Biodiversity Inventory of Ashburnham Memorial Park

Includes:

Final Report

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Completed for: Ashburnham Memorial Stewardship Group

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Abstract

Monitoring environmental change is increasingly important, but is hampered by the lack of long-term observations, especially from permanent plots. The goals of this research project were: (1) to assess the diversity and distribution of woody plants in Ashburnham Memorial Park by means of an inventory, (2) to estimate the number of species unobserved in the inventory, (3) to provide Ashburnham Memorial Stewardship Group with permanent plot locations that can revisited for surveys of woody plants or other taxa, and (4) to identify species of concern and provide suggestions of what may encourage or discourage their growth. I used systematic sampling at 33 locations in the Park to measure the density of trees and the percent cover of shrubs in concentric circular plots. To describe and characterize the assemblages of these species, I applied classification and ordination. To assess the adequacy of my sampling, I applied the Chao-1 technique to estimate the number of unsampled species. I documented 22 species in the Park, generally in two community types distinguished by the abundance of European buckthorn, and an estimated one or two species in the Park were not in inventory. The lack of estimated unobserved species suggests that the number of permanent plots was adequate for this inventory of woody plants. Locations dominated by common buckthorn were nearly devoid of other shrub species, implying that this invasive plant may deter the growth of common understory shrubs. All ash trees in the Park were juvenile, indicating that they may require more sunlight to optimize their growth. My inventory and sampling design could serve as the basis for inventories on other species, in support of long-term monitoring of this urban park.

1. Introduction

1.1. Ashburnham Memorial Park and Stewardship Group

1.1.1. General Information

Ashburnham Memorial Park (AMP), locally known as Armour Hill, is a park located in the East City neighbourhood of Peterborough, Ontario, Canada. The Park is host to Peterborough Museum & Archives, Kaawaate East City Public School, and various recreational activities. AMP has over 93,000 m^2 of mostly coniferous forest. For this and other important biological areas, long-term monitoring of forest cover and other natural attributes is essential for understanding and managing change (Lindenmayer et al. 2022). In the case of AMP, the Ashburnham Memorial Stewardship Group (AMSG), founded in 2021, has a mission to increase stewardship in the Park while decreasing negative behaviours such as garbage dumping and reckless driving (AMSG, n.d.).

1.1.2. Previous Bio-Inventory Related Projects at AMP

The Park has supported a couple of previous projects relating to the species makeup of the Park, including woody plants. The most recent of these projects was a iNaturalist page that was created in 2022 (Cockburn et al., 2022). iNaturalist is a citizen science site where people can report sightings to be identified by other users, and which contains records of any taxa (iNaturalist, n.d.). The other project was a 2008 survey on plants and birds at the Peterborough Museum and Archives done by Peterborough Field Naturalists. Although this survey was comprehensive, the land surveyed only extended a maximum of 90 m from any museum buildings (Peterborough Field Naturalists, 2008). As a result, this survey documented mostly open habitat, rather than forest-dwelling birds and plants.

1.2. Research Goals

In this community-based research project, the goal was to assess the abundance and diversity of woody plant species (trees, shrubs, vines) through quantitative means with an inventory. As an evaluation of the adequacy of this survey, I also estimated how many species were undocumented by the inventory. Another goal was to archive the observations, including plot locations, for future inventories of woody plants and other biota. These plot locations, alongside the methods of these project, can be used as a blueprint for future inventories of other taxa. Indeed, permanent plots represent a simple, powerful means to detect change (Schaefer 2023). I also identified any species at risk in AMP, as well as invasive species that may have a negative impact on species diversity in the Park. Lastly, I provided some recommendations on how to encourage or discourage the presence of these particular species.

2. Methods

2.1. Sampling Design

I used a stratified systematic design to sample woody plants in AMP. I used ArcGIS Pro (Version 3.1.2) to determine the plot locations. I acquired AMP landcover datum on a 15 x 15 m grid (Mostoway, 2019) through Trent University's Maps, Data & Government Information Centre (MaDGIC). I combined the layers within the Park classified as "Forest" or "Coniferous Forest" into one layer. I then overlayed a 50 x 50 m grid onto the range of the forested areas in AMP, and created a plot location at each intersection of the grid. The rows of the grid were numbered 1-14, from south to north, while the columns of the grid were lettered A-J, from west to east (Figure 1). The plot locations were thus classified by the alphanumeric system, and only the ones located within the forested areas of AMP were kept. In total, my sampling included 37 plots, whose geographic coordinates were transferred to a handheld GPS (Garmin Oregon 750).

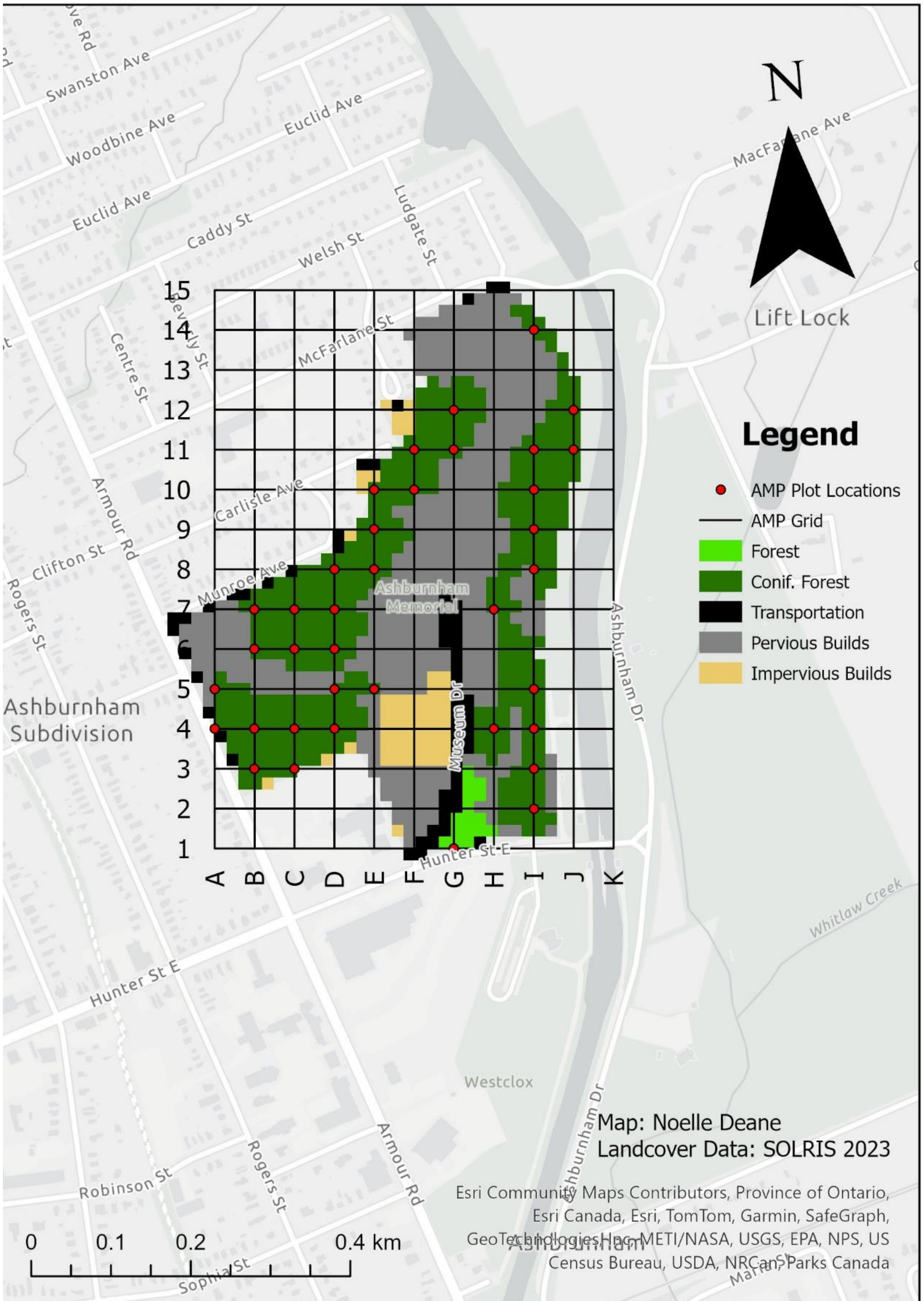

Figure 1: A map of Ashburnham Memorial Park, Peterborough, Ontario, September 2023 - January 2024. Colour coded by landcover type and with all 37 plot locations and the 50 x 50 m grid overlay on which they were based.

2.2. Woody Plant Inventory

Fieldwork took place in the forested areas of AMP from September 2023 to January 2024. I located plots with the use of the handheld GPS. At that point, I drove a stake into the ground which represented the centre of the plot. Each plot was concentric and circular. I recorded and identified each woody plant in the plot. I recorded shrubs and vines if the stem originating from the ground was within a 1 m radius of the center point of the plot, and I recorded trees if they were within a 3 m radius. Trees were differentiated from shrubs by species. For trees, I recorded the density of the species (number of stems originating from the ground) within the plot. For shrubs and vines, I recorded estimated percent cover (of the stems) to the nearest class: 1%, 5%, 10%, 25%, 33%, 50%, 66%, 75%, 95%, 100%. I discarded four plots due to a discrepancy in the SOLRIS landcover layer or inaccessibility for field work. These four plots were within the forested area according to the SOLRIS data but fell just outside the forested area in reality. One of the four plots was in the forest but could not be surveyed due to a large log pile. As a result, I quantified woody vegetation at 33 out of the original 37 plots (Figure 1). These data are available at Borealis, the Canadian Dataverse Repository (https://doi.org/10.5683/SP3/AWLKYG).

2.3. Data Analysis

I used PAST (Version 4.15) for the majority of the analysis. To determine if enough plot locations were visited to adequately estimate species count, I calculated a Chao-1 value for the Park. A Chao-1 value is an estimate of species in a study area based on the total number of species observed, number of singletons (species observed at one plot location) and number of doubletons (species observed at two plot locations) (Gotelli & Colwell, 2011). I used an Excel spreadsheet to calculate the Chao-1 value with this formula:

$$S_{Chao} = S_{obs} + \frac{f_1^2}{2f_2}$$

S_{Chao} represents the Chao-1 value, S_{obs} represents the number of species observed, f_1 represents the number of singletons, and f_2 represents the number of doubletons (Gotelli & Colwell, 2011). To further determine the adequacy of my sample size, I performed a sample rarefaction analysis, the number of species as a function of the number of plots. To help interpret the sample rarefaction analysis, I created a rarefaction curve to the maximum of my sample size (n = 33) and a curve extrapolated to four times that sample size (n = 132). To identify vegetation classes and their characteristics, I created a dendrogram following Ward's method, based on a matrix of Euclidean distances. I identified the number of communities based on the largest discrepancy between dendrogram branches. Finally, to identify major vegetation gradients, as a complement to the classification, I performed a Principal Component Analysis (PCA) on a correlation matrix. I excluded singletons (<5% frequency) because such rare species often dominate the ordination. To help interpret the PCA axes, I scrutinized the eigenvectors (species loadings) on each axis.

3. Results

Table 1: Common name and scientific name of every species observed at Ashburnham Memorial Park, Peterborough, Ontario, September 2023 - January 2024.

Common Name	Scientific Name
Shrubs	
Alternate-leaf Dogwood	*Cornus alternifolia*
Black Raspberry	*Rubus occidentalis*
Common Buckthorn	*Rhamnus cathartica*
Red Osier Dogwood	*Cornus sericea*
Riverbank Grape	*Vitis riparia*
Staghorn Sumac	*Rhus typhina*
Virginia Creeper	*Parthenocissus quinquefolia*
Trees	
American Elm	*Ulmus americana*
Bitternut Hickory	*Carya cordiformis*
Black Walnut	*Juglans nigra*
Eastern Red Cedar	*Juniperus virginiana*
Eastern White Cedar	*Thuja occidentalis*
Green Ash	*Fraxinus pennsylvanica*
Ironwood	*Ostrya virginiana*
Paper Birch	*Betula papyrifera*
Red Pine	*Pinus resinosa*
Scot's Pine	*Pinus sylvestris*
Sugar Maple	*Acer saccharum*
Tamarack	*Larix laricina*
White Ash	*Fraxinus americana*
White Pine	*Pinus strobus*
White Spruce	*Picea glauca*

3.1. General Species Information, Chao-1, and Sample Rarefaction

Overall, 22 species of woody plants were observed during field work. Seven of these species were shrubs or vines and the other 15 species were trees. The most common woody plant was common buckthorn with a frequency of 51.5% (Table 2). The most frequent tree was Scots pine, which was in about 30% of plots. Average percent cover and density were highly skewed, with few plots with high abundance and many plots with low or zero abundance. The species with the highest average percent cover was common buckthorn at 15.9%. The species with the highest average density was Eastern red cedar at 214.4 trees per hectare. One species of tree, quaking aspen (*Populus tremuloides*), was observed in the forested area of the Park, but not at any plot locations.

There were four singletons and five doubletons in the Park, resulting in a Chao-1 estimated species count of 23.6. (Table 1). The sample rarefaction analysis had a more conservative estimation. The non extrapolated curve nearly reached an asymptote at 33 plots, and the extrapolated graph reached a peak estimated species count at 22.935 (Figure 2; Figure 3).

Table 2: Overview of species counts, and Chao-1 function values.

Statistics	Values
SHRUB SPECIES	7
TREE SPECIES	15
TOTAL SPECIES	22
SINGLETONS	4
DOUBLETONS	5
CHAO-1:	23.6

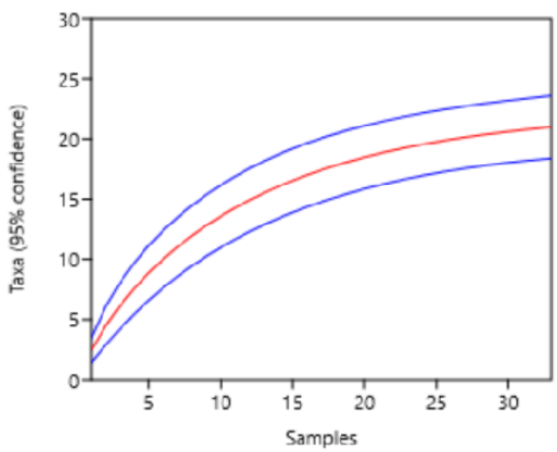

Figure 2: Estimated trend of species observed (95% confidence interval) in Ashburnham Memorial Park, Peterborough, Ontario, September 2023 - January 2024, increasing as samples visited increases. Trendline stops at the 22 species observed and x-axis stops at 33 plots surveyed in AMP

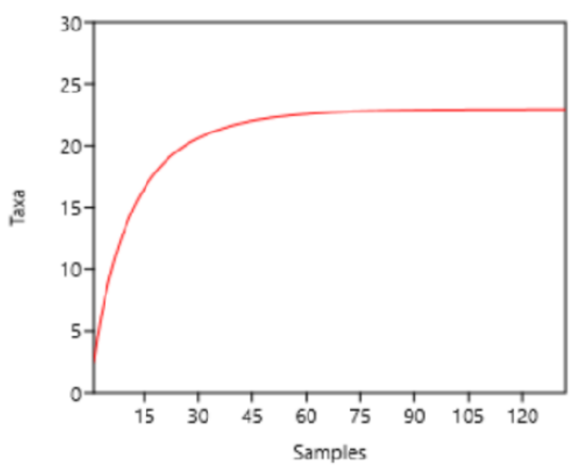

Figure 3: Estimated trend of species observed in Ashburnham Memorial Park, Peterborough, Ontario, September 2023 - January 2024, increasing as samples visited increases. Trendline is extrapolated over 132 plots, and species count reaches 22.935.

Table 3: Abundance of woody plant species found in Ashburnham Memorial Park, Peterborough, Ontario, September 2023 - January 2024. Average percent cover (for shrubs) or average density (for trees), standard error and frequency. Data based on n = 33 plots.

SPECIES	PERCENT COVER (%) OR DENSITY (per m²)		FREQUENCY (%)
Shrubs	**MEAN**	**STANDARD ERROR**	
Alternate-leaf Dogwood	1.36	0.85	9.09
Black Raspberry*	0.30	0.30	3.03
Common Buckthorn	15.97	4.23	51.52
Red Osier Dogwood*	0.30	0.30	3.03
Riverbank Grape	0.21	0.16	9.09
Staghorn Sumac**	0.91	0.77	6.06
Virginia Creeper*	1.00	1.00	3.03
Trees			
American Elm	0.0110	0.0042	18.18
Bitternut Hickory	0.0032	0.0018	9.09
Black Walnut	0.0054	0.0027	12.12
Eastern Red Cedar	0.0214	0.0163	12.12
Eastern White Cedar**	0.0021	0.0015	6.06
Green Ash	0.0075	0.0048	9.09
Ironwood	0.0075	0.0048	9.09
Paper Birch*	0.0021	0.0021	3.03
Red Pine	0.0032	0.0018	9.09
Scot's Pine	0.0193	0.0072	30.30
Sugar Maple**	0.0043	0.0034	6.06
Tamarack**	0.0032	0.0024	6.06
White Ash	0.0161	0.0093	15.15
White Pine**	0.0021	0.0015	6.06
White Spruce	0.0172	0.0074	18.18

**singleton*
***doubleton*

3.2. Classification and Ordination of Communities

The dendrogram displayed two different species assemblages (Figure 4). The classification of these groups was highly dependent on buckthorn; Group 1 plots had a mean common buckthorn percent cover of 6.57%, while Group 2 plots had a mean common buckthorn percent cover of 48.10% (Table 4). Group 1 plots tended to have a higher species diversity, as there were multiple species in those plots that were not observed in any Group 2 plots.

The ordination reiterated the importance of buckthorn in distinguishing these two assemblages. In the PCA, common buckthorn by far had the largest eigenvalue under PC1 at 0.9996; the next furthest eigenvalue from 0 was alternate-leaf dogwood at -0.19622 (Table 5). For PC2, the largest eigenvalue was alternate-leaf dogwood at 0.92557. However, eigenvalues were also significant for sugar maple (0.75417), staghorn sumac (-0.40951), riverbank grape (0.27543), and tamarack (-0.22132).

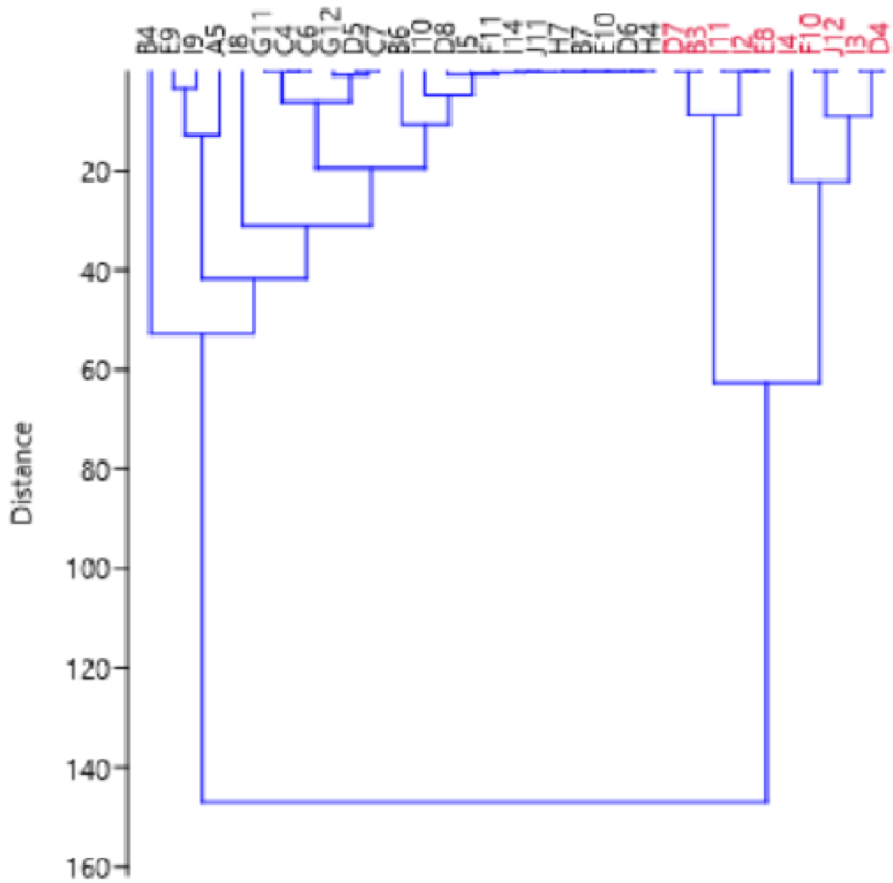

Figure 4: Cluster analysis of woody plants in Ashburnham Memorial Park, Peterborough, Ontario, September 2023 - January 2024. Number and letter codes refer to each plot location (Figure 1).. Distance is unitless, defined species makeup "groups" are coloured in black (Group 1) and red (Group 2).

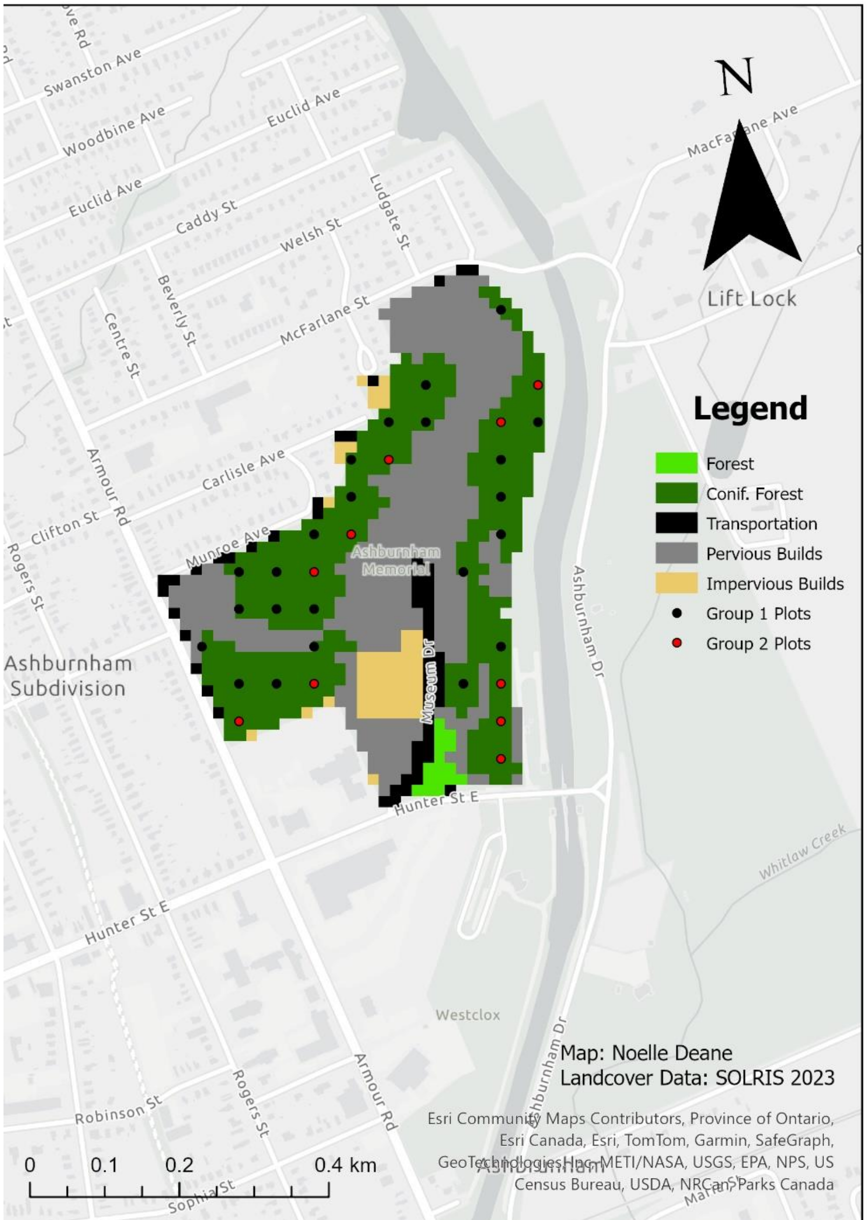

Figure 5: Map of two forest classes in Ashburnham Memorial Park, Peterborough, Ontario, September 2023 - January 2024. Colour at each point represents the forest class (Figure 4).

Table 4: Abundance of woody plant species in two communities: Group 1 (low buckthorn, high diversity; sample size = 23) and Group 2 (high buckthorn, low diversity, sample size = 10). Average percent cover (for shrubs) or average density (for trees), standard error and frequency. Data collected in Ashburnham Memorial Park, Peterborough, Ontario, September 2023 - January 2024.

SPECIES	**FREQUENCY**		**PERCENT COVER (%) OR DENSITY (per m²)**			
			Mean		**Standard Error**	
Shrubs	**Group 1**	**Group 2**	**Group 1**	**Group 2**	**Group 1**	**Group 2**
Alternate-leaf Dogwood	13.04	0.00	1.96	0.00	1.21	0.00
Black Raspberry*	4.35	0.00	0.43	0.00	0.43	0.00
Common Buckthorn	30.43	100.00	2.00	48.10	0.75	20.66
Red Osier Dogwood*	0.00	10.00	0.00	1.00	0.00	1.00
Riverbank Grape	13.04	0.00	0.30	0.00	0.22	0.00
Staghorn Sumac**	8.70	0.00	1.30	0.00	1.10	0.00
Virginia Creeper*	4.35	0.00	1.43	0.00	1.43	0.00
Trees						
American Elm	17.39	20.00	0.009	0.014	0.005	0.009
Bitternut Hickory	8.70	10.00	0.003	0.004	0.002	0.004
Black Walnut	13.04	10.00	0.006	0.004	0.004	0.004
Eastern Red Cedar	17.39	0.00	0.031	0.000	0.023	0.000
Eastern White Cedar**	4.35	10.00	0.002	0.004	0.002	0.004
Green Ash	4.35	20.00	0.003	0.018	0.003	0.014
Ironwood	13.04	0.00	0.011	0.000	0.007	0.000
Paper Birch*	4.35	0.00	0.003	0.000	0.003	0.000
Red Pine	8.70	10.00	0.003	0.004	0.002	0.004
Scot's Pine	30.43	30.00	0.014	0.032	0.005	0.021
Sugar Maple**	8.70	0.00	0.006	0.000	0.005	0.000
Tamarack**	8.70	0.00	0.005	0.000	0.003	0.000
White Ash	17.39	10.00	0.022	0.004	0.013	0.004
White Pine**	8.70	0.00	0.003	0.000	0.002	0.000
White Spruce	21.74	10.00	0.023	0.004	0.010	0.004

**singleton*
***doubleton*

Table 5: Eigenvectors (species loadings) from the first two axes PCA, Ashburnham Memorial Park, Peterborough, Ontario, September 2023 - January 2024. Not including singletons.

Species	PC 1	PC 2
White Spruce	-0.1593	-0.0199
Scots Pine	-0.0061	-0.0526
Sugar Maple	-0.1446	0.7542
Eastern Red Cedar	-0.1545	-0.0100
Green Ash	0.0932	-0.0414
American Elm	0.1276	-0.0708
Red Pine	-0.0442	0.1358
White Ash	-0.1401	0.0006
White Pine	-0.0888	-0.0605
Eastern White Cedar	0.0964	-0.0366
Black Walnut	-0.0133	-0.0968
Bitternut Hickory	0.1200	-0.0445
Tamarack	-0.1612	-0.2213
Ironwood	-0.1862	0.1495
Common Buckthorn	1.0000	0.0054
Alternate-Leaf Dogwood	-0.1962	0.9256
Riverbank Grape	-0.1484	0.2754
Staghorn Sumac	-0.1434	-0.4095

4. Discussion

4.1. Interpretation of Results

Overall, my inventory and analyses suggest the number of woody plant species in AMP is likely 23 or 24 species. I observed 22 species of woody plants in my sampling plots as well as the quaking aspen outside of plot locations. The sample rarefaction analysis peak of 22.935. and the Chao-1 value of 23.6. suggests there are only 1 or 2 species that were unobserved (Table 2; Figure 3). This means that an adequate number of plots (n = 33) was used to get a good idea of the woody plant community in AMP.

The dendrogram and PCA also gave us further insight into the species makeup of AMP. Woody plant communities in the Park were distinguished largely by common buckthorn. The dendrogram's Group 1 plots had little to no buckthorn coverage and high diversity, while Group 2 plots had lots of buckthorn coverage and low diversity. It is plausible that this invasive plant may have a negative effect on other woody understory species. Indeed, the species loadings from PCA emphasized common buckthorn as a distinguishing feature of the two plant communities (Table 5).

4.2. Species of Interest

4.2.1. Invasive Species

Two species observed in the woody plant inventory are considered to be invasive: Scots pine and common buckthorn (Puric-Mladenovic & Bradley, 2012). It is important to note that there were also native species that are often considered "aggressive", such as Virginia creeper and riverbank grape, but these species were not observed very often in the Park. Scots pine has an invasive ranking of 2, meaning it is considered to be highly invasive (Puric-Mladenovic & Bradley, 2012). Scots pine often forms thickets in moist habitats, and is known for shading out other plant species (Catling & Carbyn, 2005). In AMP, Scots pine likely replaces the role that red pine would have in a typical coniferous forest in Peterborough. However, Scots pine did not correlate significantly with PC1 or 2 (Table 5), and was not a significant feature of Group 1 or 2 (Figure 4). On the other hand, common buckthorn correlated heavily with PC1 and this species tended to distinguish the two groups. Common buckthorn has an invasive ranking of 1, meaning it is considered to be aggressively invasive, which is the highest invasive ranking that can be given (Puric-Mladenovic & Bradley, 2012). Like Scots pine, common buckthorn is known to form dense thickets and to shade out other plants (Klionsky et al., 2011). Furthermore, the species can also change soil pH levels and the plant makeup of local ecosystems (Hong, 2018; Klionsky et al., 2011). Common buckthorn is also able to affect some predator-prey relationships; for example, coyotes (*Canis latrans*) are more likely to show up in large buckthorn stands, while white-tailed deer (*Odocoileus virginianus*) are less likely to show up (Hong, 2018). Common buckthorn can also dissuade birds from nesting nearby it if the buckthorn has formed a large enough stand (Hong, 2018). The presence of common buckthorn in roughly half the plots (Table 3) in AMP may have ecological effects, but the removal of the species entirely would be near impossible. To dissuade common buckthorn from spreading further at AMP, it might be halted or slowed by planting more shade-tolerant, generalist species such as sugar maple (Burns & Honkala, 1990), or perhaps ironwood or alternate-leaf dogwood that can fill the buckthorn niche.

4.2.2. Species of Conservation Concern

Two species observed in AMP are of conservation concern: white ash and green ash. Both ash trees have declined due to emerald ash-borer (*Agrilus planipennis*), an exotic species of insect whose larvae nest exclusively in true ash trees (Tidman, 2020). The larvae feed on the phloem of the tree, which often results in the ash tree's death (Tidman, 2020). This has resulted in two species of ash tree, black ash (*Fraxinus nigra*) and blue ash (*Fraxinus quadrangulata*) to become species-at-risk in Ontario; however, white ash and green ash are still of least concern (Government of Ontario, 2023). Although emerald ash-borer has been observed in Peterborough, I noticed no signs of emerald ash-borer on any trees observed inside or outside of the plots in AMP (City of Peterborough, 2021). However, most of the ash trees observed at AMP appeared to be juvenile. This may be due to their change in shade tolerance with age. Ash trees are very shade tolerant as juveniles, but as they mature, they become intolerant of shade (Burns & Honkala, 1990). The growth of these species may improve if they are planted in more open areas of the Park, and if measures are taken to protect ash trees from the emerald ash borer, such as treatment with TeeAzin every two years (City of Peterborough, 2021).

4.3. Recommendations for Future Research

The Chao-1 calculation and sample rarefaction analysis determined that the number of plots used was adequate to get a good idea of the woody plant community in AMP. This means that these plots can be revisited to assess the change in the woody plant community over time. The frequency of these visits can vary based on how quickly vegetation in the Park changes; however, revisiting these plots for woody plant surveys every 10 years would be a good baseline. On top of revisiting woody plant surveys, surveys of other taxa could be performed at these plots to get an idea of the environmental relationships between taxa in the Park. Some examples of other taxa surveys could include bird point counts, invertebrate surveys, and herbaceous understory surveys. These surveys would need their own Chao-1 calculation and sample rarefaction analysis to determine if the plot amount is suitable for the taxa being surveyed.

4.4. Conclusions

Overall, the research goals that were set out at the beginning of this project have been reached. In addition to inventorying the woody plants, these 33 permanent plot locations can be used for surveys on other taxa, such as bird point counts, mammal fecal plots, and herbaceous plant surveys. Long-term observations of multiple plant and animal taxa and of environmental conditions can improve our understanding of their interrelationships and how they change over time. Inventories of plant and animal taxa in Central Park, New York and from Fairmount Park, Philadelphia from the 1800s have outlined the rise of non-native species in the parks and more recent efforts to reduce those species (Loeb, 2010). Similar efforts in High Park, Toronto, to preserve Black Oak Savannah habitat have been observed due to inventories undertaken in the 1800s (Varga, 2008). The use of circular concentric plots can also be divided further than just trees and shrubs when collecting data for these inventories. Concentric circular plots were used to assess overstory trees, logs, snags, and stumps in Catchcoma Forest in the Kawartha Lakes region (Folland et al., 2022). Options to possibly limit the spread of common buckthorn were suggested, such as the planting of shade tolerant species and the planting of native understory species that could replace buckthorn in the AMP species makeup. Options that would possibly encourage the growth of these species were suggested, such as planting them in more open areas so the species can reach maturity easier. The addition of permanent concentric plot locations and a description of the current woody plant community in AMP provides AMSG with a baseline to track their progress towards promoting stewardship in the Park.

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Appendix

Table 6: Plot ID (alphanumerically), community type (or "group"), latitude, and longitude of each plot location that was surveyed.

PLOT ID	COMMUNITY	LATITUDE (°N)	LONGITUDE (°E)
A5	1	44.310043	-78.306378
B3	2	44.309107	-78.305864
B4	1	44.309555	-78.305809
B6	1	44.310451	-78.305699
B7	1	44.310899	-78.305643
C4	1	44.309515	-78.305185
C6	1	44.310412	-78.305075
C7	1	44.310860	-78.305019
D4	2	44.309476	-78.304561
D5	1	44.309924	-78.304506
D6	1	44.310372	-78.304451
D7	2	44.310820	-78.304395
D8	1	44.311268	78.304340
E8	2	44.311229	-78.303716
E9	1	44.311677	-78.303661
E10	1	44.312125	-78.303606
F10	2	44.312085	-78.302981
F11	1	44.312533	-78.302926
G11	1	44.312493	-78.302302
G12	1	44.312942	-78.302247
H4	1	44.309317	-78.302065
H7	1	44.310661	-78.301899
I2	2	44.308381	-78.301551
I3	2	44.308829	-78.301496
I4	2	44.309277	-78.301441
I5	1	44.309725	-78.301386
I8	1	44.311070	-78.301220
I9	1	44.311518	-78.301164
I10	1	44.311966	-78.301109
I11	2	44.312414	-78.301054
I14	1	44.313758	-78.300888
J11	1	44.312374	-78.300430
J12	2	44.312823	-78.300375