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Establishing a Baseline Plant Species Inventory Within the Penn's Woods Deer Exclosure

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An independent study project report by The Hay Honey Farm Endowed Natural Lands Intern (2018-2019)

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Abstract
Overpopulation of white-tailed deer (*Odocoileus virginianus*) is a problem adversely affecting the ecological health of eastern deciduous forests in the United States, including those in southeastern Pennsylvania. Trampling and herbivory have led to the loss of native understory and ground cover species and expedited the invasion of aggressive exotic plants. The use of deer exclosure fencing has become common practice as a method of protecting vulnerable sites from these impacts. In 2016, an exclosure was installed in the Penn's Woods section of Morris Arboretum's natural lands with the hopes of facilitating forest restoration and learning about the response of the plant community. This project was designed as a comprehensive survey to establish a baseline record of plant species present within the exclosure so that changes in species composition can be monitored over time. In order to organize this inventory, a grid system of 22 plots was created and mapped using a GPS device and ArcGIS software. The herbaceous and woody plant layers within each plot were surveyed and documented. Statistical analysis was used to identify the most ecologically significant plants. In addition, photographs were taken of each plot and of the tree canopy in both winter and spring, so that these can be repeated over time to visualize changes to the canopy and understory layers. This data will be available to the manager of the Morris Arboretum natural lands and may be referenced for planning and restoration efforts going forward. Strategic corners of the grid were permanently marked so that it may be easily rebuilt and this inventory can be replicated at regular intervals in the future. Information gleaned from these surveys will afford a better understanding for how the exclusion of white-tailed deer impacts the forest ecology, and can inform future uses of deer exclosures on the property for habitat improvement.

Disciplines
Horticulture

Comments
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INTRODUCTION

The woodlands of Morris Arboretum's natural areas provide key ecological habitat and a natural buffer along the Wissahickon Creek. Unfortunately, heavy deer pressure has severely impacted the forest understory and has made restoration challenging. As a result, a deer exclosure has been installed to protect a previously neglected portion of the woods, and efforts to reestablish a healthy native habitat have begun. With this ongoing management, it became important to identify and record any changes observed in the plant life on this site. In August of 2018, the present study began as an initial step in that cause, aiming to survey woody and herbaceous plant species living inside of the deer exclosure so that a baseline record could be attained. With this data, the goal was to provide information for management and restoration, while establishing a record that can be referenced and added to in the future. This could allow Morris Arboretum to learn additional strategies for combating the deer impacts and ultimately maintain its natural woodlands more effectively.

BACKGROUND

Populations of white-tailed deer (*Odocoileus virginianus*) have grown out of control, bringing about severe impacts to the ecology of eastern deciduous forests. The deer preferentially browse the plant species' that evolved alongside them, and this selective herbivory reduces the population and diversity of native plants in the understory (Knight et al., 2009). A study in a Pennsylvania forest impacted by deer found that the number of botanical families present decreased from 27 to 10 over a 66-year period (Rooney & Dress, 1997). Greater numbers of deer also means more trampling of the soil, which diminishes the ability of plants to establish and grow (Heckel et al., 2010). Additionally, young trees can be girdled and killed by antler rub (Ramos et al., 2006). These factors boost the ability of invasive non-native species to proliferate and take over vulnerable forest communities (Knight et al., 2009; Eschtruth & Battles, 2009).

Ecologists and land managers have adapted methods for counteracting these effects. One popular strategy is to use large exclosures, where fencing is erected to protect certain areas from deer impacts. Structures like these have proven helpful not only for habitat restoration, but also in examining the ways in which deer alter their environment. Studies have used exclosures to show how the presence of white-tailed deer results in greater numbers of invasive plant species (Abrams & Johnson, 2012; Shen et al., 2016). In Pennsylvania, the oldest known exclosure in the eastern deciduous forest has stood in the Allegheny National Forest for over 60 years, and has been utilized to highlight declines in species density and diversity due to deer browse over that time (Goetsch et al., 2011; Kain et al., 2011). Examples like these illustrate the benefit of using a deer exclosure when trying to re-establish a healthy forest community.

Morris Arboretum maintains a deer exclosure in the Penn's Woods section of their natural lands. It is on a rocky slope just above the Wissahickon Creek. The underlying geology is Wissahickon schist, and the soil is well-drained and slightly acidic (Contosta & Franklin, 2010); (Web soil survey, 2019). The native forest of this location was likely made up of American chestnut (*Castanea dentata*), oak (*Quercus sp*.), American beech (*Fagus grandifolia*), and eastern hemlock (*Tsuga canadensis*) trees. Studies of similar sites in the Wissahickon Valley suggest that the understory may have been populated by plants such as sassafras (*Sassafras*

albidium) and shadbush (*Amelanchier* sp.), with an herbaceous layer consisting of many ferns and spring ephemerals. (Contosta & Franklin, 2010)

When John and Lydia Morris lived on the property in the early 1900's, the site was woodland bordered by two roads. To the east was a service road into the garden, and to the south was the road that led down to the Morris' boathouse on the Wissahickon. A trail meandered through the woods, passing by John's Japanese-style garden near a large rock outcrop. Records indicate that during this time, Lydia purchased many trilliums (*Trillium* sp.), trout lilies (*Erythronium* sp.), and other spring ephemerals (Archives, 2019). It is not clear where they were planted, but writers from this era made note of the lovely wildflowers and spring ephemerals growing in the woods. It is possible that some of these species found their way to the woods where the deer exclosure now sits, while others are undoubtedly native to the site. In the latter part of the 20th century, the boathouse road was used to carry both organic and inorganic garden debris to be discarded in this area of the floodplain (R. Gutowski, personal communication, 2019). Evidence of this dumpsite can still be seen in the woods. A visible pile of brick, tile, cement and other rubble can be found near the bottom corner of the exclosure, and a large iron bowl leftover from the Morris Iron Works still rests on the ground nearby.

After previously going mostly unmanaged by Arboretum staff, the site came into active management in 2008 with the construction of *Out on a Limb* tree canopy adventure, overlooking Penn's Woods. With the base of the structure already fenced off for visitor safety, the decision was made to expand the fencing to protect part of the woods from the deer. In December of 2016, the full deer exclosure was built, surrounding roughly 3/4 of an acre of habitat.

Management plans for the site proceeded actively throughout this process. Prior to the construction, a number of invasive trees were removed so that the fencing would not impede the work that needed to be done, including such species as: bee-bee tree (*Tetradium daniellii)*, cork tree (*Phellodendron amurense)*, Zelkova (*Zelkova serrata)*, Norway maple (*Acer platanoides)*, Japanese maple (*Acer palmatum)*, and princess tree (*Paulownia tomentosa*). In these instances, the wood was mostly left in place and the stumps were treated with herbicide in order to prevent re-sprouting. At this point, no invasive canopy trees remain within the exclosure. Two ash trees (*Fraxinus* sp.) were removed in anticipation of dieback due to emerald ash borer (EAB), while three remaining ash trees within the exclosure are being treated for EAB in hopes to preserve some of the canopy that is shading the understory. Other trees standing in the exclosure, specifically Carolina silverbell (*Halesia carolina)* and umbrella magnolia (*Magnolia tripetala)*, are likely not native to the site and have naturalized from plantings in the garden. For now, these species are not being managed. Meanwhile, management of invasive species in the understory is ongoing, targeting culprits such as Japanese pachysandra (*Pachysandra terminalis)*, burning bush (*Euonymus alatus)*, Japanese honeysuckle (*Lonicera japonica)*, linden viburnum (*Viburnum dilatatum)*, and lesser celandine (*Ficaria verna)*.

New plantings have also been proceeding. After *Out on a Limb* was erected, a planting project was completed within the initial exclosure at the base of the structure. Woody and herbaceous species were added, including native azaleas (*Rhododendron sp*.), mountain laurel (*Kalmia latifolia*), spicebush (*Lindera benzoin*), lowbush blueberry (*Vaccinium angustifolium*), and mayapple (*Podophyllum peltatum*) (Oellerich, 2010). In 2015 and 2016, more plantings were added to Penn's woods. Included were species such as dwarf crested iris (*Iris cristata*), wild ginger (*Asarum canadense*), sedges (*Carex* sp.), white wood aster (*Eurybia divaricata*), marginal wood fern (*Dryopteris marginalis*), and Christmas fern (*Polystichum acrostichoides*), but there is not a record of exact locations for these plantings. Additions have been made since the expansion

of the exclosure as well, including a major effort in spring of 2017. The goal of this project was to close gaps using trees such as tulip poplar (*Liriodendron tulipifera*) and various oaks *(Quercus* sp.), while adding diversity to the native herbaceous layer with species like black cohosh (*Actaea racemosa*), big leaf aster (*Eurybia macrophylla*), blue-stem goldenrod (*Solidago caesii*), and Christmas fern (*Polystichum acrostichoides*).

METHODS

In order to more easily organize and complete the survey, a grid was established within the exclosure. The area was divided into square units measuring 10 x 10 meters, resulting in 22 individual plots. This was designed with the goal of achieving the most possible complete plots that could fit in a contiguous grid. The plots were laid out with these specifications using a tape measure, and each corner was marked with a temporary wooden stake and labeled. To create a unique identification for each plot, the grid columns were lettered A-H going from west to east, and the rows were numbered 1-5 going from north to south. GPS data points were gathered for both the perimeter fence of the exclosure, and for every corner in the grid, using ArcPad on a Trimble Geo 7x device. This data was then downloaded and mapped in ArcGIS.

Once the grid was established, surveys were done of each plot. These were completed one plot at a time, using twine wrapped around the four corner posts of every square to define the perimeters. Beginning in September 2018 and lasting through mid-October, the inventory first identified plants in the herbaceous layer. This included all non-woody plants, and woody plants less than two feet tall. For each plot, any species present was recorded. Additionally, an estimate of "percent cover" was made, approximating the percentage of the area within that plot represented by each species. This data was entered into an excel spreadsheet where it could be organized both by species and by plot. The herbaceous survey was then repeated in April of 2019, in order to account for spring ephemeral species not apparent in the autumn.

To identify the most dominant herbaceous species, some statistical analysis was completed to calculate the relative importance values (RIV). First, relative percent cover was found by adding each species' percent cover across all plots and then dividing that amount by the sum of all species' total percent cover. Next, frequency was established by dividing the number of plots in which one species was found by the total number of plots in the grid. To find relative frequency, each species' frequency was divided by the sum of all frequencies. By adding together relative percent cover and relative frequency, and then dividing that sum by two, the RIVs were determined

In February and March, 2019, each plot was surveyed to identify the woody plants. This layer included all woody flora greater than two feet tall. Many of these specimens had already been recorded and mapped either in GIS, or in BG Base, the Arboretum's collections database. By adding this data to the grid map that had been created in ArcMap, any woody plants already recorded could be surveyed on the computer. The rest of this layer was identified in the field. Any trees with a diameter at breast height (DBH) greater than 12 centimeters were counted individually and considered to be part of the overstory, or canopy layer. All other woody plants were measured by taking an estimate of percent cover, the same way it was done for the herbaceous layer, and were classified as the shrub layer. For this layer, RIVs were determined using the same method as with the herbaceous plants.

To supplement the survey data, photographs were taken of each plot in the winter, and repeated in the spring. These were taken uniformly, from the northwest corner of every plot facing diagonally towards the opposite corner, so that they could be easily replicated and compared. After surveying, the wooden stakes were removed. Small steel stakes were labeled and added in 18 strategically chosen corners to remain permanently, and their locations were mapped in GIS. This will serve to maintain a frame from which to work when re-constructing the grid for the purpose of future surveys. Using 16 of these corners as markers, canopy photographs were also taken in the winter and the spring, so that changes in the canopy can be monitored over time.

RESULTS

The fall herbaceous inventory identified 92 species, representing 48 families. Some of the most widespread examples included white snakeroot (*Ageratina altissima*), pokeweed (*Phytolacca americana*), and jumpseed (*Persicaria virginiana*). There were also some invasive species that appeared frequently, such as porcelain berry (*Ampelopsis brevipendunculata*), smartweed (*Persicaria longiseta*), and Asian bittersweet (*Celastrus orbiculatus*). Table #1 shows the ten herbaceous species that had the highest RIV.

The inventory of woody plants yielded 40 species from 18 families. The lower portion of the exclosure (plots A1-A4 and B1-B4) was dominated by Carolina silverbell (*Halesia carolina*), with red maple (*Acer rubrum*), boxelder (*Acer negundo*), and ash (*Fraxinus* sp.) in the canopy. The upper portion (plots D3-E3 and D4-H4) was dominated by American beech (*Fagus grandifolia*). Large individuals comprised most of the canopy, while suckers crowded the understory. A population of black cherry (*Prunus serotina*) also proliferated here, including five significant specimens in G4 and H4. On the slope above the trail, a mass of black tupelo (*Nyssa sylvatica*) suckers covered the ground, beneath four large black tupelo trees.

Table #2 lists the five shrub layer species that ranked highest in RIV. These numbers illustrate how much the small *H. carolina* and *M. tripetala* trees dominated the understory, and the degree to which some of the suckering trees have spread. In the canopy layer, American beech had the most specimens with 14. This was twice as many as the next highest species, red maple. In all, 54 canopy trees were identified in the survey plots.

Species (Herbaceous Layer)	**RIV**
Ageratina altissima	.145
Phytolacca americana	.058
Persicaria virginiana	.057
Eurybia divaricata	.046
Parthenocissus quinquefolia	.038
Maianthemum racemosum	.036
Pilea pumila	.027
Circaea lutetiana	.026
Ampelopsis brevipendunculata	.025
Persicaria longiseta	.025

Table #1: Top ten species RIV in the fall herbaceous layer

Species (Shrub Layer)	**RIV**
Halesia carolina	.169
Fagus grandifolia	.133
Magnolia tripetala	.075
Aesculus parviflora	.073
Nyssa sylvatica	.063

Table #2: Top five species RIV in the shrub layer

The spring survey added 28 herbaceous species from 17 families. These were dominated by yellow trout lily (*Erythronium americanum*), mayapple (*Podophyllum peltatum*), lesser celandine (*Ficaria verna*), and chickweed (*Stellaria media*), a mix of natives and exotic invasives. Large patches of other wildflowers such as hybrid Trillium species (*Trillium x* sp.) and cutleaf toothwort (*Cardamine concatenata*) were present as well. Some species counted were previously identified in the fall but now appeared in much greater numbers, including lily of the valley (*Convallaria majalis*), violets (*Viola* sp.) and blue cohosh (*Caulophyllum thalictroides*). The combination of the fall and spring surveys revealed the full extent of the herbaceous layer.

DISCUSSION

The data collected in this survey provides managers of the natural areas with valuable information for purposes of management and monitoring that can be referenced and expanded upon. It gives them an easily accessible and adaptable record of species frequency and distribution for the bulk of the deer exclosure, which can also be used in combination with the maps that have been created in ArcGIS to visualize any number of specific details that may aid research or restoration efforts. For instance, Figure #1 shows a map displaying all of the plots in which oriental bittersweet (*Celastrus orbiculatus*) was found. This would allow a manager to visualize the locations where the invasive vine is growing so that it can be monitored over time. In Figure #2, the percent cover of false Solomon's seal (*Maianthemum racemosum*) in each plot is shown, illustrating the places where populations are concentrated, and potentially guiding additional plantings. These represent just some of the many ways in which managers can utilize this information, in collaboration with the newly created maps in GIS, for the benefit of ongoing stewardship.

This project also enhanced the organization of information gathered pertaining to the deer exclosure, which can be used moving forward. Any future plantings and removals done within the exclosure should be added to this file folder on the computer system so that the materials are consolidated in the same easily accessible location. This will prove very useful alongside future surveys and continued integration of data with the working map in GIS. It may also be valuable to record and add other significant observations or management steps to this folder.

Research has shown that species are slow to recover after deer exclusion, so dramatic changes are not likely to occur for some time (Collard et al., 2010). However, active management can help to accelerate the understory recovery in a few ways. Removing invasive species will reduce the amount of competition for natives, while planting trees and shrubs will help to close gaps in the canopy more quickly, shading out those exotics. Furthermore, the new plantings will reinvigorate the seed bank, accelerating the spread of the desirable plants (Tanentzap et al., 2012). Pedestrian activity from management and visitors, however, may impede some of this regeneration through soil compaction.

The information gathered for this project is designed to provide a baseline inventory that will be expanded upon subsequently. The overall survey should be repeated every three to five years in order to maintain an account of how the plant community is responding over time. This periodic analysis will be useful for management and offer unique research opportunities for studying the effectiveness of deer exclusion.

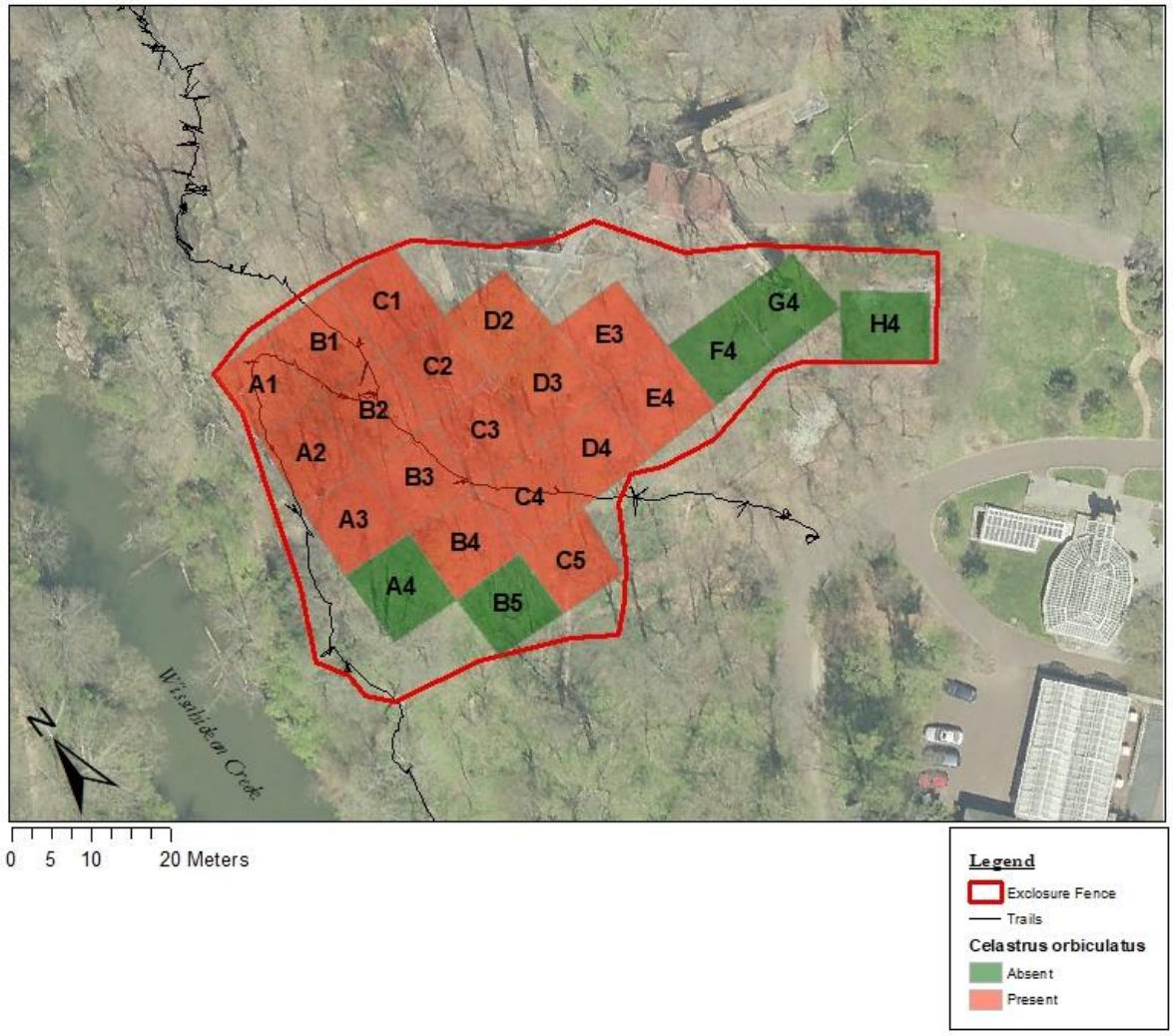

Figure #1: Map of plots where oriental bittersweet (*Celastrus orbiculatus*) was found

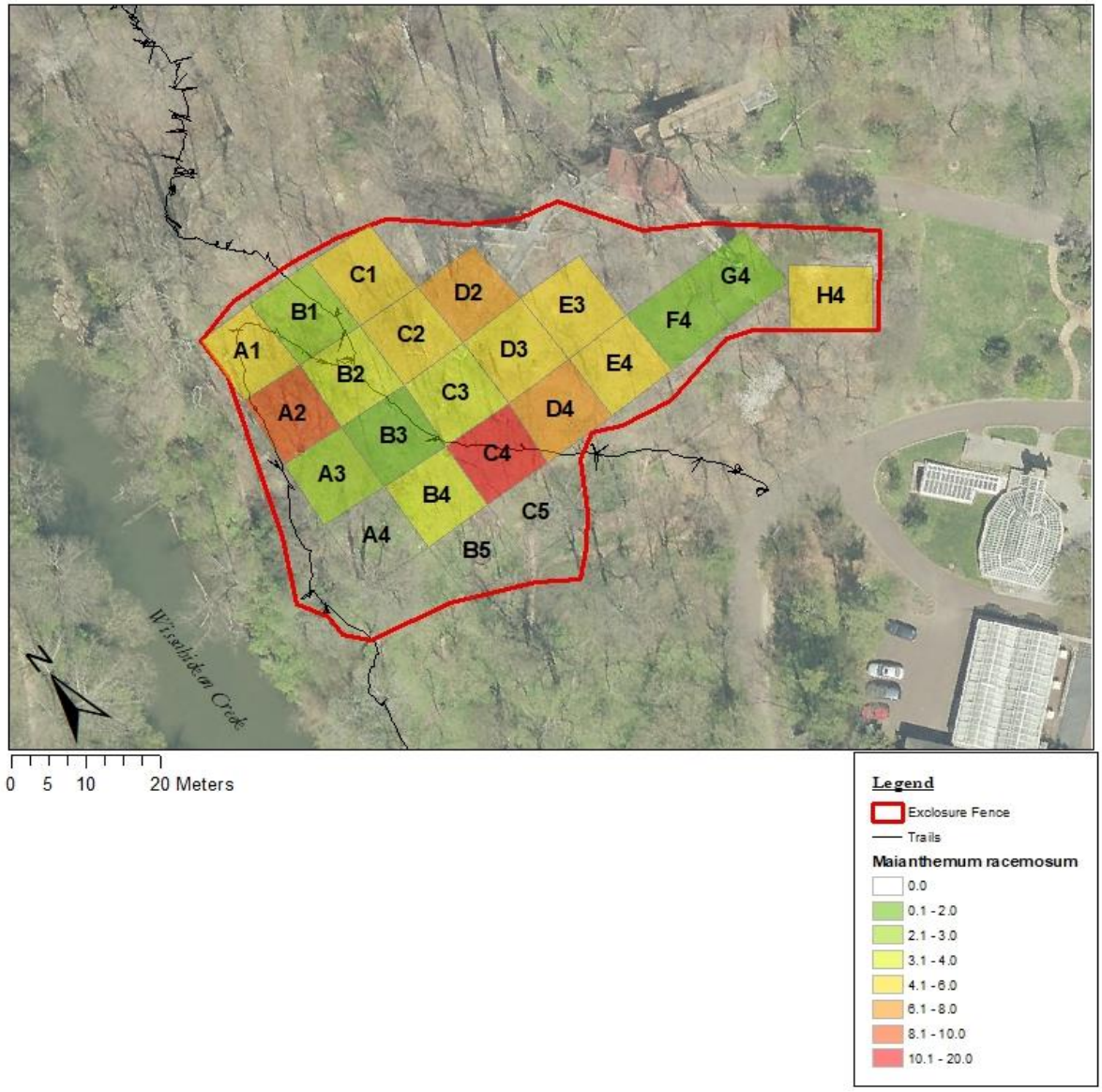

Figure #2: Map showing percent cover of false Solomon's seal (Maianthemum racemosum)

CONCLUSION

As restoration efforts continue throughout the woodlands of Morris Arboretum, the deer exclosure will provide a stable habitat and valuable feedback concerning the ecological response to protection from deer impacts. The baseline inventory established by this project will be a key resource and help guide future studies looking at how the forest plant communities respond in the absence of deer pressure. It also supplies a framework from which to move forward, with an organized system of information regarding management of the deer exclosure, including better integration of species survey data with GIS mapping. This work will improve Morris Arboretum's ability to provide habitat for native ecosystems, preserving a healthy corridor along the Wissahickon Creek and allowing both visitors and professionals the opportunity to learn more about how these systems function within the environment.

Appendix 1: Fall herbaceous survey

Species	Family	RIV
Acer negundo	Sapindaceae	0.014
Acer platanoides	Sapindaceae	0.003
Acer rubrum	Sapindaceae	0.012
Actaea pachypoda	Ranunculaceae	0.001
Actaea racemosa	Ranunculaceae	0.015
Ageratina altissima	Asteraceae	0.145
Alliaria petiolata	Brassicaceae	0.011
Ampelopsis brevipendunculata	Vitaceae	0.025
Amphicarpaea bracteata	Fabaceae	0.001
Aralia elata	Araliaceae	0.012
Asarum canadense	Aristolochiaceae	0.003
Aster sp.	Asteraceae	0.005
Betula lenta	Betulaceae	0.003
Callicarpa dichotoma	Lamiaceae	0.001
Carex sp.	Cyperaceae	0.004
Carya cordiformis	Juglandaceae	0.002
Caulophyllum thalictroides	Berberidaceae	0.001
Celastrus orbiculatus	Celastraceae	0.022
Cephalotaxus sp.	Cephalotaxaceae	0.006
Cercis canadensis	Fabaceae	0.002
Chelidonium majus	Papaveraceae	0.003
Circaea lutetiana	Onagraceae	0.026
Commelina communis	Commalinaceae	0.001
Convallaria majalis	Asparagaceae	0.008
Cornus florida	Cornaceae	0.001
Cornus sp.	Cornaceae	0.001
Dennstaedtia punctilobula	Dennstaedtiaceae	0.004
Dryopteris marginalis	Dryopteridaceae	0.007
Dryopteris intermedia	Dryopteridaceae	0.006
Euonymus alatus	Celastraceae	0.006
Eurybia divaricata	Asteraceae	0.046
Eurybia macrophylla	Asteraceae	0.007
Fern sp.	Polypodiaceae	0.014
Duchesnia indica	Rosaceae	0.005
Fraxinus sp.	Oleaceae	0.020
Geum canadense	Rosaceae	0.004
Gingko biloba	Ginkgoaceae	0.004
Glechoma hederacea	Lamiaceae	0.012

Hackelia virginiana	Boraginaceae	0.006
Hedera helix	Araliaceae	0.016
Hosta sp.	Asparagaceae	0.003
Hydrophyllum virginianum	Boraginaceae	0.002
Impatiens capensis	Balsaminaceae	0.002
Iris cristata	Iridaceae	0.003
Juncus tenuis	Juncaceae	0.001
Liriodendren tulipifera	Magnoliaceae	0.009
Liriope muscari	Asparagaceae	0.001
Lonicera japonica	Caprifoliaceae	0.007
Lonicera machii	Caprifoliaceae	0.002
Lysimachia quadrifolia	Primulaceae	0.004
Magnolia tripetala	Magnoliaceae	0.001
Maianthemum racemosum	Asparagaceae	0.036
Malus sp.	Rosaceae	0.002
Matteuccia struthiopteris	Onocleaceae	0.022
Microstegium vimineum	Poaceae	0.003
Mustard sp.	Brassicaceae	0.001
Nyssa sylvatica	Nyssaceae	0.024
Oenothera biennis	Onagraceae	0.001
Oxalis sp.	Oxalidaceae	0.014
Pachysandra procumbens	Buxaceae	0.004
Parthenocissus quinquefolia	Vitaceae	0.038
Persicaria virgniana	Polygonaceae	0.025
Phellodendron amurense	Rutaceae	0.057
Photinia villosa	Rosaceae	0.004
Phytolacca americana	Phytolaccaceae	0.003
Pilea pumila	Urticaceae	0.058
Podophyllum peltatum	Berberidaceae	0.027
Polygonum cuspidatum	Polygonaceae	0.001
Polystichum acrostichoides	Dryopteridaceae	0.019
Prunus serotina	Rosaceae	0.001
Prunus sp.	Rosaceae	0.008
Pyrus calleryana	Rosaceae	0.001
Quercus coccinea	Fagaceae	0.002
Rhodotypos scandens	Rosaceae	0.002
Rubus phoenicolasius	Rosaceae	0.006
Rubus sp.	Rosaceae	0.016
Sanguinaria canadensis	Papaveraceae	0.001
Sassafras sp.	Lauraceae	0.001
Solidago caesia	Asteraceae	0.012

Solidago canadensis	Asteraceae	0.011
Solidago flexicaulis	Asteraceae	0.001
Solidago sp.	Asteraceae	0.007
Toxicodendron radicans	Anacardiaceae	0.023
Trillium sp.	Trilliaceae	0.002
Ulmus sp.	Ulmaceae	0.001
Urtica dioica	Urticaceae	0.001
Uvularia perfoliata	Colchicaceae	0.003
Verbesina alternifolia	Asteraceae	0.003
Vinca minor	Apocynaceae	0.010
Viola sp.	Violaceae	0.014
Wisteria sinensis	Fabaceae	0.015
Zelkova serrata	Ulmaceae	0.001

Appendix 2: Spring herbaceous survey

Species	Family	RIV
Alliaria petiolata	Brassicaceae	0.024
Allium tricoccum	Amaryllidaceae	0.003
Anemone quinquefolia	Ranunculaceae	0.004
Asarum canadense	Aristolochiaceae	0.018
Brassica sp.	Brassicaceae	0.013
Cardamine angustata	Brassicaceae	0.005
Cardamine concatenata	Brassicaceae	0.051
Caulophyllum thalictroides	Berberidaceae	0.024
Chelidonium majus	Papaveraceae	0.008
Claytonia virginica	Montiaceae	0.035
Convallaria majalis	Asparagaceae	0.055
Dicentra cucullaria	Fumariaceae	0.005
Erythronium americanum	Lilliaceae	0.163
Fallopia japonica	Polygonaceae	0.006
Ficaria verna	Ranunculaceae	0.141
Galium aparine	Rubiaceae	0.042
Geranium sp.	Geraniaceae	0.004
Geum canadense	Rosaceae	0.009
Hesperis matronalis	Brassicaceae	0.002
Iris cristata	Iridaceae	0.005
Lamium purpureum	Lamiaceae	0.002
Maianthemum canadense	Asparagaceae	0.002
Mertensia virginica	Boraginaceae	0.008
Narcissus sp.	Amaryllidaceae	0.015
Podophyllum peltatum	Berberidaceae	0.083
Polygonatum biflorum	Polygonaceae	0.050
Ranunculus aborvitus	Ranunculaceae	0.009
Sanguinaria canadense	Papaveraceae	0.007
Sedum sp.	Crassulaceae	0.002
Stellaria media	Caryophyllaceae	0.099
Tiarella cordifolia	Saxifragaceae	0.002
Trillium grandiflorum	Melanthiaceae	0.005
Trillium sessile	Melanthiaceae	0.002
Trillium sp.	Melanthiaceae	0.017
Trillium x sp.	Melanthiaceae	0.012
Uvularia perfoliata	Colchicaceae	0.002
Viola sororia	Violaceae	0.049
Viola sp.	Violaceae	0.016

Appendix 3: Woody survey

Species	Family	RIV
Acer negundo	Sapindaceae	0.015
Acer rubrum	Sapindaceae	0.010
Acer spicatum	Sapindaceae	0.004
Aesculus glabra	Sapindaceae	0.008
Aesculus parviflora	Sapindaceae	0.073
Aesculus sp.	Sapindaceae	0.006
Amelanchier laevis	Rosaceae	0.022
Asimina triloba	Annonaceae	0.004
Betula lenta	Betulaceae	0.025
Carpinus caroliniana	Betulaceae	0.011
Castanea dentata	Fagaceae	0.010
Cercis canadensis	Fabaceae	0.005
Cladrastis kentukea	Fabaceae	0.000
Cornus florida	Cornaceae	0.028
Euonymus americanus	Celastraceae	0.010
Fagus grandifolia	Fagaceae	0.133
Fraxinus americana	Oleaceae	0.004
Fraxinus sp.	Oleaceae	0.013
Halesia carolina	Styracaceae	0.169
Hamamelis virginiana	Hamamelidaceae	0.018
Ilex opaca	Aquifoliaceae	0.034
Kalmia latifolia	Ericaceae	0.014
Lindera benzoin	Lauraceae	0.028
Liriodendron tulipifera	Magnoliaceae	0.046
Magnolia tripetala	Magnoliaceae	0.075
Nyssa sylvatica	Nyssaceae	0.063
Ostrya virginiana	Betulaceae	0.000
Prunus serotina	Rosaceae	0.024
Prunus sp.	Rosaceae	0.022
Quercus alba	Fagaceae	0.004
Quercus bicolor	Fagaceae	0.005
Quercus coccinea	Fagaceae	0.015
Quercus montana	Fagaceae	0.025
Quercus rubra	Fagaceae	0.000
Quercus velutina	Fagaceae	0.015
Rhododendron calendulaceum	Ericaceae	0.006
Rhododendron maximum	Ericaceae	0.017
Sassafras albidum	Lauraceae	0.027

Tsuga canadensis	Pinaceae	0.000
Viburnum lentago	Adoxaceae	0.013

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