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Abstract

Forests have been on the decline since the rise of agriculture and urbanization in the last few centuries. The maple-basswood forest, a unique forest type found in southeastern Minnesota, is no exception. Keeping these forests healthy, or restoring them to health, is important in order to preserve high levels of biodiversity to facilitate ecosystem resilience. In this study, we measured over 2000 trees at St. Olaf College in Northfield, Minnesota, to assess their health and compare tree growth among four sections in two adjacent fields. We also gathered seedling and sapling data as well as soil data to assess the overall health and growth of the forests. The restoration project is dominated by white ash, with black walnut, maples, and oaks being the next most common. Sections one and two had the trees with the largest diameter, lead by red oak, white oak, and basswood, while sections three and four had higher levels of moisture and organic matter. The trees are growing steadily and properties of soil such as moisture and organic matter are increasing as well, indicating that this restoration project is on a healthy trajectory.
Keywords: trees, maple-basswood, Minnesota, seedlings, saplings, DBH, soil

Introduction

Restoration of communities, compared to restoring specific species, is becoming an increasingly popular method of conservation. Recent literature is strongly favoring the idea that diverse communities are better suited to withstand perturbations. Restoring a community requires that the correct abiotic and biotic factors be put in place, following the “if you build it, they will come” mantra

(Menninger, 2006). Once the habitat is in place, there must a nearby regional pool of species available to colonize the habitat, or species can be located there by people. These species then need to pass through the environmental filter (species must have the traits that match the habitat characteristics). Lastly, they must pass the biotic filter (Menninger, 2006). Can the species withstand competition and predation? If so, the community is on the right track to a successful restoration, but should be monitored carefully to ensure it does not deviate too far from its proposed natural trajectory.

Restoration is performed when land that was being used for an anthropogenic purpose (farming, parking lot, waste site, etc.) is returned to a previous, natural, often pre-settlement state. Environmentalists, conservationists, and government officials alike take on restoration projects for reasons including aesthetics, increasing biodiversity, or regaining environmental services. Each restoration project is often a trial and error process since every habitat is unique in its original form and type of degradation (Menninger, 2006). As more restoration projects are taken on and their process is published, the body of knowledge on good restoration practices grows. We hope to further the knowledge of restoration of maple-basswood forests with the research presented here.

Very few old growth forests remain in Minnesota (Grimm, 1984). Due to the expansion of agriculture and the spread of the suburbs, forests were cut down to give way to modernization (Minnesota, 2006). Because there are so few forest patches left, it is imperative that their health is monitored closely. Furthermore, restoring land to its native forest has been a growing trend as society recognizes the importance of the ecosystem services a forest provides.

Reduction in forest size and diversity leads to a decrease in biodiversity (Menninger, 2006). Small patches cannot support the same diversity of life that large patches of forest can, but a small patch of restored forest is better than industrial development or a parking lot. The maple-basswood forests of Minnesota harbor 121 Species in Greatest Conservation Need (Minnesota, 2006). With the maple-basswood forests being cut down to less than 10% of their range in the early 1900's, it is imperative that they are closely monitored (Shea, 1993). By restoring these forests and keeping them healthy, we are adding to the diversity of the landscape. Diversity has consistently been hailed as a factor that increases a community's resistance to change. In an age of climate change and ecological uncertainty, resilience is a key function of landscapes to prioritize (Menninger, 2006).

In order for a forest to survive and sustain itself, it must reproduce and nurture seedlings and saplings to maturity. In a recently planted forest, canopy cover is often an initial goal. Once the canopy is fully assembled, the shade it creates makes it difficult for invasive species and shrubs to take root. Instead, the tree seedlings will have a chance to prosper. As a young tree focuses its energy on upward growth, it doesn't devote energy to reproduction. The forest can either allocate energy to closing the canopy or reproducing, but not both equally. In this study, reproduction, via the presence of seedlings, will represent a marker for the maturity of the forest.

Inevitably, the forest will withstand some disturbances. In the maple-basswood forest, windfall is the most common disturbance. A fallen tree opens up a gap in the canopy for light to reach the forest floor. The seedlings then race to claim the sunlight for themselves, and succession in the patch begins. The speediest growers will dominate at first, but as the gap closes, only the shade tolerant species will survive to maturity (Burns and Honkala, 1990). Disturbance does a good job of enabling diversity within the forest by opening up patches for colonizing species.

The study site was a corn/bean agricultural field until it was replanted as forest in 1990. The site has been monitored for tree growth and soil characteristics periodically for the last twenty-seven years. The objectives of this study were to 1) characterize the composition of the forests, including seedling, sapling, and mature trees, 2) analyze tree growth between sections and fields, and 3) relate physical and chemical soil characteristics to tree growth in sections and fields.

Methods

Study Area

The study area consists of two fields, each 2.15 hectares, at latitude 44.46 and longitude -93.19 in the St. Olaf Natural Lands located in southeastern Minnesota. The study site is in the native range of the Big Woods, or maple-basswood forests (Grimm, 1984). There are 28 transects (15m x 75m) spread across two fields separated by a path. The fields were planted in 1990 with 11 original species: white ash (WA, *Fraxinus Americana*), black walnut (BW, *Juglans nigra)*, bur oak (BO, *Quercus macrocarpa*), white oak (WO, *Quercus alba*), sugar maple (SM, *Acer* *saccharum*), red maple (RM, *Acer rubrum*), red oak (NRO, *Quercus rubra*), basswood (B, *Tilla americana*), wild plum (WP, *Prunus Americana*), and ironwood (I, *Ostrya virginiana*). Data from these fields has been collected every 3-4 years since 1990.

Tree Data Collection

Height and diameter at breast height (DBH) were measured for each tree within the transects with DBH greater than 2.5cm. Height was measured with a Suunto clinometer and DBH was measured using a diameter tape. All new trees (DBH>2.5cm) were identified, measured, tagged, and GPS mapped with a Trimble Geo 7 unit. Mortality of the trees was noted as well. A tree was considered dead if it were no longer growing or if it were missing. This data was collected in June and July of 2017.

Seedlings (height < .5m) and saplings (.5m height > tree <2.5cm DBH) were sampled in September and October of 2017. Within each transect, 3 points thirty paces apart were selected for sampling. At each point, a 1m^2 plot was surveyed for seedlings, and a 10m^2 plot was surveyed for saplings. Additionally, the surrounding area of each point was divided into quarters (NE, SE, SW, NW). In each quarter, the nearest mature tree was checked for signs of reproduction. Reproduction was recorded as a binary; trees were either marked as reproducing or non-reproducing.

Soil Data Collection

Soil samples were taken from two points in each transect in October and November 2017. A standard 15cm corer was used to collect two samples at each point, one for physical and one for chemical analysis. The soil samples were collected forty paces from the edges in the middle of the transects. To discern the physical characteristics of the soil we followed standard methods by Robertson, Coleman, Bledsoe, and Sollins (1999). Physical tests included percent soil moisture, percent soil organic matter, and bulk density. Chemical characteristics were analyzed using a SmartChem (Robertson, Coleman, Bledsoe, and Sollins,1999). Chemical characteristics included soil nitrate and ammonia levels measured using a salt extractant.

Data Analysis

Data was entered in Excel to generate summary statistics and basic computations. Statistical analyses, including ANOVAs, were performed in the RCommander module of R, version 3.2.3. Mortality rates were calculated for each species using tree growth data collected in the summer of 2013 and 2017. Growth curves for height and DBH were calculated using data from the past 27 years.

Results

Population Structure

There are eighteen different species found as seedlings, saplings, or mature trees in the two restored fields (Table 1). Mature trees were found at a density of 974 trees / ha in the two fields. When dividing the fields into sections, bur oak was the most numerous species in section one, while white ash dominated sections two, three, and four with increasing numbers (Fig. 1). Black walnut was the second most numerous species in sections two, three, and four, while other species didn't have significant contributions. Sections one and two had about one-hundred fewer trees than sections three and four, but sections three and four each contained an extra transect, so the densities between the two fields are even (Table 2).

Seedlings and saplings were more numerous in sections three and four than sections one and two, even when accounting for the extra transects (Tables 3 and 4). Seedlings were found at a density of 10,000 seeds per ha and saplings at a density of 1761 saplings per hectare (Table 1). The most common seedling found was amur maple, which is an invasive species. In section one where bur oak was the most common mature tree, the most common seedling was also bur oak (Table 3). Likewise, in section four where white ash has more trees than all of the other combined, more white ash seedlings were found than any other species (Table 3). For saplings, amur maple was only outnumbered by white ash; there were more white ash seedlings in section four than the rest of the seedlings combined (Table 4). For reproduction via seeds, amur maple was found to be reproducing the most often, followed by black walnut and basswood. However, less than eight percent of trees surveyed in the two fields had seeds.

Size

The trees in the two fields have continued to grow, with no sign of slowing down, since they were planted in 1990 (Fig. 1). White ash, closely followed by white oak, were the tallest trees averaging twelve and eleven meters respectively. Sugar maple, red maple, bur oak, and black walnut all averaged between six and eight meters tall (Fig. 1). The trees with the largest DBH, however, were the red oaks averaging just below sixteen cm DBH, followed by white oak at 14cm and basswood at 11cm (Fig. 3).

In terms of the growth in each section, section one produced the trees with the largest DBH on average at 10.91cm (Table 5). However, when broken down into the three most common species, white ash grow the best in section two, black walnuts grow the best in section four, and white oaks grow just about equally in all sections. When broken down into added trees versus originals, the added trees have grown to the largest DBH in section one, while the original trees have grown the largest DBH in section two (Table 5).

Diversity

Section two had the greatest diversity with a Shannon value of .971, while section four had the lowest diversity with a Shannon score of .732. Section one had the highest species richness at fourteen and section four had the lowest species richness at twelve. However, in terms of seedlings, section four had the highest species richness with seven; the other sections had four and five different species. For saplings, there were not significant differences in the numbers of species found between the sections.

Mortality

There was a high mortality rate of about 30% through the first five years, but after 1995 the mortality rate was around 1% per year (Fig. 4). The species with the highest mortality rate is wild plum (95%), followed by ironwood (75%), and sugar maple (54%). Broken down by section, section four has the highest mortality rate at 56%, and sections one and two have the lowest at 48% and 47% respectively.

Soil

Soil moisture, organic matter, bulk density, and nitrates all varied significantly by section. Moisture and organic matter both started low in section one, increased up to section three, then had a slight drop off with section four (Table 9). Bulk density had the highest values in section one while nitrates had the highest values in section four in the summer and section three in the fall. Soil moisture, nitrates, and ammonia all varied significantly by season (Table 9). Moisture levels were much higher in the fall than the summer, and they followed the same pattern of variation by section. Nitrates were much higher (up to a 100-fold increase) in the fall than the summer. Ammonia levels were also higher in the fall than the summer with higher levels in sections three and four in both seasons.

Organic matter has been measured in this site for twenty years with a great deal of fluctuation. Sections three and four consistently had higher scores than sections one and two throughout the years (Table 10). Organic matter of 2017 (measured in the fall) shows average levels for the past twenty years.

Discussion

Population Structure and Size

White ashes were the most common species in the two fields. Black walnut, bur oak, white oak, and sugar maple round out the top five (Table 2). Eight other species, lead by red oak, box elder, and basswoods make up the rest of the composition of the forest. Each species has a unique life history that affects how well it grows in a forest.

White ash grows relatively quickly (Burns and Honkala, 1990). By using most of its energy to grow vertically instead of branching out widely, it quickly becomes one of the taller trees in the forest. As seen in the growth curve (Fig 2), white ash was the tallest tree in the restoration site. Ashes are known for intermediate shade tolerance (Clatterbuck). Within the sections, they were found just about everywhere. They were much more popular in sections three and four, which appeared denser at times than sections one and two.

Oaks are excellent colonizers of open space. Since they are not very shade tolerant, they thrive in lots of light (Clatterbuck, 2002). White oaks are currently the second-largest tree to the red oak in terms of diameter (Figure 2). In the right conditions, they can grow very quickly and reach canopy height before other trees have a chance.

Basswood, one of the goal species of the restored forest, is one of the larger trees in terms of DBH in the field. They are not yet dominant by any means, but they have a strong foothold on which to propagate. Basswood is known to be nitrogen demanding, and happens to have the most trees in section three which reported the highest nitrogen levels in the fall of 2017 (Tables 2, 9).

Sugar maples have remained quite small in the two fields, and have also endured a high mortality rate (Figure 2, Table 7). Sugar maples differ from the other species in the fields because they are known to be the most shade tolerant (Clatterbuck, 2002). The restoration site is 27 years old and is just beginning to reach canopy closure in many areas. Because of the availability of light early on, many less shade-tolerant species such as ash, black walnut, and basswoods were able to thrive. However, with the closure of the canopy, the sugar maples will likely grow steadily and begin to outcompete other species in the new, darker environment. Within the last four years, sugar maple did grow at a faster rate than all species but white oak (Figure 2).

Black walnut is a species known for being quite shade intolerant (Clatterbuck). Within the fields, they were consistently seen on the edges of transects where there is more light available. In these areas, they were densely packed, but often a few had died due to overcrowding. Black walnut grew poorly in section one, were most numerous in section three, but grew the biggest in section four (Tables 2, 5).

Species diversity was significantly different between the different sections. Sections one and two had higher diversity levels and also had lower mortality rates. Biodiversity is often declared as being a good indicator of healthy ecosystem that is resistant to perturbations (Menninger, 2006). This study supports those findings. Trees were taller in sections one and two as well (Table 5). The reduced mortality and increased growth in areas of higher diversity is owed to the differing life histories of the trees. As previously mentioned, different species have different levels of shade tolerance, but they also vary in amounts of nutrients required and growth patterns. With many species present, each individual is able to occupy their own niche of the forest, taking what they need without spoiling it for the others.

Soil

Soil characteristics varied significantly by section for bulk density, nitrates, moisture and organic matter (Table 9). As shown by Khuat (2016), soils can critically affect forest restoration results. Aspects such as slope, topography, and minute changes in soil characteristics can have profound influence on plant growth. Soil moisture and organic matter were both higher in field two than field one. While nitrate levels and bulk density significantly differed by section, no clear trends could be drawn. The higher levels of moisture and organic matter in field one contrast the higher growth, greater diversity, and lower mortality of field one. In this case, it appears as though moisture and organic matter, as measured in this study, don't correlate with tree growth.

Any trend in nitrate levels is skewed by the incredibly high values found in the fall of 2017. They were about 100x greater than values in 2006. This is of concern, but literature also states that nitrogen and ammonia levels can fluctuate widely quickly with soil and weather conditions (Spargo, 2013). Ammonia levels also went up in a similar manner for the fall levels. Additional research needs to be done on shorter time scales to see the range of fluctuation present for chemicals in the soil.

Over time, soil organic matter was shown to slightly increase from 1990 levels. This is in line with results found from Huang (2012) who found that soil organic carbon increases with the process of restoration. Others such as Xue (2008) say that soils need around 100 years of restoration process to reach a pre-disturbed state. If that is the case, this restoration project is showing encouraging signs with increase organic matter.

New Growth

Seedling measurements were nearly even between fields one and two (Table 3). Additionally, there was not a large enough sample size to confirm any significant differences. Amur maple was the most common seedling found. It was also the most commonly reproducing tree. Amur maples reach reproductive maturity much more quickly than other species in the fields (Groover, 2017). White ash was the second most common seedling, likely because of the sheer number of white ash present. Saplings were slightly more numerous in field two, but again the low sample size makes it difficult to make significant claims. Box elder, amur maple, and white ash dominated the counts. Box elder also has a young reproductive age (Groover, 2017). It is unclear whether the seedlings were a result of reproduction of the trees in the transects or the result of dispersion from trees outside of the restoration plot.

Most of the trees examined for reproduction showed no signs of seeds. This is because most of the trees have not yet attained their reproductive age. Sugar maples are not known to reproduce until they are 22 years old, and bur oak until they are 35 years old (Burns and Honkala, 1990). Although the restoration site is 27 years old, many factors go in to seed production; it is not unheard of that a sugar maple wouldn't reproduce at 27 years old. White ash, however, are supposed to be able to reproduce at 8cm DBH (Burns and Honkala, 1990). The higher counts of seedlings and saplings concur with this earlier age of reproduction. While basswoods were not found to be reproducing via seeds very often, their primary method of reproduction is through sending up new shoots, which was observed but not classified as reproduction (Burns and Honkala, 1990).

Conclusion

The two fields in the St. Olaf natural lands have not yet achieved a mature maple-basswood composition, but they are on their way. Important species such as maple, basswood, and ash are growing well in all of the sections. Sections three and four have more soil nutrients, but sections one and two are growing better, as evidenced by larger DBH's and higher diversity levels. The seedlings and saplings indicate that only a small amount of reproduction is occurring due to the young age of the trees, but the surrounding forests will aid reproduction through wind dispersal of their seeds. This forest should continue to be closely monitored to ensure proper growth, but it is on a healthy track.

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Tables and Figures

Table 1. Stand table (per/ha) of all species (colonizing and original) present in restoration project

Species	Seedling	Sapling	Mature
White ash *Fraxinus americana*	1667	500	315.6
Black walnut *Juglans Nigra*	0	48	151.7
Bur oak *Quercus macrocarpa*	952	24	107.9
White oak *Quercus alba*	714	0	80.0
Sugar maple *Acer saccharum*	952	119	53.3
Red maple *Acer rubrum*	0	0	41.3
Box elder *Acer negundo*	714	310	36.8
Red oak *Quercus rubra*	0	0	36.8
Basswood *Tilia americana*	0	0	31.7
Wild plum *prunus americana*	238	95	30.5
Elm *Ulmus*	476	48	26.0
Ironwood *Ostrya Virginiana*	0	0	21.6
Aspen *Populus*	0	95	18.4
Black Cherry *Prunus serotina*	476	190	12.1
Amur maple *Acer ginnala*	3571	262	6.3
Honeylocust *Gleditsia tricanthos*	0	0	2.5
Sumac *Rhus*	0	0	1.3
Hickory *Carya*	238	71	0.0
Total Area	42	420	15750
Trees / ha	10000.0	1761.9	974.0

Table 2. Number of trees (colonizing and original) currently present in each section.

Section	Asp.	B	BE	BO	BW	Elm	I	NRO	RM	SM	WA	WO	WP	Total
1	15	7	13	100	5	8	5	34	1	25	43	63	0	**319**
2	0	10	20	45	51	10	28	9	0	19	80	37	0	**309**
3	14	27	11	23	106	7	0	15	26	24	130	18	3	**404**
4	0	6	14	0	61	17	1	0	29	15	225	8	46	**422**
Totals	29	50	58	168	223	42	34	58	56	83	478	126	49	1454

Table 3. Number of seedlings measured in each section from nine 1m^2 plots in sections one and two and twelve 1m^2 plots in sections three and four.

Section	BC	BW	WA	BO	SM	BE	AM	WO	Hic.	Elm	Aspen	Plum	Total
1	1	0	1	4	1	0	3	0	0	0	0	0	**10**
2	0	0	1	0	0	1	4	1	0	0	0	0	**7**
3	0	0	0	0	3	0	7	1	1	0	0	0	**12**
4	1	0	5	0	0	2	1	1	0	2	0	1	**13**

Table 4. Number of saplings measured in each section from nine 10m^2 plots in sections one and two and twelve 10m^2 plots in sections three and four.

Section	BC	BW	WA	BO	SM	BE	AM	WO	Hic.	Elm	Aspen	Plum	Total
1	4	1	3	1	2	5	0	0	0	0	0	0	**16**
2	0	0	1	0	1	2	1	0	3	0	0	0	**8**
3	3	1	0	0	1	4	5	0	0	1	4	0	**19**
4	1	0	17	0	1	2	5	0	0	1	0	4	**31**

Table 5. DBH for colonizing trees of '17, original trees, all trees, and for dominant species white ash, black walnut, and white oak. One-way ANOVA for each variable shows colonizing trees, originals, all trees, WA, and BW vary significantly by section.

Section	Colonizing	Originals	All	WA	BW	WO
1	8.26 (5.9)	10.98 (5.5)	10.91 (5.7)	10.61 (5.2)	3.22 (2.5)	14.95 (4.9)
2	6.6 (3.8)	12 (6.6)	10.03 (6.3)	13.55 (5.8)	8.39 (6.9)	13.02 (4.4)
3	7.41 (5.7)	8.9 (5.6)	8.58 (5.7)	11.67 (4.7)	4.18 (4.2)	14.2 (2.9)
4	6.28 (4.2)	11.32 (5.8)	8.5 (5.6)	8.72 (5.2)	11.38 (5.5)	14.8 (6.0)
p-value	0.002	9.48e-9	1.05e-5	1.03e-12	6.53e-16	0.265

Table 6. Diversity indexes for each section and field. Pairwise comparisons show significant differences for all comparisons except Section 2 compared to Field 1.

	Section 1	Section 2	Section 3	Section 4	Field 1	Field 2
Richness	14	13	13	12	16	15
Shannon (H')	0.902	0.971	0.840	0.732	0.989	0.823
Simpson (Ds)	0.833	0.869	0.796	0.718	0.870	0.760

Table 7. Mortality rates for most common species

Species	# OR Trees in 2017	Mortality	Annual Mortality
Black Cherry *Prunus serotina*	2	33.33	1.23
Red maple *Acer rubrum*	63	12.50	0.46
Basswood *Tilia americana*	13	23.53	0.87
White ash *Fraxinus americana*	294	22.02	0.82
Bur oak *Quercus macrocarpa*	160	29.82	1.10
Black walnut *Juglans nigra*	218	40.92	1.52
White oak *Quercus alba*	110	46.08	1.71
Ironwood *Ostrya virginiana*	5	75.00	2.78
Red oak *Quercus rubra*	13	35.00	1.30
Sugar maple *Acer saccharum*	68	54.97	2.04
Wild plum *Prunus americana*	2	95.00	3.52
Total / Average	**948**	**34.49**	**1.28**

Table 8. Mortality for all original trees by section

Section	Alive	All	Dead	Mortality
1	223	431	208	0.48
2	209	394	185	0.47
3	299	600	301	0.50
4	217	494	277	0.56

Table 9. Means and standard deviations of soil moisture, soil organic matter, bulk density, and NO3 content for each section by season. For moisture, a two way ANOVAS showed significant differences between section and time (p = 1.17e-7, 3.11e-6). For organic matter, a two way ANOVA revealed significant differences by section only (p=7.76e-9). For bulk density, a two way ANOVA revealed significant differences only between sections (p=.001). For nitrates, a two way ANOVA revealed significant differences by time and section (p= 2.2e-16, p=.0041). For ammonium, a two way ANOVA revealed significant differences by time only (p=2e-16). Interaction between time and section was significant only for nitrates.

		Summer		**Fall**	
Test	Section	Means	*sd*	Means	*sd*
% Moisture	1	**13.83**	*5.24*	**19.81**	*4.9*
% Moisture	2	**20.65**	*5.82*	**24.73**	*8.18*
% Moisture	3	**24.65**	*4.05*	**32.65**	*5.06*
% Moisture	4	**23.72**	*3.17*	**32.21**	*4.16*
% Organic Matter	1	**3.46**	*1.42*	**3.45**	*1.29*
% Organic Matter	2	**4.85**	*2*	**4.84**	*2.02*
% Organic Matter	3	**7.63**	*1.69*	**6.92**	*1.37*
% Organic Matter	4	**7.25**	*1.17*	**7.09**	*1.49*
Bulk Density (g/cm^3)	1	**1.22**	*0.0825*	**1.29**	*0.0908*
Bulk Density (g/cm^3)	2	**1.15**	*0.102*	**1.26**	*0.136*
Bulk Density (g/cm^3)	3	**1.1**	*0.111*	**1.12**	*0.105*
Bulk Density (g/cm^3)	4	**1.13**	*0.0834*	**1.15**	*0.103*
Nitrate (mg/kg soil)	1	**0.7625**	*0.1471*	**31.87**	*4.07*
Nitrate (mg/kg soil)	2	**1.296**	*0.5241*	**38.54**	*10.42*
Nitrate (mg/kg soil)	3	**1.208**	*0.5066*	**45.17**	*7.61*
Nitrate (mg/kg soil)	4	**1.434**	*0.4198*	**37.67**	*6.22*
Ammonium (mg/kg soil)	1	**7.21**	*1.41*	**47.56**	*10.16*
Ammonium (mg/kg soil)	2	**9.6**	*3.43*	**46.3**	*12.82*
Ammonium (mg/kg soil)	3	**10.81**	*1.57*	**52.55**	*8.94*
Ammonium (mg/kg soil)	4	**11.22**	*4.58*	**54.92**	*5.39*

Table 10. Soil percent organic matter measurements from 1997- 2017 by section.

Site	1997	1999	2002	2006	2007	2010	2013	2017
1	1.903	0.29	1.817	2.051	10.209	3	2.71	3.45
2	5.053	0.66	3.87	4.253	9.435	5	4.46	4.84
3	6.8	1.17	7.343	8.025	10.898	7	5.77	6.92
4	4.423	1.41	6.067	7.03	11.679	8	5.34	7.09

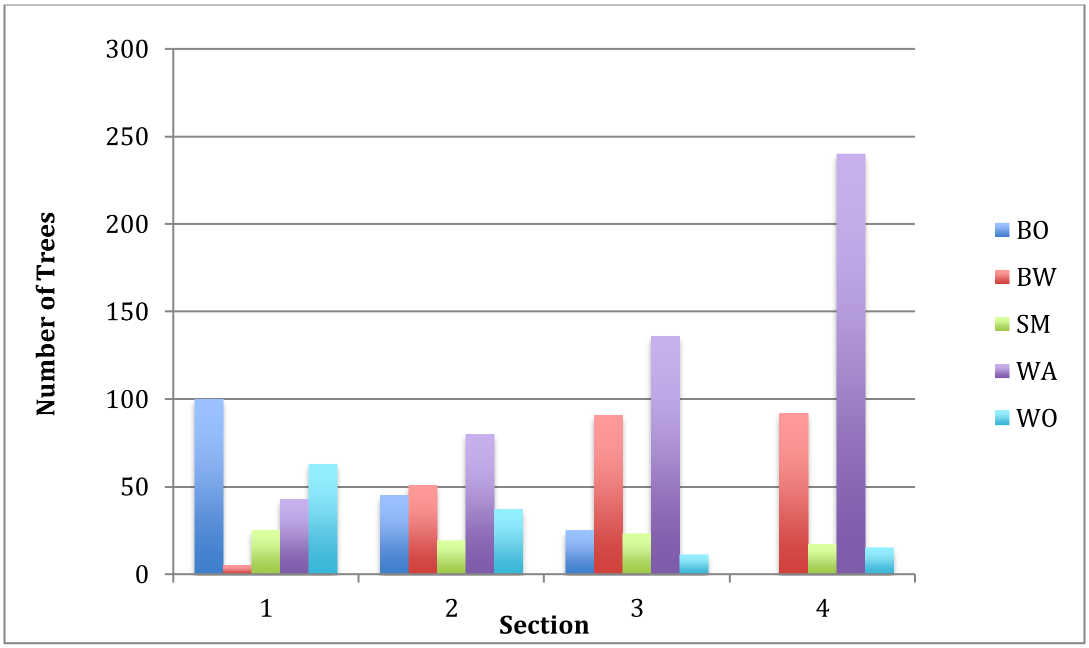

Fig 1. Number of trees alive in each section for five most common species

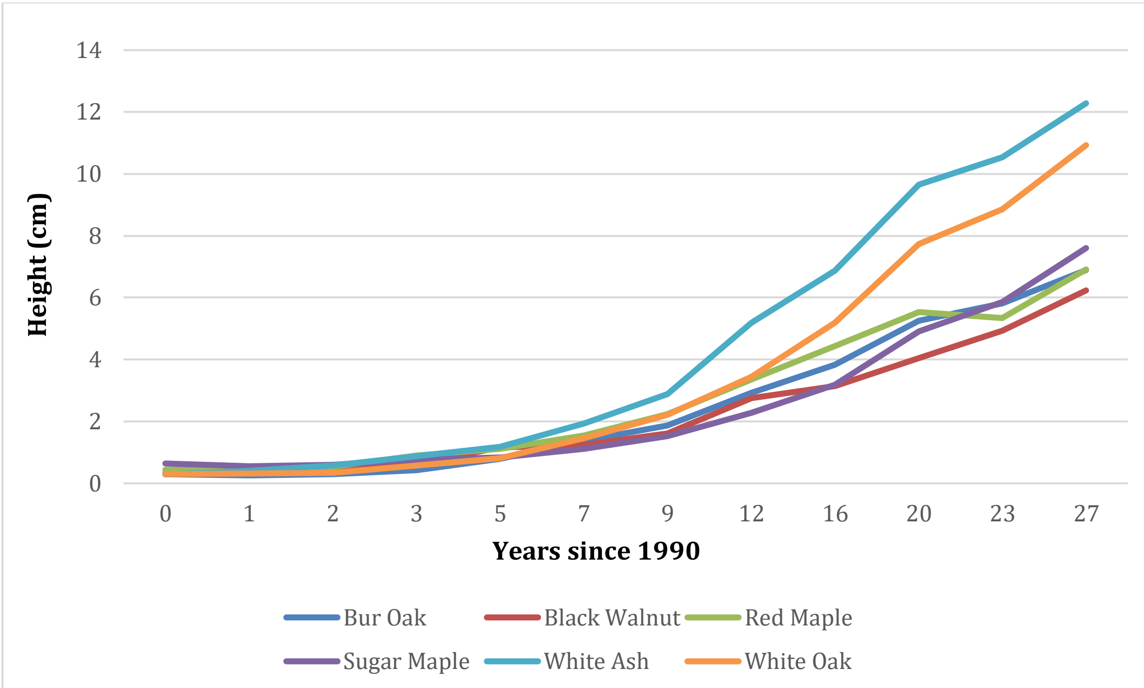

Fig 2. Growth curve of height for the six most common species in all sections

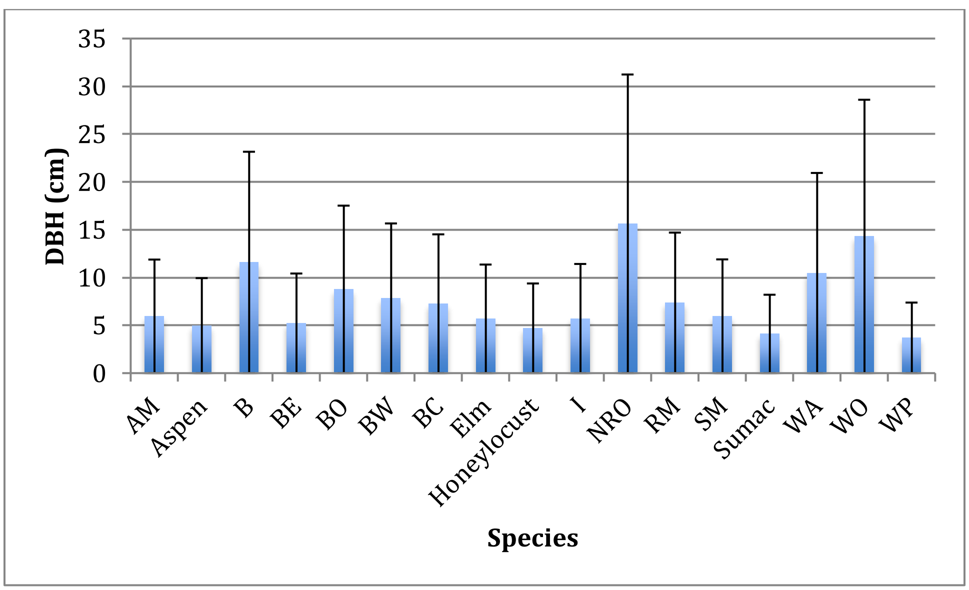

Fig 3. Bar graph of average DBH of all trees in all sections for each species. One-way ANOVA showed significant variation by species (p=2e-14).

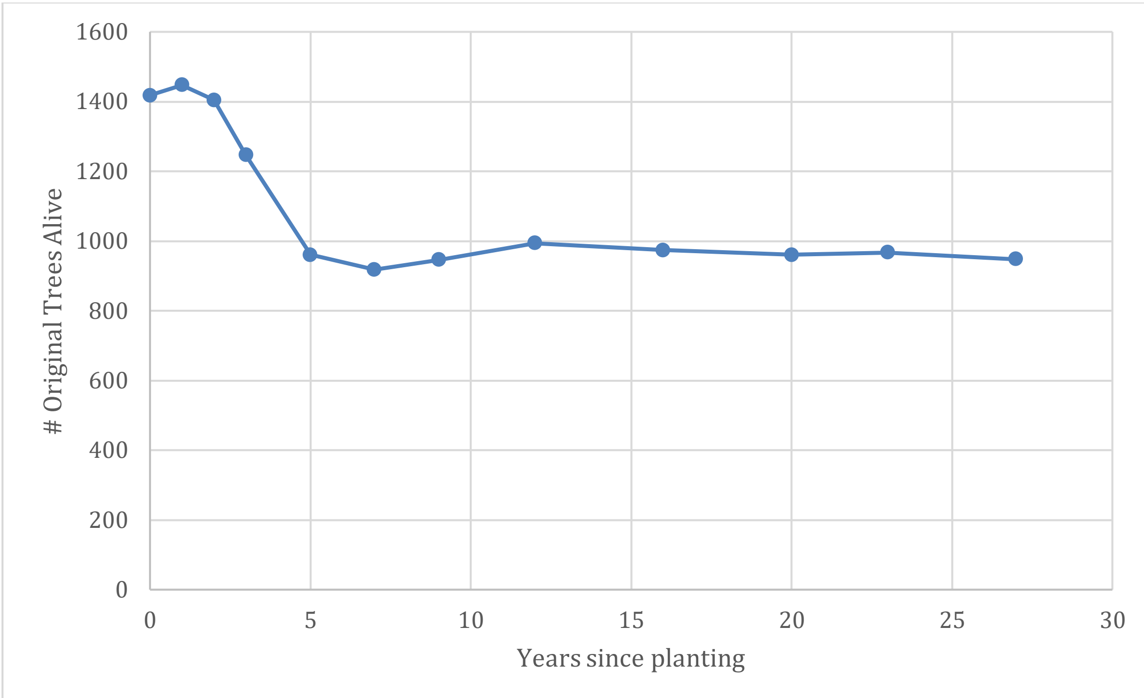

Fig 4. Number of original trees from planting in 1990 currently alive in 2017.