites was not significantly different (Df = 1, f-value = 0.3279, p-value = 0.5709), but density between different species was (Df = 15, f-value = 17.522, p-value = 2.52E-11). **5A** represents the mean density of mature trees by species. **5B** represents the standard deviation of the densities. **5C** represents the number of plots where measurements were taken.

A.

	amur maple	basswood	bitternut hickory	buckthorn	bur oak	
Exclosure	1	0.5	0	0	1	
Open	0	0	0	0.5	0	
	european white birch	green ash	ironwood	pin oak	poison ivy	quaking aspen
Exclosure	0.5	0	1.5	2.5	0	0.5
Open	0	0	0	5	0	0.5
	red oak	swamp oak	white ash	white pine	white spruce	
Exclosure	16.5	4.5	0	0	0	
Open	14	11.5	1.5	0	0	

B.

	amur maple	basswood	bitternut hickory	buckthorn	bur oak	
Exclosure	0	0.7071068	0	0	1.414214	
Open	0	0	0	0.7071068	0	
	european white birch	green ash	ironwood	pin oak	poison ivy	quaking aspen
Exclosure	0.7071068	0	2.12132	3.535534	0	0.70071068
Open	0	0	0	1.414214	0	0.7071068
	red oak	swamp oak	white ash	white pine	white spruce	
Exclosure	9.192388	0.7071068	0	0	0	
Open	1.414214	3.5355339	0.7071068	0	0	

C.

	All Species
Exclosure	2
Open	2

Table 6. A comparison of the mean density of saplings by species in both exclosed and open sites. Density between the different sites was not significantly different (Df = 1, f-value = 0.5888, p-value = 0.4485), but density between different species was (Df = 15, f-value = 5.3261, p-value = 3.60E-05). **6A** represents the mean density of saplings by species. **6B** represents the standard deviation of the densities. **6C** represents the number of plots where measurements were taken.

A.

	amur maple	basswood	bitternut hickory	buckthorn	bur oak	
Exclosure	0	1.5	0.5	2.5	1	
Open	1	0	0	0.5	0	
	european white birch	green ash	ironwood	pin oak	poison ivy	quaking aspen
Exclosure	2	0.5	2.5	2	23.5	0
Open	0	0	0	0	36	0
	red oak	swamp oak	white ash	white pine	white spruce	
Exclosure	5.5	20	18.5	0.5	0	
Open	1.5	11.5	8	0	0	

B.

	amur maple	basswood	bitternut hickory	buckthorn	bur oak	
Exclosure	0	2.12132	0.7071068	3.5355339	1.414214	
Open	0	0	0	0.7071068	0	
	european white birch	green ash	ironwood	pin oak	poison ivy	quaking aspen
Exclosure	0	0.7071068	3.535534	0	16.26346	0
Open	0	0	0	0	18.38478	0
	red oak	swamp oak	white ash	white pine	white spruce	
Exclosure	2.1213203	24.04163	20.5061	0.7071068	0	
Open	0.7071068	2.12132	0	0	0	

C.

	All Species
Exclosure	2
Open	2

Table 7. A comparison of the mean density of seedlings by species in both exclosed and open sites. Density between the different sites was not significantly different (Df = 1, f-value = 0.5888, p-value = 0.4485), but density between different species was (Df = 15, f-value = 5.3261, p-value = 3.60E-05). **7A** represents the mean density of seedlings by species. **7B** represents the standard deviation of the densities. **7C** represents the number of plots where measurements were taken.

A.

	amur maple	basswood	bitternut hickory	buckthorn	bur oak
Exclosure	15.5	0.5	0	5	0
Open	12	1.5	0	8	0

	european white birch	green ash	ironwood	pin oak	poison ivy	quaking aspen
Exclosure	1	0	2	0	28	0
Open	1	0	0	0	10	0

	red oak	swamp oak	white ash	white pine	white spruce
Exclosure	2	4.5	4	0.5	1.5
Open	1	5.5	20.5	0.5	0

B.

	amur maple	basswood	bitternut hickory	buckthorn	bur oak
Exclosure	21.92031	0.7071068	0	4.243641	0
Open	4.242641	0.7071068	0	1.414214	0

	european white birch	green ash	ironwood	pin oak	poison ivy	quaking aspen
Exclosure	1.414214	0	2.828427	0	16.970563	0
Open	0	0	0	0	8.485281	0

	red oak	swamp oak	white ash	white pine	white spruce
Exclosure	1.414214	2.12132	2.828427	0.7071068	2.12132
Open	0	2.12132	3.535534	0.7071068	0

C.

	All Species
Exclosure	2
Open	2

Table 8. A comparison of the mean densities of mature trees in oak genera. Red oak refers to red and pin oak, and white oak refers to swamp and bur oak. Density between sites did not vary significantly (Df = 1, f-value = 0.3934, p-value = 0.56452). Density between the two genera did not vary significantly (Df = 1, f-value = 4.8197, p-value = 0.09313).

	Means	
	red oak	white oak
Exclosure	19	5.5
Open	19	11.5
	Standard Deviation	
	red oak	white oak
Exclosure	12.727922	0.7071068
Open	2.828427	3.5355339
	# of Plots	
	red oak	white oak
Exclosure	2	2
Open	2	2

Table 9. A comparison of the mean densities of saplings in oak genera. Red oak refers to red and pin oak, and white oak refers to swamp and bur oak. Density between sites did not vary significantly (Df = 1, f-value = 0.9214, p-value = 0.3915). Density between the two genera did not vary significantly (Df = 1, f-value = 2.1179, p-value = 0.2193).

	Means	
	red oak	white oak
Exclosure	7.5	21
Open	1.5	11.5
	Standard Deviation	
	red oak	white oak
Exclosure	2.1213203	22.62742
Open	0.7071068	2.12132
	# of Plots	
	red oak	white oak
Exclosure	2	2
Open	2	2

Table 10. A comparison of the mean densities of seedlings in oak genera. Red oak refers to red and pin oak, and white oak refers to swamp and bur oak. Density between sites did not vary significantly (Df = 1, f-value = 0, p-value = 1). Density between the two genera did vary significantly (Df = 1, f-value = 8.9091, p-value = 0.04055).

	Means	
	red oak	white oak
Exclosure	2	4.5
Open	1	5.5
	Standard Deviation	
	red oak	white oak
Exclosure	1.414214	2.12132
Open	0	2.12132
	# of Plots	
	red oak	white oak
Exclosure	2	2
Open	2	2

Table 11. A comparison of the mean diameter at breast height (DBH) (in cm) of mature trees by species in both exclosed and open sites. DBH between the different sites was not significantly different (Df = 1, f-value = 0.8007, p-value = 0.3729), but DBH among different species was significantly different (Df = 10, f-value = 11.7994, p-value = 1.63E-13). **11A** represents the mean DBH of mature trees by species. **11B** represents the standard deviation of the mean DBH. **11C** represents the number of measurements taken.

A.

	amur maple	basswood	buckthorn	bur oak	european white birch	ironwood
Exclosure	17.15	26.8	NA	3.7	10	5.13333
Open	NA	NA	9.2	NA	NA	NA

	pin oak	quaking aspen	red oak	swamp oak	white ash
Exclosure	6.12	10	4.693939	3.74444	NA
Open	6.61	18.9	5.035714	4.36087	15.9

B.

	amur maple	basswood	buckthorn	bur oak	european white birch	ironwood
Exclosure	20.71823	NA	NA	0.7071068	NA	1.625833
Open	NA	NA	NA	NA	NA	NA

	pin oak	quaking aspen	red oak	swamp oak	white ash
Exclosure	1.333042	NA	1.737804	1.09443	NA
Open	2.511507	NA	2.744451	1.601062	13.55249

C.

	amur maple	basswood	buckthorn	bur oak	european white birch	ironwood
Exclosure	2	1	0	2	1	3
Open	0	0	1	0	0	0

	pin oak	quaking aspen	red oak	swamp oak	white ash
Exclosure	5	1	33	9	0
Open	10	1	28	23	3