



Morris Arboretum of the
University of Pennsylvania

Official arboretum of the Commonwealth of Pennsylvania

FINAL INDEPENDENT PROJECT REPORTS

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Morris Arboretum Internship Program

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TITLE: Reinterpreting the Virtual Visitor Experience of the
Dorrance H. Hamilton Fernery

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DATE: April 2012

ABSTRACT:

The purpose of this project was to update and improve the web presence for the Dorrance H. Hamilton Fernery at the Morris Arboretum. To do this I first evaluated the resources already present on the website and then researched how other gardens and institutions utilize their online resources. Using this information I created a new design template for the website, which included an interactive, comprehensive timeline feature, a downloadable self-guided tour, and external resource links. Once fully implemented the new fernery website will be a place for people to visit and learn about the structure, history, and fern collection housed within the Dorrance H. Hamilton Fernery.

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INTRODUCTION & GOALS

The Morris Arboretum of the University Pennsylvania is home to the Dorrance H. Hamilton Fernery, the only existing freestanding fernery in North America. It is a very unique structure rich in history, architectural ingenuity, and botanical treasures. Many visitors however do not realize this, and subsequently do not truly appreciate the time they spend in the Fernery. Though signage is present around the Fernery and the Fernery plaza, not all of it is relevant to the structure, and few people take the time to read all of it. The challenge thus becomes how to reach out to people prior to visitation and provide them with the information needed to better their time inside the Fernery. Thanks in part to the work of Sara Levin, The McLean Contributionship Endowed Education Intern 2010-2011, the Morris Arboretum website has a new look and increased visitation. More importantly increased average visitation has opened new possibilities in reaching out to guests. This project focused on the Fernery section of the website and looked at how it could be redesigned and improved to try and educate visitors, students, and the general public. To do this the original Dorrance H. Hamilton Fernery website was completely redone with many new sections added, educational material created, and external resources provided. While the scope of this project only focused on the Fernery website, the new design created could easily be used as a template for the improving the websites of other features at the Morris Arboretum.

RESEARCH – Initial Design

To start on this project it was first necessary to understand the current resources available online for the Fernery at the Morris Arboretum. The website was very simple consisting of only three paragraphs and a single picture at the bottom of the page (Figure 1). The website was lacking real substance, and was not engaging at all. Websites have the potential to be a great tool for disseminating information, but the first obstacle to overcome is to convince online visitors to stay on the page. According to the 2011 Google Analytics Report the average viewer stays on a page for only 5.23 minutes, yet this is not enough time to achieve the desired affects. By adding some interactive feature to the website it draws viewers in and encourages them to stay on the website longer and learn more about the Fernery before navigating away.

At this point it was necessary to start researching how other public gardens have attempted to provide online information about their garden attractions. It quickly became clear that in fact many gardens are using a similar model for website design as the Morris Arboretum does. There were very few, if any, good examples to emulate for the Fernery website. Possibly the best model I discovered was already being used by the Arboretum for the Springfield Mill at Bloomfield Farm, designed by Robert Gutowski, Director of Public Programs. This website contains a slideshow of pictures, contact information, and in-depth historical timeline, along with links to external resources and downloadable documents.

Though there was no exemplary example to use as a starting point, I was able to gather various ideas and concepts that could be combined into remaking the website. The sections would include a slideshow of historical and modern pictures, a short description of the Fernery

and the collection housed inside, an interactive, illustrated timeline, a downloadable illustrated tour and supplemental fern list, and external resources.

RESEARCH – Online Content

With the new design established, more research had to be conducted to compile all the information that would be presented on the website. First I consulted the slideshow that was created by Shelley Dillard, Propagator at Morris Arboretum, on the restoration of the Fernery in 1994. This slideshow contained photographs of the Fernery, and the ferns, going all the way back to 1901. Six of these photos were selected to be used as a small photo-gallery placed at the top of the new website (figure 2). Then, with some minor editing, the description of the Fernery, from the old website, was used to give visitors a quick overview of what the Fernery is. The first big feature, however, on the website is the interactive timeline.

The first challenge in creating this was assembling all of the information for it. Luckily over the years there have been several publications that have either focused exclusively on the Fernery or mentioned the Fernery in some aspect. Most of these are housed in the Morris Arboretum Library. Furthermore the Historical Collection at the Morris Arboretum Library contains many original documents pertaining to the Fernery such as John T. Morris's ledgers (figure 3), correspondences with architects (figure 4), and even the original blueprints for the Fernery (figure 5). Using all of this information I was able to assemble a comprehensive timeline of the Fernery (figure 5). The next part was finding a template to use to create this interactive feature. The goal was to find something that would allow the information to be presented in a more streamlined form, not requiring the viewer to scroll through lots of information, and something that was intuitive and easy to use. A template was found online that included a time-bar on top with bars representing each important date. When a user clicks on one of those spots a window opens below it with more information and pictures (optional).

The final piece of intense research and development that needed to be done was to create an illustrated self-guided tour of the Fernery. With the help of Dianne Smith, Fernery Volunteer, twenty ferns were selected as important or notable in some way. As I began to write the actual tour however, I realized for time reasons, it was not going to be feasible to use all twenty in one tour. The tour would be very long and few visitors would want to print it out and bring it with them. So from those twenty ferns, the top ten were chosen to be integrated into the tour. The criteria used to select these ferns was that they must be dispersed out around the Fernery, they must have some importance, and they must be able to be used to teach visitors about ferns, ecology, or history. A copy of the tour is provided as Figure 7. The other ten ferns not integrated into the tour were still organized into a list with some information about them and will also be available to visitors who are interested as a supplemental fern tour. Fern enthusiasts can use these, or returning visitors who wish to discover some ferns that they may not have noticed previously may also be interested.

The final part the website is a list of external links for those who wish to learn more about what ferns are, how to grow them, or what research is being conducted with them. The purpose was to find links for all types of visitors – those who are new to ferns, home gardeners, and scientists. By offering more services on the website there are more reasons for people to visit the

site and to stay on it longer. This not only raises awareness about the Fernery, but also about the Morris Arboretum in general and could possibly even lead to more first time visits. The sites selected were the British Pteridological Society, the America Fern Society, the Hardy Fern Foundation, and Microsoft's Photosynth. The latter is a simulated three-dimensional representation of the fernery created by a volunteer. By clicking on this link you are able to virtually tour the Fernery and see stunning photographs of the structure and ferns from the inside. This can allow those from far away to still get a sense of what ferneries are like even if they are unable to come in person.

IMPLEMENTATION

As of writing this paper, the new website has not been made live and accessible to the public. The next step of this project will be to meet with Zac Brooks, Morris Arboretum webmaster, and work with him to implement the project. All the data has been collected a conceptual design has been created so ideally this last step of the project will be the simplest. After the website is satisfactory and running online I will provide the new link with staff members, volunteers, and other interested persons to not only promote the website but to also get their feedback and comments. Since there are still several months before the internship finishes, this will allow for time to fine-tune and correct any mistakes that may have made it onto the website.

LOOKING TO THE FUTURE

While the main goal of this project was to re-create the website devoted to the Dorrance H. Hamilton Fernery at the Morris Arboretum, the product created has implications for the Morris Arboretum website at large. Some of the features and concepts used could be easily repurposed for other sections of the website. The most obvious application of the design is to use it for redoing the web content for other features at the Morris Arboretum. The structures, gardens, and sculptures could all use the design created for this project, either in its entirety or relevant selections. This would build continuity through the website as well as improving each site individually.

The concept of streamlining and condensing information into smaller window spaces was highly influential when working on this project. There is already evidence of this appearing on other parts of the website, and hopefully the design presented here will encourage this trend to persist. Things like slideshow windows, interactive screens, and user friendly menus all encourage visitors to spend longer amounts of time on the website and to therefore glean more information and build interest.

CONCLUSION

The Dorrance H. Hamilton Fernery at the Morris Arboretum of the University of Pennsylvania is a wonderful unique feature that has the potential to draw in more visitors than it currently does. One of the largest obstacles that it faces is a lack of communication of the

information about the structure or the collection housed inside. Though there is educational signage placed around the Fernery, it is really only accessible to those already visiting. To help improve this situation the section of the website devoted to the Fernery has been redesigned and improved upon. Online visitors are now able to learn about the history of the building and the collection inside. While also on the website a visitor is able to download a self-guided tour, view pictures of the Fernery, explore other websites devoted to ferns, and even take a virtual of the building.

Figure 1

3/31/12

The Morris Arboretum of the University of Pennsylvania



Plan Your Visit The Gardens & Exhibits Events Education Consulting Rentals Join Us Support

- › Dorrance H. Hamilton Fernery
- › Gates Hall
- › Widener Visitor Center
- › Greenhouse Complex
- › Horticulture Center
- › Log Cabin
- › Mercury Temple and Grotto
- › Springhouse
- › Pumphouse
- › Horticulture Center
- › Springfield Mills

Garden Buildings

THE DORRANCE H. HAMILTON FERNERY

The Dorrance H. Hamilton Fernery is the only remaining freestanding Victorian fernery in North America. The Fernery documents a time when Victorians were consumed with ferns and glasshouses. It was designed by the original owner and namesake of the Arboretum, John Morris. The Fernery nestles in a curve of land below the Rose Garden, its filigree roof sparkling in the sunlight.

Over the decades, the Fernery fell into disrepair and was renovated a number of times. In 1957, Arboretum staff spared the Fernery from certain destruction by replacing the unique carved roof with a traditional sloping roof and updating the heating system. To return the Fernery to its original Victorian essence, the Arboretum completed a meticulous restoration in 1994, funded by board member Dorrance H. Hamilton and other donors who responded to a major matching grant from the National Endowment for the Humanities.

The \$1.2 million renovation included reconstruction of the curving roof, replacing the electrical and heating systems, as well as restoring the waterfalls, pools, and stone walls. The rustic wooden bridge was replaced with a new structure hewn from Arboretum cypresses. In front of the Fernery, an elegant bluestone plaza now welcomes visitors.



SELECT A BUILDING

- Dorrance H. Hamilton Fernery
- Gates Hall
- Widener Visitor Center
- Greenhouse Complex
- Horticulture Center
- Log Cabin
- Mercury Temple and Grotto
- Springhouse
- Pumphouse
- Horticulture Center
- Springfield Mills

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SEARCH OUR SITE

Search



PLAN YOUR VISIT

THE GARDENS &

EVENTS

EDUCATION

www.business-services.upenn.edu/arboretum/gardens_buildings_fernery.shtml

1/2

Figure 3

To		Credit	Debit
3/ Compton.	W. O. Beorpe. Ag Loughery	10.48	235.66
	P. Henderson & Co. A. P. Kerper	111.63	
	Dan Brant Co. 42,000 lbs manure	47.89	
	J. J. Buckley Co. duty on 1000 tons	128.29	
	Geo W. Sisson Jr. Cow. Pedro's Mystic	105.	
Sub pag 99	Hood Farm " Liphill 2d	175.	
	Petty expenses	18.16	
	General Advance	263.61	
	Ink Ramey Hauling manure	39.52	889.23
3/ Horse Acc't. John J. P. Mellon	45.00 27.50	72.50	
3/ Ternery - P. Borshwick	14.00		
	R. de Cow. Beams.	9.24	
	Hitchings & Co.	15.00	
3/ J. S. Allow.	Salary & exps.	50.00	2959.24
3/ Rent of Offices - Ellis Williamsatty		225.00	
		95.83	4477.
<u>Fourth Month</u>			
To		Credit	Debit
3/ Cash	Sundries		
3/ Jno T Morris.	4/	2000.00	
3/ L. J. Morris	4/	1000	
3/ East Church Alley.	Needles & Bro. G. Aubin	92.50	
3/ Rent of Offices	J. J. Morris J. P. Logan D. H. Star.	39.55 21.24 27.04.	95.83 3188.5
Sundries		To	Cash
3/ Compton.	Genl. advance	546.97	581.96

Figure 4

Complete transcription

19 December 1898

Dear Sir

You Favour bearing Dec. 8th is to hand.

In reply whereto we beg to say what we shall be pleased to forward plans suggesting the best arrangement of Rockwork for the growth of Ferns in your intended Fernery as soon as we can get them ready. We shall also have pleasure in giving you an estimate of the cost of Ferns necessary to complete the same, on hearing that our plan is accepted.

In the meantime we wish to express our opinion that a greater height of wall would be necessary to admit of the best effect being produced. If it could be built 9' or 10' or even 12' high so much the better for effect. Every extra inch in altitude tends to increase the impression of boldness produced by the rock structure. Of course a greater elevation would necessitate a greater amount of heating power to maintain a given temperature in winter; & this & other things must be taken into account in arriving at a decision as to the best height of wall to fit you. We should require to know if the height of the walls is increased before we could make out a list & estimates of the necessary ferns.

The heating pipes should go round the bottom or near the bottom of the wall; & should be encased in a brick chamber; into the bottom of which air passages should be made from the front of the rockwork i.e. from the path right under the rock [] to the air chamber. From the top of the air chamber upright shafts should be built at intervals for the passage of the heated air to the base of the roof. By this means the most perfect circulation of air is secured and the top of the air chamber is useful as a support for the rock built up at the back. This should show in our plan.

Our cable address is "Birkenhead Nurserymen Sale England" the word "accepted" would be enough to tell us the plan would do. We shall be pleased however to hear from you again as to the height of the walls.

We are dear sir

Yours obediently

W. & J. Birkenhead.

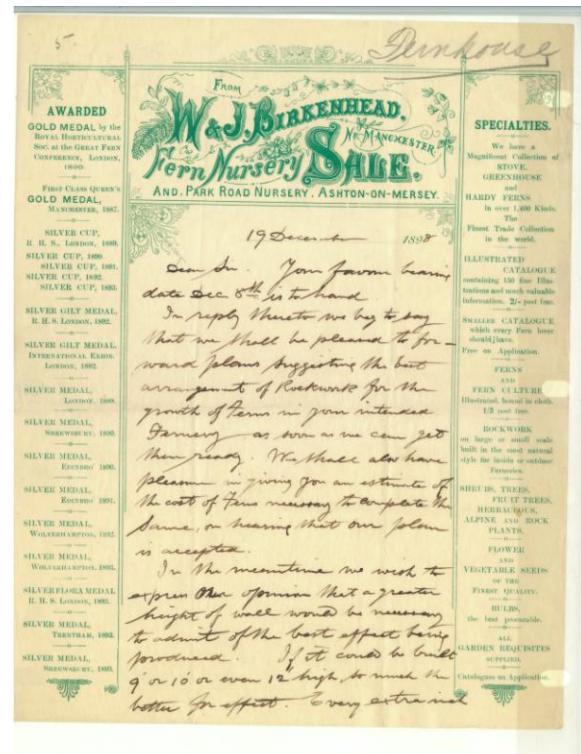


Figure 5

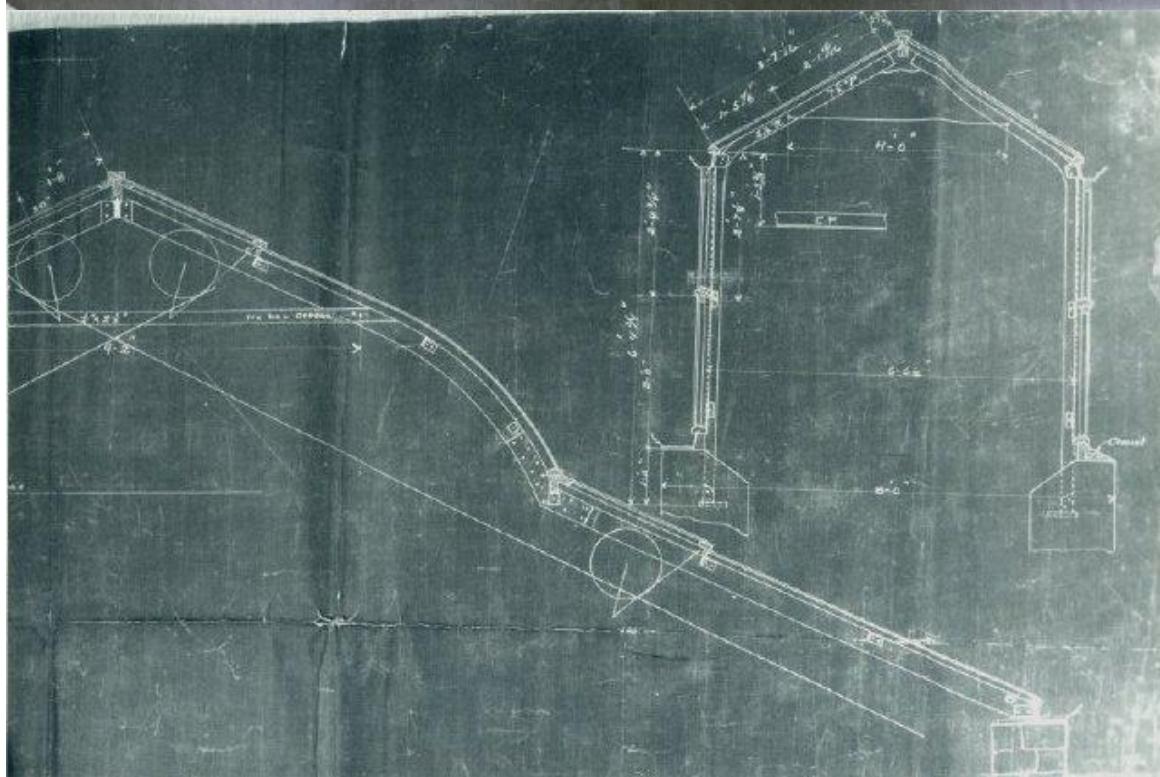
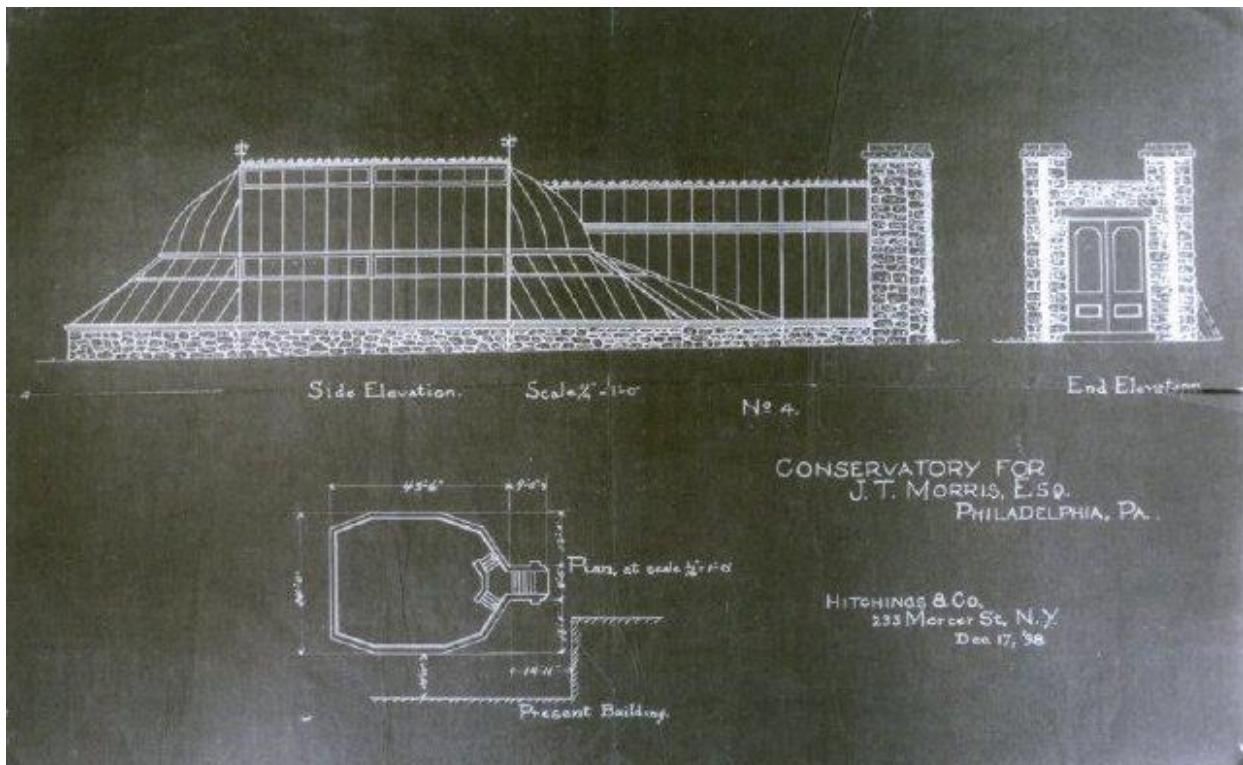


Figure 6

1887 – Compton Estate founded by John T. Morris and Lydia T. Morris in Chestnut Hill

1898 – Designs for Fernery are completed and drawn and foundation excavation completed. John Morris begins to correspond with fern experts W. & J. Birkenhead about the interior design of the Fernery including rock work, water features, and paths.

1899 – J.T. Morris hires Kushibiki & Arai from Japan to help design the rock work inside the Fernery. Once the Fernery is completed Frank Gould, Compton Gardener, installs over 575 different varieties of ferns and selaginellas ordered from the W. & J. Birkenhead catalogue.

1915 – John T. Morris passes away leaving the estate in the hands of his sister Lydia T. Morris.

1917 – As the United States enters into World War I, coal is rationed to the public to help support the war effort. Since the Fernery was heated with coal, this threatened to devastate the Morrises's collection. Lydia T. Morris appeals to then Secretary of Treasury William McAdoo and is granted an exemption for the Fernery due to the “irreplaceable and scholarly character of the fern collection”.

1932 – Lydia T. Morris passes away and grants the administration of the Compton Estate to the University of Pennsylvania. At this time the University creates the Morris Arboretum.

1933 – The Morris Arboretum of the University of Pennsylvania is opened to the public.

1956 – The Fernery is deemed unsafe for the public and closed for necessary repairs including replacing the roof, fixing the heating system, and repainting sections of metal work.

1987 – The A-frame roofed (installed during the 1956 renovation) is deemed structurally unsound and the Fernery is closed to all visitors. Volunteers and staff are allowed to enter for maintenance and upkeep of the collection.

1994 – With support from Dorrance H. Hamilton the Morris Arboretum restored the Fernery to its original condition. This included restoring the curved roof, replacing the heating system, reconstructing the rockwork, and installing the blue flagstone plaza outside of the Fernery.

Figure 7

Welcome to the self-guided Dorrance H. Hamilton Fernery Tour. The Fernery was first built in 1898 by John T. Morris, the original owner of the Morris Arboretum property, and is fashioned after the traditional Victorian fernery style that was extremely popular in England at the turn of the 20th century. The Dorrance H. Hamilton Fernery is the only free standing fernery left in North America and is home to over 200 different species of ferns and fern allies. During this tour you will be introduced to some of the most notable ferns in the current collection and be able to learn a little bit more about them.

As you enter the Fernery you will be on a balcony overlooking the two coy ponds. From here you can see many ferns. Our tour will begin with the largest fern:

Birds-nest Fern (*Asplenium nidus*): This fern is in the Spleenwort family (Aspleniaceae) and is native to Southeast Asia and Eastern Australia. This fern is quite noticeable for its long undivided fronds that form a distinctive bowl shape in the middle (a bird's nest). In places where the fern is native, the new fronds of young ferns are used as salad greens. If you flip over the fronds you will see many sori, collection of sporangia each containing hundreds of spores. From just this one plant you could start growing a lot of fern salad greens!

To the left of the Birds-nest fern you will see a fern with large rhizomes growing over the rocks this is:

Bear-Paw Fern (*Aglomorpha meyeniana*): This fern, native to the Philippines and Taiwan, is a member of the Polypodiaceae family (one of the largest fern families). It is an epiphytic fern, meaning that it grows with its roots exposed to the air (not in the soil). The thick, hairy rhizome and pinnatifid fronds make this a beautiful fern in the collection. Some fronds have terminal fertile sections that are constricted into bead-like lobes adding to the appeal of this fern.

If you turn around, you will find a rock covered in another epiphytic fern:

Felt Fern (*Pyrrosia lingua*): We believe this fern was originally purchased by John T. Morris and has been growing in the Fernery ever since. It is also in the Polypodiaceae family and is endemic to (native only in) Taiwan. The slightly lobed fronds grow vertically out of the rhizome that slowly creeps to form a dense mat over this rock. The name comes from the dense pubescence on the underside of each frond.

Located just to the left of the wooden bridge is:

Tasmanian Tree Fern (*Dicksonia antarctica*): 350 million years ago trees as we know them today had not evolved, but rather large tree ferns dominated the canopy. Though these large tree ferns no longer exist there are smaller tree ferns still found around the globe. This fern is native to parts of Australia and is one of the three extant genera in the family Dicksoniaceae. The species can grow to over 20 feet tall in nature and can withstand temperatures dropping to below freezing making this a very unique specimen.

On the far side of the bridge are two more tree ferns:

Australian Tree Fern (*Cyathea cooperii*): These tree ferns belong to the scaly tree fern family (Cyatheaceae), and are native to Australia as the name suggests. These are much faster growing tree ferns and are commonly used as ornamentals. These ferns can reproduce easily and have become a problem in parts of Hawaii. For more information you can read the sign located at the base of these two ferns.

While on the bridge with the tree ferns to your left on the right up on the wall you will see:

Asian Basket Fern (*Drynaria sparsisora*): This is one of the rarest ferns currently in the Fernery. This epiphytic fern belongs to the Polypodiaceae family and is native to Southeast Asia. It gets its name from its sterile basket-looking fronds that grow over and protect the thick scaly rhizome (similar to the Bear-Paw Fern). These baskets are used to collect falling leaves and debris, creating a humus-rich soil even while growing on rocky hillsides.

Now continue down the path and look up above the waterfall, here lives:

Japanese Holly Fern (*Cyrtomium falcatum ‘Rochfordianum’*): This is one of the most prolific ferns in the collection. A member of the Dryopteridaceae family, this fern easily reproduce through spore dispersal. Look around the Fernery. Can you find it growing in the tiniest cracks? The fern has a very distinctive vase-shape and when mature can have fronds over a foot long. Native to Eastern Asia, this is a great option for growing at home.

Located on the slope to the right of the tunnel entrance you can find a selection of various:

Maidenhair ferns (*Adiantum*): These ferns are all part of a large genus in the Pteridaceae family and can be found around the globe. There are hardy species in this genus that you can grow outside in your garden and other species that make great indoor plants for your house. These ferns have very graceful foliage and some emerge with a brilliant rose color. Compare the similarities and differences of the fronds between the large leafed *A. peruvianum* and the smaller *A. capillus-veneris*.

Pass through the tunnel, and as you start up the stone steps look to your right and you will see:

Australian King Fern (*Todea Barbara*): This is a low growing tree fern (notice the multiple bulbous stems) native to southern Australia. This tree fern is a member of the Royal Fern family Osmundaceae and is not actually a true tree fern, in fact it is in the order Osmundales, different than the other two true tree ferns seen today (both in the order Cyatheales). The king fern can grow to be around five feet tall with fronds over four feet long. It can withstand temperatures down to 15°F making it possible to grow in southern parts of the country.

We conclude this tour with possibly the most remarkable, but small fern located to left of the stairs leading up to the overlook (please do not climb the stairs). Look for a fern with simple undivided fronds and a distinct blue color:

Blue Fern (*Microsorum thailandicum*) – This fern is very unique and known for its blue sheen that is almost iridescent. It is an epiphytic fern that grows on limestone outcrops in Taiwan and southern China. This is a unique specimen and is often overlooked or missed by visitors.

This concludes the guided tour of the Fernery, but it does not mean there aren't more amazing ferns to see. Take some time to walk around more and observe the plants closely. If you would like you can also download the supplemental plant list and learn more about some selected ferns.

TITLE: **Foundation for the Expansion of Botany Education at the Morris Arboretum**

AUTHOR: **Ariel Dreyfus**
The McLean Contributionship Endowed Education Intern

DATE: **April 2012**

ABSTRACT:

The Morris Arboretum identifies education and promoting the relationship between plant and people as a huge part of its mission and has long been regarded as the center for botanical knowledge in the Philadelphia region. Though historically botany education has been present at the Arboretum, it has diminished in recent years. In order to uphold our mission and reputation, the idea of the Arboretum launching a botany certificate program was proposed. This project focuses on finding similar programs that might be a model for our program, surveying our regional market, gauging the interest of our current constituents and evaluating the cost of such a program. It is my hope that these findings will be used to inform any decision made about such a program here at the Arboretum.

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HISTORY

Since its opening in 1933, education has been an integral part of the mission of the Morris Arboretum. Upon Lydia Morris's death, her will stated that the Arboretum should be turned over to the University of Pennsylvania and that its exceptional collection of native and exotic plants be used for education purposes. Using the news bulletins from Morris Arboretum archives, I began to piece together a history of educational activities at the Arboretum, specifically focusing on botany learning. I found that the Arboretum has been committed to botany education in various forms since the beginning.

When the Arboretum opened to the public in 1933, the first director, Rodney H. True, instituted a winter lecture series. This program consisted of a series of indoor lectures for the Arboretum's constituents throughout the winter months. These lectures were highly botanical in nature, focusing on topics such as Dutch elm disease and diseases of the plane tree. Though these lectures were only open to associates, or members, they appear to have been very well attended.

After the death of Rodney True in 1940, J.R. Schramm took over as director. There only mentions of a few "Lecture Tours" throughout the 1940's, which consisted of a presentation and then a walk around the garden. Records from the 1940's are incomplete, so it is not certain with what frequency these lectures were taking place, but they seem to have dropped off. This is also evidenced by John Fogg's declaration upon taking over as director in 1954.

"A great deal needs to be done to increase our educational offerings and even to offer regular courses of instruction comparable to those given at the Arnold Arboretum, NYBG, and the Morton Arboretum."¹

This quote implies educational activities were dropping off in the 1940's. It is likely that this is due to World War II. With such societal unrest, Arboretum Associates probably had less time to devote to such things.

After the War, Dr. John Fogg takes on the role of director and under the new leadership, regularly scheduled lectures begin again and the Summer Course is instituted. The Summer Course was a woody plant class accredited through the University of Pennsylvania. The class was attended by mostly university students for credit, but there were also many teachers, professionals and interested people in attendance. This class appeared to be hugely successful and ran for almost twenty years.

It wasn't until the 1960's that the Arboretum started charging a fee for lectures. In 1963 Dr. Edgar T. Wherry taught an ecology series that was made up of four lectures and a field trip. The Arboretum charged twelve dollars for this. These types of courses continued throughout the 1960's, most with heavily botanical themes. As the number of courses offered increased, there became a need for one place to publish them all.

In 1971 the Arboretum printed its first separate publication solely for listing class offerings. Within this brochure, there were many botanical science offerings including *Wildflower Families*, *Botany for Gardeners* and *Plant Nomenclature*. These classes were listed

in a botany series, which implied that when a participant had completed a set of required classes, he or she would receive a certificate of completion. Throughout the 1970's the Arboretum continued to offer such botany classes but there was no mention of the certificate in publications over the next ten years.

What is now the Widener Visitor Center underwent its transformation from horse stable and garage to visitor center in 1982. Part of this renovation was creation of the Fogg Lab, which was an intended laboratory teaching space. It is my assumption that the addition of this new teaching space made the Arboretum more equipped for handling large volumes of classes, and consequently the botany certificate program was re-launched in the 1983 course brochure. Throughout the next couple of years the series ran with varying attendance and eventually in 1988, the series was cancelled. Verbal accounts I received from Arboretum staff that were hear during that time suggest it was due to dwindling participation; however I was not able to find attendance or registration records to support these claims.

Since then, the Arboretum has continued to have a robust educational program with a wide variety of classes. Though botany continues to be a part of the class offerings, it is often in conjunction with horticulture or on a trip. The teaching expertise of the botany department at the Arboretum has largely been utilized by the University of Pennsylvania over the past twenty years, leaving little room for teaching at the Arboretum.

CERTIFICATE PROGRAMS

The idea of having a certificate program in botany at Morris came from the desire of the botany and the education departments to increase our commitment to botanical learning, uphold our reputation as a regional authority in the plant science field, and utilize our expert staff. With our staff botanists, Dr. Tim Block and Dr. Ann Rhoads teaching fewer classes at the University, they possess more time to devote to teaching at the arboretum.

When I began my research, I first endeavored to define what a certificate program is and what similar botany certificate programs look like. Very little research has been done about the viability of certificate programs, let alone botany certificate programs. However, I managed to find some relevant research. A graduate student at Cornell University did their thesis on the evaluation of certificate programs at public gardens. This is the definition she compiled for a certificate program at a public garden:

“A certificate at a public garden is a series of courses on a plant referenced theme, offered on the site of the public garden. Participants must pass each individual course with some measure of attendance and performance, and completion of all the courses in the series results in some recognition of achievement.”²²

This is a good summation of what defines a certificate program. There are a few, possibly unexpected, things to note. First is that the certificate be offered on-site at the public garden. Second is the reference to some measure of attendance and performance. This is vague and offers room for interpretation, but does imply that students are evaluated in some manner.

Next, I began examining the advantages of having a certificate program. Simply based on prior knowledge of continuing education programs at public gardens, I was reasonably sure that financial gain was not a primary motive. Without financial gain, that leaves public interest and institutional values and mission as the key reasons for offering a certificate. Public interest will be discussed later but there is research supporting institutional mission as a primary reason for running a certificate program.

“A certificate program represents a high level of commitment to education by a public garden because these programs cover large quantities of information in-depth over time, thus increasing the possibility for long-term, behavioral and attitudinal change, as well as the opportunity for application of knowledge, in addition to technical mastery”³

This seems very relevant to Morris, as our mission implies a deep commitment to education and plants. So if the Arboretum was to add a botany certificate program, it would bolster our commitment to botany and education, and possibly our reputation. This quote also implies a commitment to the community served by suggesting that a certificate program would potentially affect long-term attitudinal change and application of knowledge. Additionally, I identified the reasons in which participants usually take certificate programs. In no particular order they are for professional development, personal growth, entertainment, and socialization.³ These seem to be the same reasons that our students take our classes.

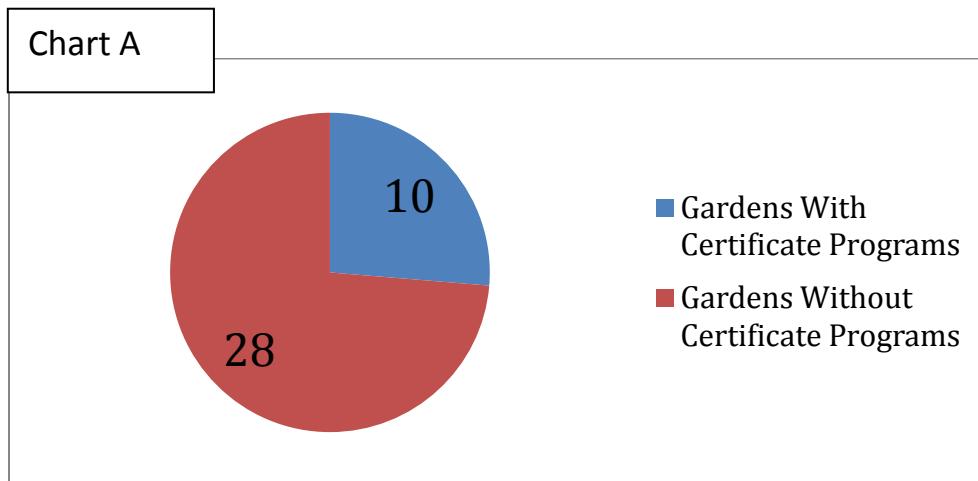
Subsequently, I reviewed certificate programs throughout the nation that closely resembled what we could do at Morris. Three programs that I studied in-depth for this project were the New York Botanical Gardens Botany Certificate Program, The North Carolina Botanic Gardens Certificate in Native Plant Studies, and Costal Maine Botanic Gardens Certificate in Native Plants and Ecological Horticulture. These institutions represent very different types of public gardens and as such their certificate programs have differences, as an informal interview with a staff member from each of these programs revealed. It might be more useful to describe what they have in common.

Completing each of these programs is a significant time commitment. The average amount of class time it takes a student to complete each of these programs is 155 hours. That does not include any outside work, or homework, that students may be asked to do. The average price point per hour of instruction is \$14. This totals \$2,170 to complete the whole program. None of these programs are designed for completion in a year, however. Students are welcome to take as long as they like, but they are all designed to make two year completion possible. These programs also follow a similar formula consisting of required core classes and then a specified number of elective classes.

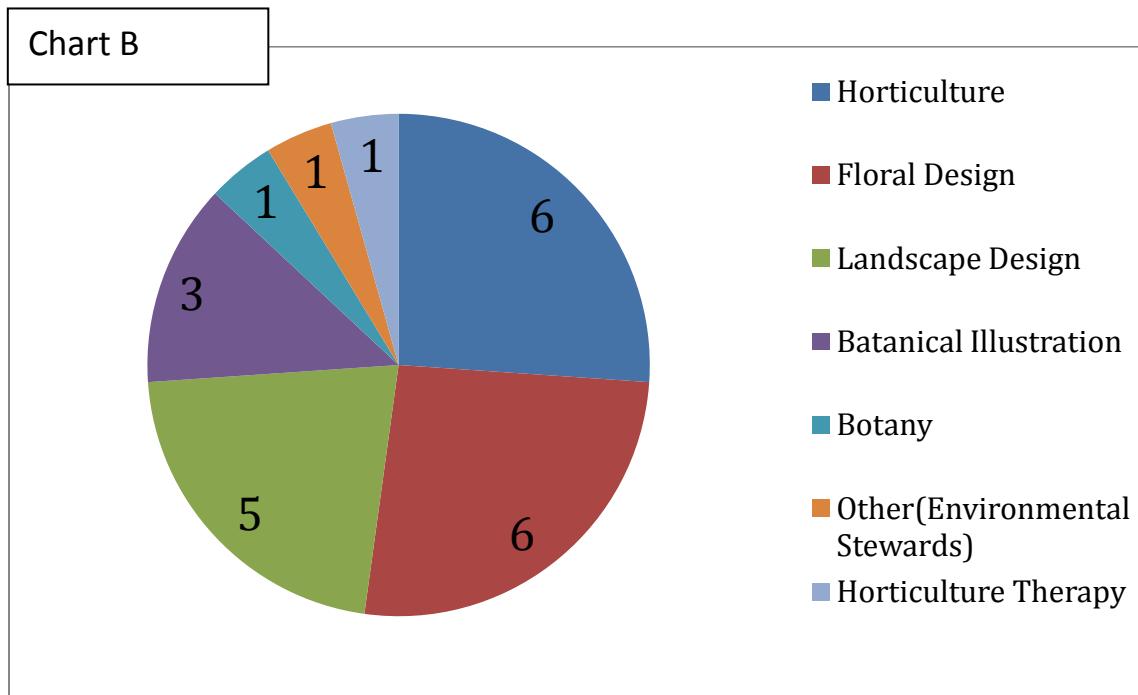
REGIONAL DATA

From here I wanted to learn more about what programs are being offered in our region. Using the American Public Gardens Association's data base of registered public gardens, I surveyed those in the Mid-Atlantic Region. I defined Mid-Atlantic as NY, NJ, DE, PA, VA, WV and MD. Here are some key results I gathered from this inquiry.

- I. Out of 73 public garden institutions, only 38 have adult education programs.
- II. Out of those 38 gardens with education programs, 10 have certificate programs, as I have defined them earlier. This is displayed in Chart A.



III. Certificate programs were then divided by topic. This is displayed in Chart B. I will note here that many gardens had more than one certificate program, which is why the number of programs in this chart exceeds ten. Of the twenty-three certificate programs, only one is a botany certificate. The most popular programs appear to be horticulture and floral design.



It's worth mentioning that even though there is only one pure botany certificate program, other programs incorporate botany knowledge such as plant identification and ecology. The lack of comprehensive botany programs in the Mid-Atlantic region could be a result of lack of interest or could be a niche that few institutions have the expertise to fill. Unfortunately, this inquiry did not indicate which of those is more likely.

SURVEY

Subsequently, I attempted to capture the level of interest for a botany certificate program among Morris Arboretum members and class takers. To accomplish this I developed an eleven question survey to deploy electronically. The survey was sent on January 13, 2012 to 7,489 class takers and members. Before discussing the results, the limitations of the survey should be pointed out. I received a very low participation rate of about 1%. This is not ideal for reliable data. Another consideration is that most certificate programs rely on branding and marketing of the program to gain interest. Since we have not made any marketing efforts, this might be reflected in the results.

The full results of the survey are attached as Appendix 1. The overall response to a botany certificate program and certificate programs in general was not very positive. Though the majority of respondents indicated they would be “Somewhat Interested” in deepening their knowledge of botany by taking classes at Morris, the majority then said that they would be “Not At All Interested” in completing a botany certificate program. Questions were also asked to discern what topics people would be most interested in learning about. The results indicated that “native plants” and “plant identification” were the subjects of most interest.

COST ANALYSIS

Finally, I conducted a cost analysis to find out how much it would cost to run a certificate program and how many students we would need to not lose money. The cost analysis is attached in full as Appendix 2. It attempts to gather all the costs associated with the first year of running a botany certificate program and then determine the potential generated revenue. I operated on a few assumptions in this analysis. One is that our program would consist of four core classes and four elective classes over the year, totaling 72 hours of instruction. The next is that the instruction would be done by our staff and would account for 5% of two full time employees. Coordination would account for another 5% of a botany staff member’s time. Another assumption is that half the classes would take place after hours at the Arboretum taking into account a visitor services staff and facilities staff. On top of this a 20% overhead was added for any unforeseen costs. To price the classes I used an average of our current prices to come up with a \$13-15 per hour cost for members and non-members respectively.

I found that without the potential cost of marketing and onetime cost of microscopes, year one of the botany certificate program would cost the Arboretum \$17,170. Consequently, we would need at least 17 to 18 students per class to recover our costs.

In the spring of 2012 Dr. Tim Block taught an Introduction to Botany class. This class was structured much like a core class of a certificate program, running over six weeks and totaling twelve hours. There were in fact, seventeen students registered for the class, however about half of the class was comprised of Morris Arboretum staff members, who attended classes free of charge. This leaves us pretty far from recovering our initial costs.

CONCLUSION

From this research, I have gleaned that launching a botany certificate program at the Morris Arboretum would strengthen our commitment connecting people and plants through education and possibly more firmly assert the Arboretum as a region plant science expert. However the lack of positive response from the survey and the high cost of the certificate program present significant challenges. Therefore I would think it unwise to commit to a comprehensive botany certificate program at this time. I would recommend continuing to offer classes such as Introduction to Botany and more advanced and specialized classes such as Plant Physiology, Mycology, and Aquatic Plants. Offering classes on native plants and plant identification are also recommended, as those topics were ranked of high interest in the survey. It is my hope that this information will aid in the decision making around botany education at the Arboretum.

REFERENCES

- 1 Fogg, John. (1955). *Morris Arboretum Bulletin: April 1955*.
- 2 Waresowe, Julie A. (2004). *Certificate Program Evaluation at Public Gardens*. Cornell University.
- 3 Sachatello-Sawyer, B., Fellenz, R.A., Burton, H., Gittings-Carlson, L., Lewis-Mahony, J., & Woolbaugh, W. (2002). *Adult museum programs: Designing meaningful experiences*. Walnut Creek: AltaMira Press.
- 4 New York Botanic Gardens. www.NYBG.org
- 5 North Carolina Botanical Gardens. www.ncbg.unc.org
- 6 Costal Maine Botanic Gardens. www.mainegardens.org

Appendix 1

Morris Arboretum Member and Class Participation SurveyMonkey Survey

1. How interested would you be in deepening your knowledge of botany by taking classes at the Morris Arboretum?

		Response Percent	Response Count
Very Interested		20.0%	26
Somewhat Interested		40.0%	52
Neither Interested Nor Uninterested		15.4%	20
Somewhat Uninterested		10.0%	13
Not At All Interested		14.6%	19

Please provide any additional comments pertaining to your answer above.

28

answered question	130
skipped question	0

2. How important is it to obtain a certificate of completion in a subject of interest to you?

		Response Percent	Response Count
Very Important		9.2%	12
Somewhat Important		19.2%	25
Neither Important Nor Unimportant		19.2%	25
Somewhat Unimportant		6.9%	9
Not At All Important		45.4%	59

Please provide any additional comments pertaining to your answer above.

14

answered question	130
skipped question	0

3. If offered, how interested would you be in completing a certificate program in botany at the Morris Arboretum?

		Response Percent	Response Count
Very Interested		7.7%	10
Somewhat Interested		19.2%	25
Neither Interested Nor Uninterested		21.5%	28
Somewhat Uninterested		7.7%	10
Not At All Interested		43.8%	57
Please provide any additional comments pertaining to your answer above.			8
			answered question 130
			skipped question 0

4. Please indicate your level of interest in learning about each of the following topics:

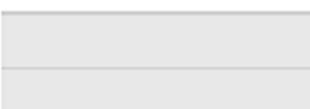
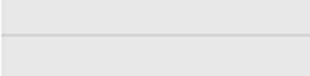
	Very Interested	Somewhat Interested	Neither Interested Nor Uninterested	Somewhat Uninterested	Not At All Interested	Response Count
Native plants	60.0% (36)	28.3% (17)	10.0% (6)	1.7% (1)	0.0% (0)	60
Plant identification	60.0% (36)	33.3% (20)	6.7% (4)	0.0% (0)	0.0% (0)	60
How plants function	38.7% (22)	40.0% (24)	18.3% (11)	3.3% (2)	1.7% (1)	60
How plants interact with their environment	40.0% (24)	43.3% (26)	15.0% (9)	1.7% (1)	0.0% (0)	60
Plant specimen pressing and mounting	13.3% (8)	26.7% (16)	33.3% (20)	13.3% (8)	13.3% (8)	60
Field study	28.3% (17)	50.0% (30)	10.0% (6)	6.7% (4)	5.0% (3)	60
Plant evolution	21.7% (13)	36.7% (22)	21.7% (13)	16.7% (10)	3.3% (2)	60
History of botany	21.7% (13)	20.0% (12)	33.3% (20)	21.7% (13)	3.3% (2)	60
Please provide any additional comments pertaining to your answer above.						2
				answered question 60		
				skipped question 70		

5. Are there any other botany-related topics you would like to learn about?

		Response Percent	Response Count
Yes		25.0%	13
No		75.0%	39

If Yes, please list the topics below.

14

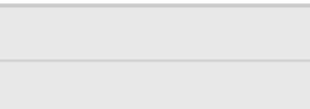
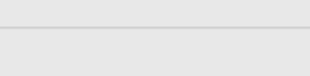
	answered question	52
	skipped question	78

6. When would you be most likely to attend a class?

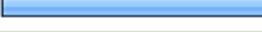
		Response Percent	Response Count
Mid-week, daytime classes		31.7%	19
Mid-week, evening classes		35.0%	21
Weekend classes		33.3%	20

Please provide any additional comments pertaining to your answer above.

8

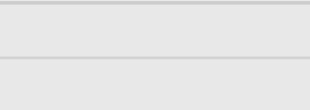
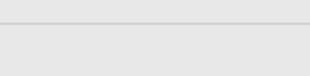
	answered question	60
	skipped question	70

7. What learning experience are you most interested in?

		Response Percent	Response Count
One-day field trips		16.7%	10
Multi-day field trips		5.0%	3
Single-session classes		53.3%	32
Multi-session classes		25.0%	15

Please provide any additional comments pertaining to your answer above.

10

	answered question	60
	skipped question	70

8. Please rank the reasons for why you have chosen or would choose to take classes at the Morris Arboretum over another institution. Only one response per column.

	1 (most applicable reason)	2	3	4	5 (least applicable reason)	Response Count
Convenience	41.7% (25)	28.3% (17)	11.7% (7)	8.3% (5)	10.0% (6)	60
Quality of classes	63.3% (38)	30.0% (18)	5.0% (3)	0.0% (0)	1.7% (1)	60
Reputation of institution	58.3% (35)	16.7% (10)	16.7% (10)	5.0% (3)	3.3% (2)	60
Unique classes	45.0% (27)	26.7% (16)	15.0% (9)	10.0% (6)	3.3% (2)	60
Networking with people of similar interests	25.0% (15)	28.3% (17)	16.7% (10)	13.3% (8)	16.7% (10)	60

Please provide any additional comments pertaining to your answer above.

2

answered question	60
skipped question	70

9. Gender:

		Response Percent	Response Count
Male		22.4%	28
Female		77.6%	97
answered question			125
skipped question			5

10. Age range:

		Response Percent	Response Count
Younger than 24		0.8%	1
25-35		11.2%	14
36-50		31.2%	39
51-70		44.0%	55
71 and over		12.8%	16
		answered question	125
		skipped question	5

11. Please provide your email address if you would like to enter a drawing to receive a \$50 continuing education gift certificate for the Morris Arboretum.

	Response Count
	85
answered question	85
skipped question	45

Page 2, Q1. How interested would you be in deepening your knowledge of botany by taking classes at the Morris Arboretum?

1	Not enough spare time right now.	Jan 29, 2012 4:34 PM
2	Particular interest in native meadows	Jan 18, 2012 4:50 AM
3	Having children and a job prevents me from participating in such things.	Jan 16, 2012 3:28 PM
4	limited hours with getting to class	Jan 16, 2012 7:44 AM
5	Too busy	Jan 14, 2012 10:25 AM
6	I am very interested in the topic, but can't usually find the time to actually attend a class.	Jan 14, 2012 8:11 AM
7	I would be very interested in learning more about botany, especially issues that are relevant to plants and trees within the region.	Jan 14, 2012 7:43 AM
8	I just have a huge commitment at work that precludes this now.	Jan 13, 2012 8:44 PM
9	would like to take a class for "dummies" on landscaping (how do I keep my arbor vitae alive? or how do I fix the roses that are growing weirdly in my yard)	Jan 13, 2012 7:11 PM
10	As a biologist with a heavy botany concentration, I probably know more botany than would be presented in a class at the Arb	Jan 13, 2012 3:34 PM
11	particularly local genotype native plants	Jan 13, 2012 2:10 PM
12	I live just outside Washington, DC.	Jan 13, 2012 2:06 PM
13	I love my garden but a class would be too much for me I am too old	Jan 13, 2012 2:05 PM
14	Weekends are best for me.	Jan 13, 2012 1:29 PM
15	I love plants, know little about them. Would like to learn IF the info. is presented in an exciting hands on way.	Jan 13, 2012 12:33 PM
16	Gardening as a strong hobby would be a wonderful outcome. As a teacher, bringing my students for a field trip.	Jan 13, 2012 12:07 PM
17	I'm a very engaged longtime gardener and fairly knowledgeable but open to learning.	Jan 13, 2012 11:22 AM
18	i would take it if it pertained to my personal garden.	Jan 13, 2012 11:05 AM
19	As a MAste rGArden I'm always lookingto understand more about plants - this would be super	Jan 13, 2012 11:02 AM
20	I have taken classes with Paul Meyer years ago and love to garden. I also was a volunteer for a short time.	Jan 13, 2012 10:52 AM
21	The interaction with the environment—and plants role in our more urbanized life of today would be of most interest.	Jan 13, 2012 10:39 AM
22	I would only be interested in an overview of the subject and not an in depth	Jan 13, 2012 10:19 AM

Page 2, Q1. How interested would you be in deepening your knowledge of botany by taking classes at the Morris Arboretum?

	class. My interest lies only in the generalities of plants. i.e.the plant parts name and briefly their function.	
23	I'd LOVE to do this, but currently have a 5 month old baby at home, so would be unlikely to sign up for any such classes in the next 2 years - at that point most likely if they were toddler-focused.	Jan 13, 2012 9:51 AM
24	I attended classes last Fall that were billed as continuing education for professionals. I found the content to be well below my own amateur level of understanding and did not learn anything new.	Jan 13, 2012 9:41 AM
25	I don't live in the Philadelphia region, so although I am interested I wouldn't be able to attend classes.	Jan 13, 2012 9:26 AM
26	No time.	Jan 13, 2012 9:21 AM
27	I probably wouldn't have any interest, but with a really interesting topic, I could be swayed.	Jan 13, 2012 9:19 AM
28	I haven't so far been interested, but after meeting Tim Block and hearing him speak - I'm WAY more interested.	Jan 13, 2012 9:18 AM

Page 2, Q2. How important is it to obtain a certificate of completion in a subject of interest to you?

1	For a portfolio.	Jan 29, 2012 4:34 PM
2	or work towards a degree	Jan 18, 2012 7:06 AM
3	I need continuing education credits.	Jan 18, 2012 7:47 AM
4	I take classes for personal knowledge and enjoyment	Jan 14, 2012 6:31 AM
5	Have already obtained ana certificate in landscaping. No interest in any other certificate for the time being.	Jan 13, 2012 5:23 PM
6	I am a seasoned Gardner and now persuing studies in horticulture.	Jan 13, 2012 2:43 PM
7	good way to certify attendance for CEUs	Jan 13, 2012 2:10 PM
8	I live just outside Washington, DC.	Jan 13, 2012 2:06 PM
9	I'm an MD. could i be MD, professional botanist too?	Jan 13, 2012 11:05 AM
10	I would just want to learn—not to get a degree	Jan 13, 2012 10:39 AM
11	I would not be using it in a career situation	Jan 13, 2012 10:19 AM
12	If I were interested in taking a class, I would want a certificate.	Jan 13, 2012 9:21 AM
13	Unless there's a benefit to having a certificate of completion, I wouldn't see it as important.	Jan 13, 2012 9:19 AM
14	I'm an amateur. I did think about landscape design..but after one class - decided to leave it to the professionals	Jan 13, 2012 9:18 AM

Page 2, Q3. If offered, how interested would you be in completing a certificate program in botany at the Morris Arboretum?

1	I am a graduate student, part-time, in 3 years I will be finished and then I could consider studying botany.	Jan 29, 2012 4:34 PM
2	It would be great if it was something I was able to afford	Jan 13, 2012 2:43 PM
3	I live just outside Washington, DC.	Jan 13, 2012 2:06 PM
4	if it means i could work p/t for a little pay at the arboretum.	Jan 13, 2012 12:33 PM
5	I am 72 years old, botany was never high on my list	Jan 13, 2012 11:41 AM
6	I would love a botany program they are so hard to find now.	Jan 13, 2012 9:55 AM
7	Provided the course has the appropriate level of academic rigour.	Jan 13, 2012 9:41 AM
8	I'm involved with the Board and I feel I should really deepen my understanding. The challenge - my travel schedule!	Jan 13, 2012 9:18 AM

Page 3, Q1. Please indicate your level of interest in learning about each of the following topics:

1	pretty much anything about plants would interest me	Jan 13, 2012 10:00 AM
2	Having had a tour of the archives - the mounting and pressing was fascinating - though I can't say I'd have occasion to do it myself.	Jan 13, 2012 9:21 AM

Page 3, Q2. Are there any other botany-related topics you would like to learn about?

1	systematics how plants interact with humans restoration plant communities	Jan 18, 2012 7:13 AM
2	dragonflies.moths, butterflies	Jan 15, 2012 5:44 PM
3	Permaculture	Jan 14, 2012 8:14 AM
4	Diseases of plants	Jan 13, 2012 6:21 PM
5	Dendrology	Jan 13, 2012 2:25 PM
6	botanical illustration	Jan 13, 2012 2:13 PM
7	Year round gardening in this hemisphere	Jan 13, 2012 12:08 PM
8	Medicinal plants Food Plants and how we have bred them from the original wild forms	Jan 13, 2012 11:06 AM
9	How do plants help in reclamation of contaminated land and/or wetlands	Jan 13, 2012 10:48 AM
10	Water gardening plants	Jan 13, 2012 10:20 AM
11	Botanical Illustration	Jan 13, 2012 10:08 AM
12	ethnobotany, different applications of plant identification	Jan 13, 2012 10:00 AM
13	Invasive plants and how to control them	Jan 13, 2012 9:28 AM
14	Native plant gardening, ecological gardening, restoration ecology	Jan 13, 2012 9:25 AM

Page 3, Q3. When would you be most likely to attend a class?

1	or weekend	Jan 18, 2012 7:13 AM
2	Honestly this is the crux for me. Making time.....	Jan 15, 2012 2:28 PM
3	Both weekend and mid week evening (I could only pick one)	Jan 13, 2012 11:41 AM
4	Work full-time during the day - can't do day time courses	Jan 13, 2012 11:06 AM
5	I am retired and can attend anytime	Jan 13, 2012 10:54 AM
6	weekends if late afternoon or evening	Jan 13, 2012 10:00 AM
7	also weekend classes in the daytime	Jan 13, 2012 9:28 AM
8	Challenge to answer. I travel a lot during the week, but I spend most weekends in NJ with Dad. So if it was a class a month or something, I could hang in for the weekends.	Jan 13, 2012 9:21 AM

Appendix 2

Botany Certificate Program Budget Year 1: Fall 2012, Spring 2013	Per Unit	Total
Expenses:		
Staff Time		
Coordination: Tim	5%	
Teaching: Michael	5%	
Teaching: Tim	5%	
Facilities	36 hours	
Visitor Services	36 Hours	
Administration	\$100	
Total:		14,325
20% Overhead:		\$17,170
One Time Expenses:		
Microscopes	10 at \$1,000	\$10,000
Total:		\$27,170
Revenue for Classes:	Price per Hour of Class	
	\$ 13.30-15 member v. non-member	
2 Students per Class	72 hours x 13.3 or 15 x 2 students	\$1,915-2,160
3 Students per Class		\$2,872-3,240
4 Students per Class		\$3,830-4,320
5 Students per Class		\$4,788-5,400
6 Students per Class		\$5,745-6,480
7 Students per Class		\$6,703-7,560
8 Students per Class		\$7,660-8,640
9 Students per Class		\$8,618-9,720
10 Students per class		\$9,576-10,800
11 Students per Class		\$10,533-11,880
12 Students per Class		\$11,491-12,960
13 Students per Class		\$12,448-14,040
14 Students per Class		\$13,406-15,120
15 Students per Class		\$14,364-16,200
16 Students per Class		\$15,321-17,280
17 Students per Class		\$16,279-18,360
18 Students per Class		\$17,236-19,440
19 Students per Class		\$18,194-20,520

TITLE:	Building a Rain Garden to Address Stormwater Management in the English Park Section of the Morris Arboretum
AUTHOR:	Lauren Fine <i>The Alice & J. Liddon Pennock, Jr. Endowed Horticulture Intern</i>
DATE:	March 2012

ABSTRACT:

The area surrounding the Hillcrest building suffers from the ongoing problem of flooding and erosion during moderate to heavy rain events. Not only does the building itself succumb to flooding, but the gardens around it are constantly washed out. The stormwater runoff causes surface erosion and limits plant survival opportunities. The first objective of this project is to provide infiltration of stormwater runoff near the Hillcrest building by installing a rain garden. The rain garden will reduce erosion, flooding, and revitalize the aesthetic value of the area while providing an education component to incorporate learning opportunities.

Currently stormwater enters the garden along Hillcrest Avenue near the Hillcrest building and moves over the pavilion driveway and down the hill washing out the garden beds along the way. Erosion and flooding control are the main objectives that will be met by this project. Cleanup from floods calls for many hours of work by maintenance and horticulture staff in addition to outside contractors. Diverting some of this stormwater runoff to a rain garden would reduce impact and damage, thereby decreasing the amount of time spent cleaning up after large rain events.

The second aspect of this project is improving the aesthetic value of the area near the Hillcrest building. Revitalizing the garden beds and installing a rain garden will bring new interest to this vicinity. I plan to use low maintenance native plants appropriate for the ephemeral waves of flooding. Furthermore, I will repeat the plantings in the surrounding beds to create a node of unified plants.

Finally, I would like to tie in an educational component highlighting the rain garden's capacity to reduce runoff and demonstrate a passive technique for addressing stormwater runoff. This will include interpretive signage and an educational lesson to be used by the volunteer guides.

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INTRODUCTION

The Wissahickon Creek watershed includes 64 square miles, covering 15 municipalities in Montgomery County and Philadelphia County. The Creek originates in Montgomery Township and flows for 27 miles to the Schuylkill River (Philadelphia Water Department [PWD] Office of Watersheds, 2011). The Morris Arboretum, located within the Wissahickon watershed, is situated in one of the lowest points of the watershed basin [Figure 1]. Naturally, during rain events, water moves to the lower points of the watershed. In developed areas, this surge of water often exceeds the amount of water able to naturally infiltrate the ground. As a result, street drains and sewer systems are overwhelmed and excess water overflows into nearby streams (Stormwater PA, 2011). The Environmental Protection Agency defines stormwater runoff as excess water generated when precipitation flows over land or impervious surfaces and does not percolate the ground (Environmental Protection Agency [EPA] Office of Wastewater Management, 2011). A majority of stormwater runoff can be traced to a specific place (e.g. a building rooftop, paved parking lot, etc) where it's considered point source runoff. In situations where a considerable amount of runoff is generated, a National Pollutant Discharge Elimination System permit (NPDES) is required. An NPDES permit holder can allow a designated amount of stormwater flowing off their permitted property. Generally, NPDES permit holders are limited to municipal separate storm sewer systems, construction activities, and industrial activities such as large scale agriculture, mining, landfills, waste management facilities, and power plants. While residential locations and most business operations do not require this permit, a recent addition of a specific stormwater fee was implemented by Philadelphia Water Department in 2010. Prior to 2010 the stormwater fee was lumped together as part of the sewer service charge.

Beginning in fiscal year 2010, PWD designated a revised stormwater fee to all customers' bills. The money from this added charge goes toward funding grants and loans in a stormwater incentive program. Originally based on meter usage, the fee is transitioning to a parcel size based cost to be fully implemented by 2014. The new system takes into account the gross area and impervious area of a property. This fee revision provides a more accurate system of billing based on impervious surface. Before the revision, a residential property was being charged the same amount in stormwater fees as a large, paved parking lot for example. Based on just size and amount of paved surface, the parking lot is producing significantly more runoff and is now billed accordingly. For example, of the 45 inches of average rainfall in Philadelphia, undisturbed land has 8 inches of runoff while paved land has 43 inches of runoff (Pennsylvania Department of Environmental Protection, 2006). This represents the great deal of stormwater runoff that the city is required to handle within the sewer systems.

With the stormwater fee, residential properties are charged a uniform amount of \$13.66 based on a city-wide average of residential lot size and impervious characteristics. Non-residential properties are charged based on property size. From July 1, 2011 to June 30, 2012, the Arboretum is expected to pay \$2,887.72 in stormwater fees. By June 30, 2014, that fee will level out to \$5,775.44 per year. Based on the Water Department's records, the Arboretum includes a gross area of 3,583,479 square feet and an impervious area of only 238,199 square feet (PWD, 2011). Fortunately, PWD offers a stormwater crediting program, as part of the new stormwater fee program, which incentivizes property owners to manage and retain stormwater running off their properties.

The Arboretum has used best management practices for handling stormwater for many years. Some of the stormwater best management practices already in place at the Arboretum include the pervious parking lot with recharge bed, green roofs and cistern capturing system at the Horticulture Center, pervious pathways and water capturing and recharge system at the Pennock Garden, and the underground system from the driveway and Meadowbrook Ave. In December 2011, the Arboretum hired an engineer to evaluate the garden's stormwater management techniques in order to apply for stormwater credits. The report was submitted to PWD in December 2011 for review [Figure 2]. PWD will determine what measures are sufficiently mitigating the effects of stormwater on the garden's property and issue credits, reducing the annual stormwater fees.

STORMWATER PROBLEM

At the Arboretum, stormwater flowing into the garden does not stem from a point source [Figure 3]. While there are multiple points where water flows into the garden via natural waterways, there are several unintended entrance points along Hillcrest Avenue. Tracking stormwater from its original source and managing its flow is not always possible. Hillcrest Avenue, on the southeast boundary of the garden, serves as a channel for large amounts of stormwater flowing from many different outputs. Additionally, Hillcrest Avenue has been repaved several times over the past decades. Each time the road is re-paved, the ratio of the street to gutter diminishes. With a reduced gutter, stormwater has less space to be moved into the street storm drains. This excess stormwater enters the garden in several spots along the road, including at the Hillcrest building, creating numerous problems as a result.

Some of the problems caused by stormwater runoff near the Hillcrest building include flooding in the building and damage to garden beds from channeling water. In 2011, Hurricane Irene and Tropical Storm Lee hit the Arboretum within two weeks of each other. While these two instances are extreme cases, the Arboretum sustained considerable damage from stormwater, essentially. The total insurance claim from both storms totaled approximately \$218,000. About \$97,000 of that was associated with stream work rebuilding, \$87,000 for streambed stonework, and \$10,000 for cleanup at the Hillcrest building.

The garden area around the Hillcrest building suffers from significant stormwater runoff. As precipitation averages increase, the problems associated with stormwater are also amplified. Hourly rainfall depths have gradually increased in frequency over the past decade [Figure 4]. In 2011 the greater Philadelphia area experienced a surge in heavy rain events at 64.33 inches making it the wettest year in recorded history. From 1981 to 2010 the annual average was 41.49 inches. August 2011 set the record for the wettest month with 19.31 inches (National Oceanic and Atmospheric Administration, 2012). As rain events intensify and become more frequent, best management practices need to be in place to address the stormwater runoff to come. One method of mitigating runoff is by installing a rain garden. Rain gardens are flexible in design and can be incorporated into a variety of landscapes.

HISTORY

While management of rain water was not the intended purpose of early “water gardens” at the Morris Arboretum, these varied habitats provided a unique approach to ornamental horticulture. Early records of water gardens in the Morris Arboretum date back to 1959. In the Morris Arboretum Bulletin (Vol. 10 Number 2) a reference was made to a new bog garden. It stated, “Preparation of a small bog garden where for the first time we shall be able to grow plants which require acid bog conditions” (Arboretum Activities, 1959). The bog garden was also referenced in a 1965 issue of the Morris Arboretum Bulletin (Fogg, 1965). It stated, “One small area has been developed as a bog garden, enabling us to display plants of moist, acid habitats, such as *Ledum groenlandicum*, *Anromeda glaucophylla*, *Rhododendron canadense*, *Nemopanthes mucronata*, *Viburnum nudum*, *V. alnifolium*, etc.” The bog garden was located in the English Park section northeast of the key fountain. While this garden wasn’t installed with the purpose to mitigate stormwater, it was a unique approach to showcase a variety of water loving species. Plants documented in the bog garden included: *Aronia arbutifolia* (red chokeberry), *Aronia prunifolia* (black chokeberry), *Chamaecyparis thyoides* (Atlantic white cedar), *Ilex glabra* (inkberry), *Ilex verticillata* (winterberry), *Kalmia angustifolia* (sheep laurel), *Nemopanthus mucronatus* (mountain holly), *Rhododendron viscosum* (swamp azalea), *Viburnum cassinoides* (witherod viburnum) and *Viburnum nudum* (possumhaw). Based on plant records with removal dates, the bog garden existed for nearly 15 years. The *Viburnum nudum* was noted as being dead as early as 1963 and the *Viburnum cassinoides* was dead by 1978. In March 1984 the rest of the plants in the bog garden were removed and the area was relandscaped.

The proposed location of the rain garden is contained in quadrants G21 and F21 near the Hillcrest building [Figure 5]. The topography of the area around the Hillcrest building was altered in the early 1900s as the excavation of the Swan pond occurred [Figure 6]. The soil removed from the pond was used to build up mounds near the Gardener’s Cottage. From very early on the topography of this area has been altered and has directly influenced the flow patterns of stormwater in this area of the garden.

After the bog garden was removed and up until the construction of the Horticulture Center, rain and water gardens were nonexistent at the Arboretum. In 2010, three rain gardens were created with the completion of the Horticulture Center. These rain gardens are located between parking lots A and B, along the back side of the 4 bay garage, and along the southwest side of the office building. Planted as mostly native meadow rain gardens, they serve to capture rain water from the roofs and parking lots. The rain gardens at the Horticulture Center have been a fairly simple and successful method to manage stormwater. Repeating this stormwater technique on the public side of the Arboretum will prove to be an effective approach for addressing the stormwater runoff problem near the Hillcrest building.

PURPOSE

By managing stormwater runoff in the garden several side effects can be prevented such as soil erosion and gully formation, wash-out of garden beds, reduced water logging, and runoff infiltration. The garden beds around the Hillcrest building have suffered significantly from stormwater runoff and are limited to the planting opportunities here. In January 2012, Philadelphia experienced 2.96 inches of rainfall and 3.4 inches of snowfall (National Oceanic and Atmospheric Administration, 2012). As the trend of increased rain events continues, steps need to be taken in order to diminish the negative effects.

Rain gardens are designed to capture, absorb, and filter stormwater runoff. Because they replicate natural hydrologic processes, rain gardens are an ideal solution for managing stormwater. In addition to minimizing the amount of runoff from impervious surfaces, rain gardens provide habitat for water loving plants, animals, and insects. Rain gardens are generally planted with native plants to attract beneficial insects in addition to contributing native habitat. Native plants are better suited to handle the variable weather of the region. Generally, rain gardens capture and treat 80 to 90% of the stormwater runoff from surfaces draining in to the garden (Cooper, 2011). Installing a rain garden will not solve all of the problems with stormwater runoff around the Hillcrest building, however, it will be the first in hopefully a series of management techniques to address the problem in this area of the Arboretum. Furthermore, the rain garden will bring more attention to the problem and serve as an educational tool for garden visitors. With interpretive signage about the rain garden and stormwater, visitors can better understand the relationships with these natural cycles.

PROCESS

There are several components to consider when planning and constructing a rain garden that include flow entrance, ponding area, organic layer of mulch, planting soil and filter media (such as a diatomaceous material), native plantings, and a positive overflow point for when the garden is at maximum capacity (PWD, 2011). The first part of the planning process required selecting an appropriate location for the rain garden. A location near the Hillcrest building in the English Park [Figure 5] was selected as the most adequate area for a rain garden. Steep slopes from the pathways moving down into a bowl-shape make up the proposed vicinity. The topography has changed over the past several decades and most recently new pathways and a reconfigured Gardener's Cottage driveway were added in the 1990s. The ground was raised and lowered to accommodate that construction and in turn changed and redirected the flow of stormwater.

Our percolation test confirmed that this area would serve as a good site for a rain garden. The test involved digging a hole at the lowest point of the rain garden area and filling it with water. By dividing the distance the water dropped by the amount of time it took for it to drop, the absorption rate was determined. An ideal infiltration rate is between a $\frac{1}{2}$ inch per hour and 12 inches per hour. The percolation test yielded approximately 3 inches per hour, which falls well within the ideal range.

We then had to determine the type of rain garden to build. One option was to install a pre-made system called SustainRain™ by Complete Aquatics. This system uses interlocking crates to hold the captured water underground. Using a pump, the water is re-circulated through a fixture, such as a fountain, used for irrigation, or moved into a discharge pipe. While this system is effective, especially for capturing large quantities of stormwater, it wasn't the ideal system for the Arboretum site. Installing the SustainRain™ system would have required significantly more excavating, putting rare tree species located nearby at risk for stress and damage. We decided to excavate the rain garden area without installing any kind of underground system.

The next step involved establishing the boundaries for the garden. Creating a berm on the north and northeast side of the garden was included in order to slow down the flow of water. While redirecting water is not the objective, creating a barrier with the berm will allow stormwater to collect in the rain garden. The boundaries were also influenced by the surrounding trees including *Abies cilicica*, a rare fir tree accessioned in 1932.

The garden construction will be done by Arboretum staff with potential consultation from an engineer with Complete Aquatics. Once the garden is excavated, the soil will be amended with a diatomaceous material, such as Axis®, to give the soil optimal percolation capabilities. Generally, the planting soil depth will be at least 18 inches where herbaceous plants will be used. When planting woody plants, the soil depth will be increased depending on the species. The planting soil should be loamy and amended with composted organic material. According to the Philadelphia Stormwater Best Management Practices Manual, generally the soil is combined with 20-30% organic material (compost) and 70-80% soil base (preferably topsoil). The planting soil should be approximately 4 inches deeper than the bottom of the largest root ball. Once the native species are planted, a maximum of 2 to 3 inches of shredded mulch or leaf compost should be evenly spread out over the garden to prevent erosion. Wood chips should not be used as they will float during heavy rain events.

PLANTING CONSIDERATIONS

Rain gardens are generally divided into three planting zones. The wet zone (lowest zone) will contain species that do well in short periods of standing water as well as dry periods. The mesic zone (middle or moist zone) will contain plants that can tolerate extreme conditions of very wet or very dry. The transition zone (high zone and berm) will include plants that withstand more normal to drier conditions. Considerations for determining the planting schematic include:

- How much shade and sun the garden will receive
- Potential removal of a tree, *Zelkova sinica*, (accession number 95-174*A) located in the middle of the planned rain garden
- Prevent viewshed obstruction (Currently the viewshed consists of the Swan Pond and Love Temple from the pathway along the south side of the rain garden site)
- Deer browsing (Use deer tolerant plant species)
- Drought and water tolerance (a variety of native species meet these criteria)
- Repeat the plantings in nearby beds to create a node of a consistent theme

The following is a list of plant species native to the Mid-Atlantic and the U.S. that are suitable for planting in the wet-to-moist conditions of a rain garden:

Campanulastrum americanum (bellflower)
Lobelia siphilitica (great blue lobelia)
Ruellia humilis (fringeleaf wild petunia)
Baptisia australis (wild blue indigo)
Solidago (goldenrod)
Vernonia fasciculata (ironweed)
Asclepias incarnata (swamp milkweed)
Asclepias tuberosa (butterflyweed)
Eupatorium coelestinum (hardy ageratum)
Onoclea sensibilis (sensitive fern)
Carex pensylvanica (oak sedge)
Iris versicolor (blue flag)
Aster novae-angliae (New England aster)
Cornus sericea (red twig dogwood)
Viburnum nudum (possumhaw)
Ilex glabra (inkberry)

Lobelia cardinalis (cardinal flower)
Eupatorium dubium (dwarf Joe Pye weed)
Phlox divaricata (wild blue phlox)
Liatris spicata (blazing star)
Tradescantia virginiana (spiderwort)
Helenium autumnale (sneezeweed)
Monarda didyma (bee balm)
Rudbeckia fulgida (black-eyed susan)
Hibiscus moscheutos (marsh mallow)
Osmunda claytoniana (interrupted fern)
Schizachyrium scoparium (little bluestem)
Rhododendron viscosum (swamp azalea)
Kalmia angustifolia (sheep laurel)
Lindera benzoin (spicebush)
Cornus amomum (silky dogwood)
Photinia melanocarpa (black chokeberry)

The following list will be used for the rain garden in the Arboretum. While there are numerous native plants to select from, only a handful of woody and herbaceous plants will be used. By planting large masses of a few plants, an overall unity will be achieved. Additionally, these same plants will be repeated in the surrounding beds to create a cohesive area around the rain garden.

Woody plants:

Viburnum cassinoides, *Itea virginica*, *Chamaecyparis thyoides*, *Physocarpus opulifolius*, *Salix gracilistyla*, *Cornus sericea*

Herbaceous plants:

Asclepias tuberosa, *Lobelia cardinalis*, *Lobelia siphilitica*, *Carex flaccosperma*, *Polystichum acrostichoides*, *Osmunda regalis*

MAINTENANCE

Planting native species in the rain garden minimizes the amount of maintenance required. However, some attention is needed, particularly in the initial phases of the newly established rain garden. The following chart from the Philadelphia Stormwater Manual v 2.0 represents general maintenance routines that should be carried out in order to ensure the rain garden is successfully retaining stormwater runoff (PWD, 2011).

Maintenance Guidelines	
Activity	Schedule
<ul style="list-style-type: none"> Water vegetation at the end of each day for two weeks after planting is completed. Water vegetation regularly to ensure successful establishment. 	First year after installed
<ul style="list-style-type: none"> Re-mulch void areas. Treat diseased trees and shrubs. Keep overflow free and clear of leaves. 	As needed
<ul style="list-style-type: none"> Inspect soil and repair eroded areas. Remove litter and debris. Clear leaves and debris from overflow. 	Monthly
<ul style="list-style-type: none"> Inspect trees and shrubs to evaluate health, replace if necessary. 	Biannually
<ul style="list-style-type: none"> Add additional mulch. Inspect for sediment buildup, erosion, vegetative conditions, etc. 	Annually
<ul style="list-style-type: none"> Maintain records of all inspections and maintenance activity. 	Ongoing

BENEFITS OF A RAIN GARDEN

Rain gardens enhance, naturalize, and improve native habitat attracting beneficial insects and animals. Because rain gardens mimic natural hydrologic patterns, they are well suited for managing stormwater. By capturing stormwater runoff, they prevent stream degradation and limit the amount of non-point source pollutants entering waterways. Rain gardens reduce facility maintenance and more effectively control runoff from small frequent storms (Pennsylvania Environmental Council, 2006). They also filter sediment and pollutants by nutrient cycling and by removing pollutants through the soil and in the plants. Some other benefits of rain gardens are that they conserve water, reduce mosquito breeding, recharge local groundwater, reduce potential of flooding, reduce garden maintenance (once rain garden is established), and increase garden appeal.

EDUCATION COMPONENT

Currently, the Arboretum guides have a wetland lesson plan for teaching visitors about wetland ecosystems. Because the wetland at the Arboretum is not as accessible as other areas of the garden, creating a supplementary lesson plan for the new rain garden would be beneficial. In addition to being an easier location to visit, due to its proximity to the Visitor Center and other parts of the public garden, the lesson would provide a small scale learning tool for understanding the problems associated with stormwater runoff. Additionally, the rain garden will offer another opportunity to see the benefits of using native plants. For people not visiting as part of a guided group, interpretive signage will present visitors with a brief explanation of the rain garden including ways the rain garden helps reduce the negative impacts of stormwater runoff.

CONCLUSION

Stormwater runoff is an ongoing problem in the city of Philadelphia. Fortunately, steps are being taken to address this major issue such as the PWD stormwater fees and incentive program. The Arboretum is clearly dedicated to maintaining environmental responsibility and will continue to make every effort in order to minimize stormwater damage. One of the challenges is finding the best method for managing runoff while attempting to provide aesthetic and environmental benefits in the garden. Rain gardens meet both of these parameters and are becoming an important landscape tool for land-use planners. While the installation of a rain garden in the English Park section is not going to solve all stormwater problems, it is a step in, hopefully, a larger plan to mitigate the negative effects of stormwater in this area. The Morris Arboretum has been committed to sustainability for decades and this project will help to continue that mission.

REFERENCES

“Arboretum Activities.” *Morris Arboretum Bulletin* Vol. 10 No. 2 Jun 1959: 31. Print.

Cooper, Rick, ed. *Rain Gardens – Low Impact Development Fact Sheet*, Oregon Sea Grant, Corvallis, Oregon: Oregon State University, 2011. Print.

Environmental Protection Agency “Office of Wastewater Management” <<http://www.epa.gov>> Oct. 2011 – Mar. 2012

Fogg, John Jr. “Landscaping an Arboretum.” *Morris Arboretum Bulletin* Vol. 16 No. 1 March 1965: 3-5. Print.

National Oceanic and Atmospheric Administration “Philadelphia/Mount Holly Hydrology Data” <<http://www.noaa.gov>> Jan. – Mar. 2012

Pennsylvania Environmental Council. *Improving Stormwater Detention Basins for Better Stormwater Management*, September 2006. Print.

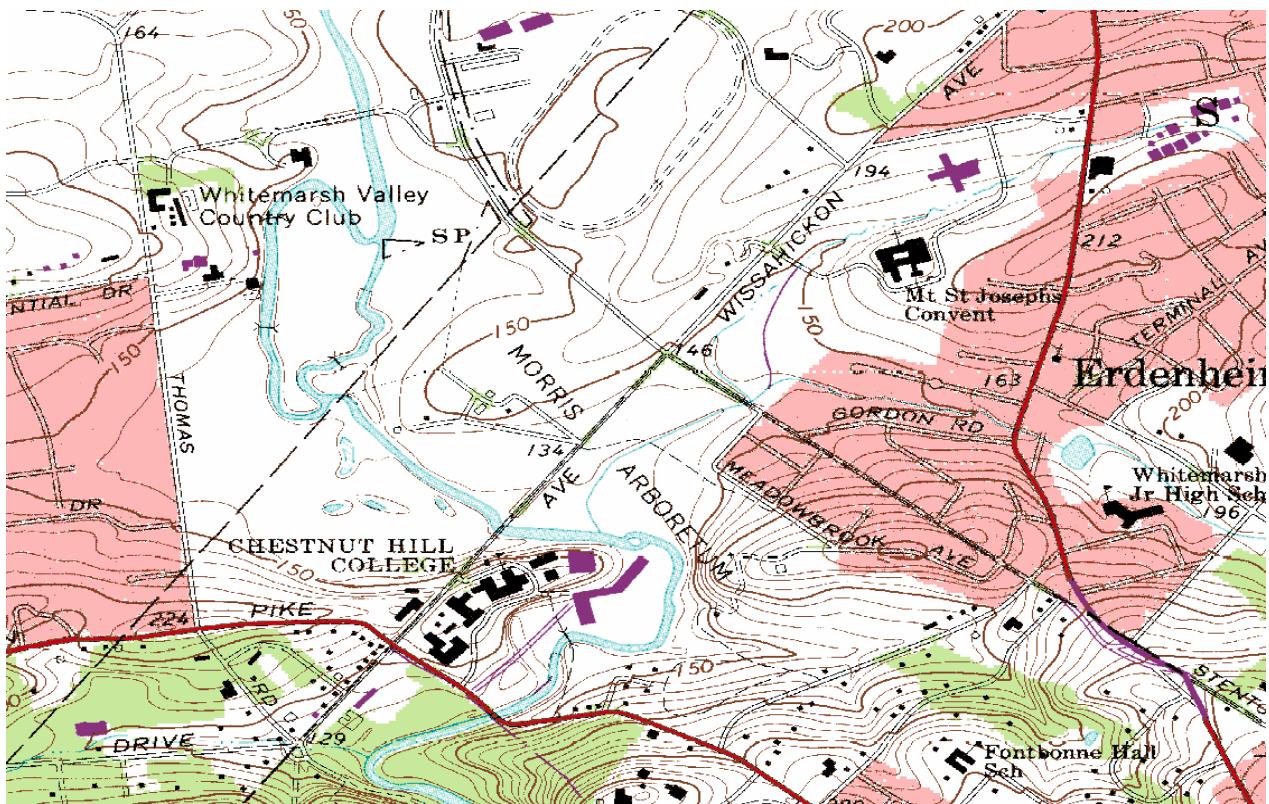
Pennsylvania Department of Environmental Protection. *Pennsylvania Stormwater Best Management Practices Manual*, Chapter 6.4.5: Structural BMPs, Pennsylvania Department of Environmental Protection: December 2006. Print.

Philadelphia Water Department and the Planning & Environmental Services Division. *Philadelphia Stormwater Manual v2.0*, Sections 7-33 to 7-41: Revised April 2011. Print.

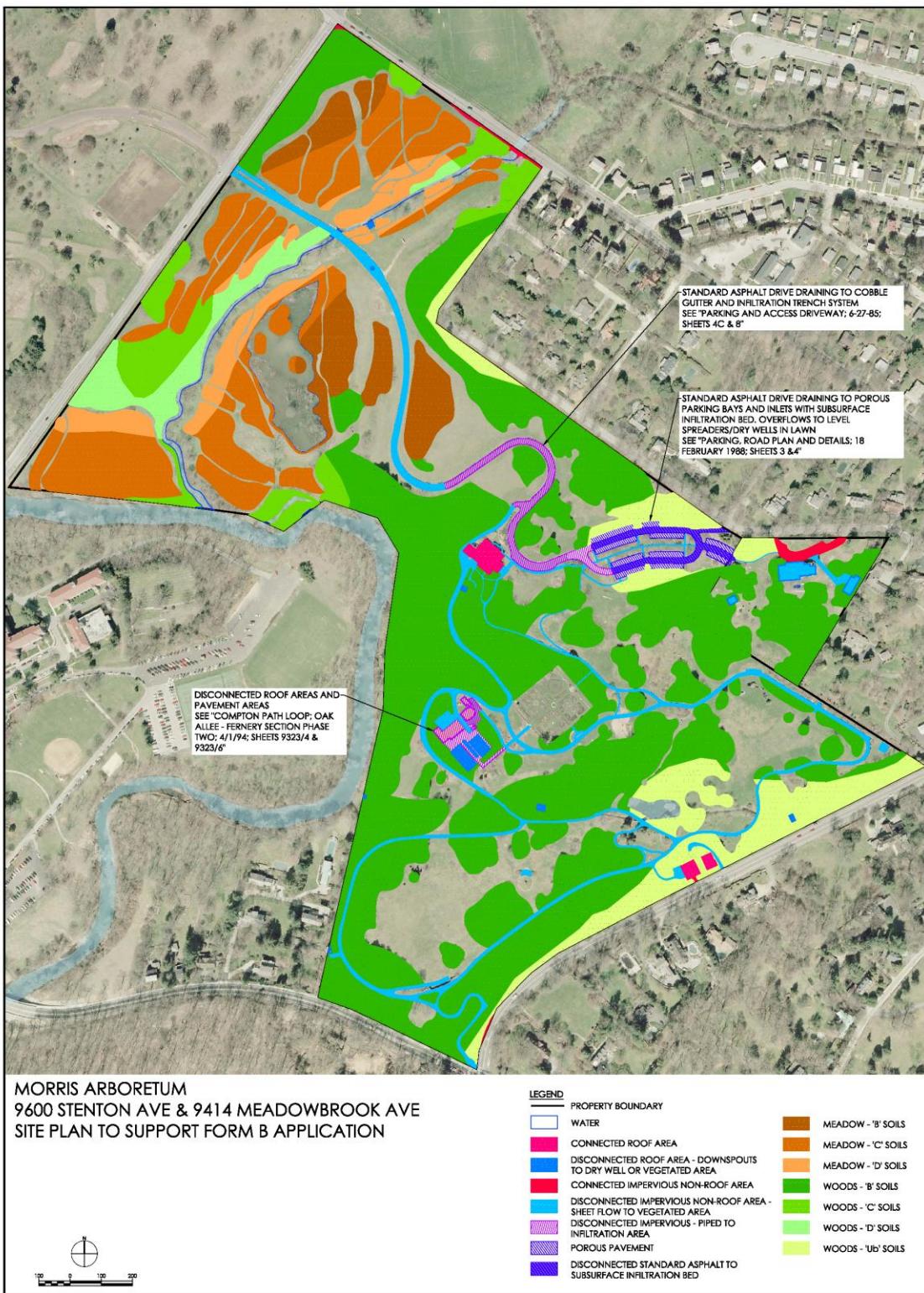
Philadelphia Water Department “Office of Watersheds” <<http://www.pwd.gov>> Sep. 2011 - March 2012

Stormwater Pennsylvania <<http://www.stormwaterpa.org>> Nov. 2011 – Mar. 2012

APPENDIX

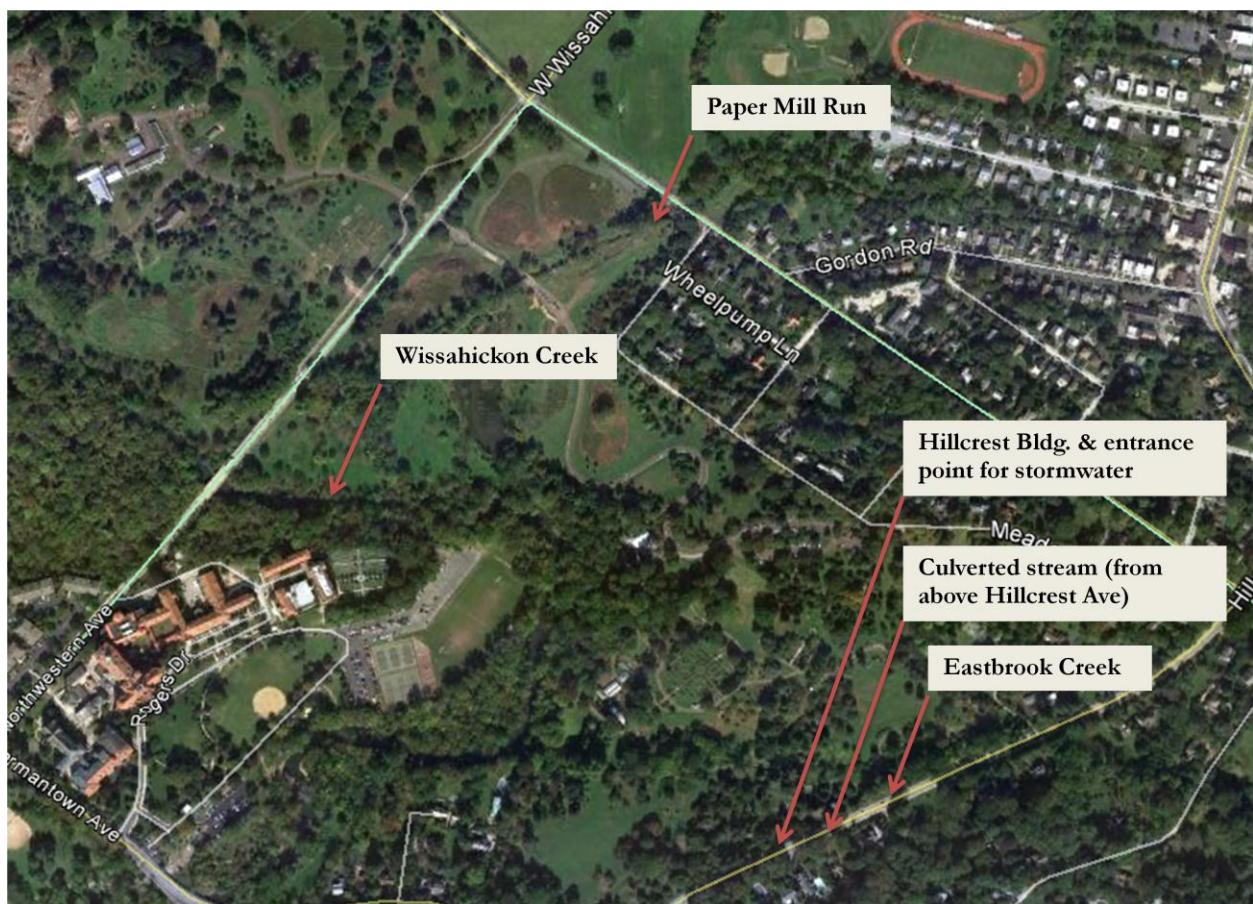


[Figure 1] Topographic map of the Morris Arboretum
The topo map shows the steep elevation in and around the south and southeast part of the Arboretum.



[Figure 2] Stormwater runoff map by Meliora Engineering

This map illustrates the Arboretum's parcels within Philadelphia and the pervious and impervious surface coverage. The map was included in the stormwater credit application to the Philadelphia Water Department.



[Figure 3] An aerial view of the Morris Arboretum
The red arrows represent incoming water sources. These sources include:
Wissahickon Creek, Paper Mill Run, Eastbrook, underground stream diverted to Eastbrook, and
stormwater runoff from Hillcrest Avenue

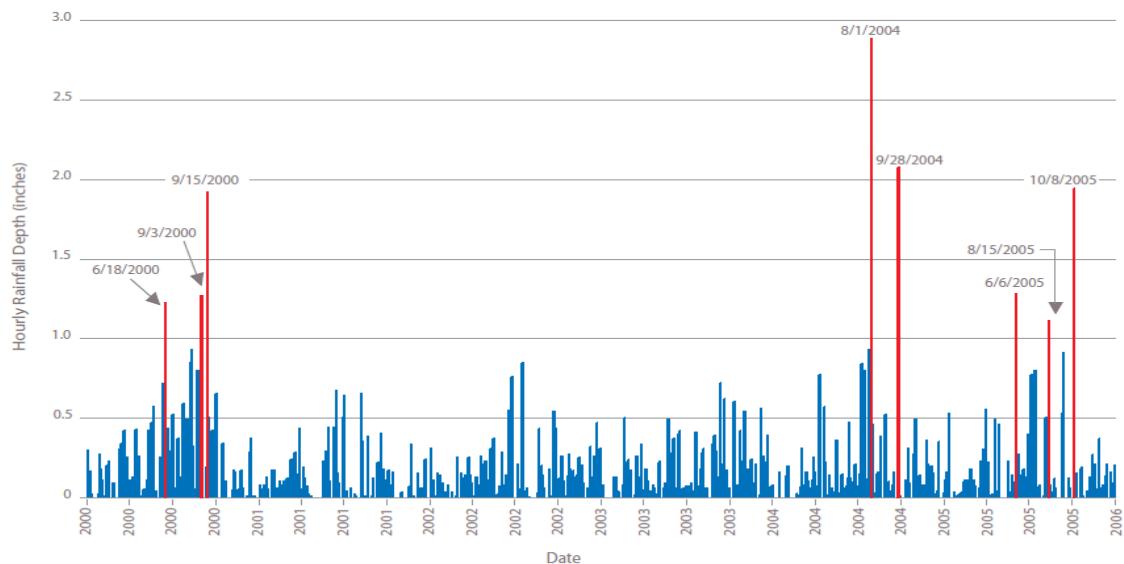
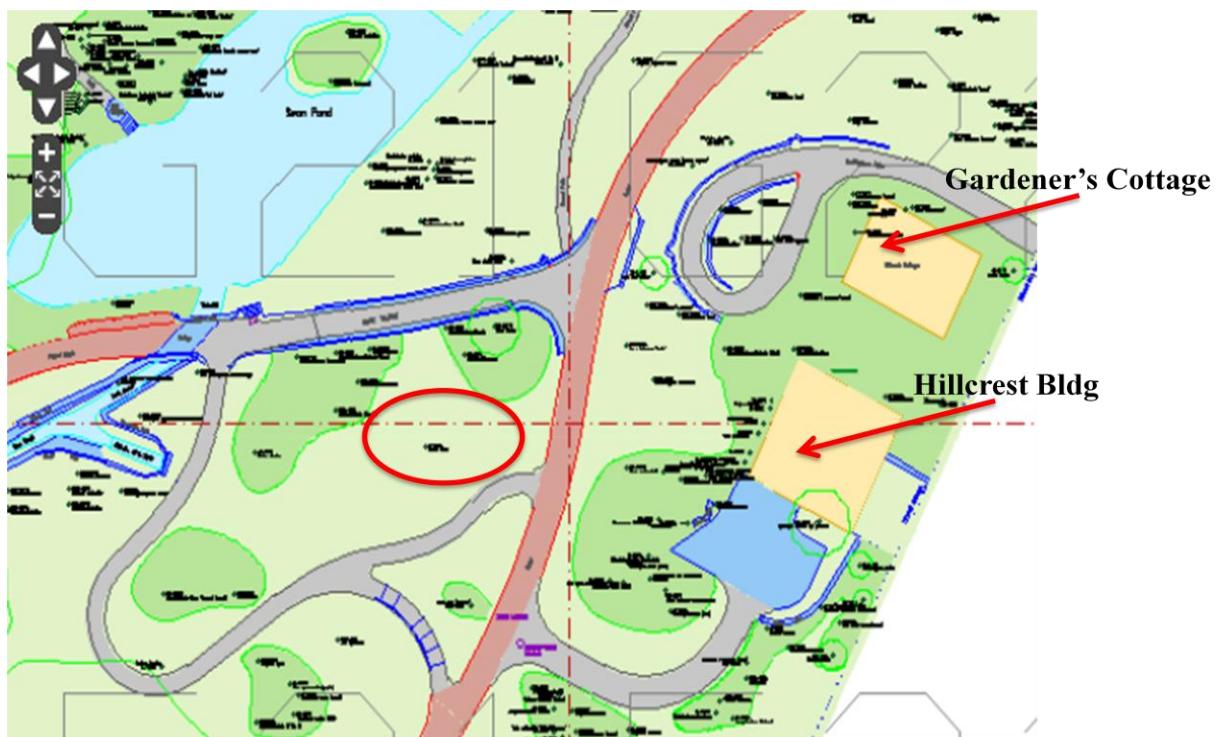


FIGURE 1: Hourly rainfall depths recorded at PWD Rain Gage #05 (South Philadelphia), 2000–August 28, 2006

[Figure 4] Philadelphia Water Department Graph
Represents the increase in hourly rainfall depth from 2000 to 2006



[Figure 5] The red circle represents the proposed location of the rain garden



[Figure 6] Looking toward Hillcrest Avenue at Gardener's Cottage
The mounds were created by the soil excavated from the Swan Pond

TITLE: **Morris Arboretum Nursery Trial:
A Study of Rose Care Treatment**

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DATE: **June 2012**

ABSTRACT:

The Arboretum's IPM program has been striving to reduce pesticide use in the Rose Garden. In 2010, Justin Jackson, the Rose Garden Section Leader, proposed a sustainable landscape management plan that would incorporate compost tea into the Rose Garden's IPM program. The study of improving the quality of the compost has been on-going.

The intent of this project was to determine the efficacy of three organic fungicides. The project was divided into two phases, the pre-trial phase and trial phase. A treatment plan was applied from the end of spring until the end of fall, 2012. The four treatments for the trial were control (just water), compost tea, CEASE, and Green Cure. CEASE and Green Cure were sprayed onto the leaves once a week as recommended and compost tea was sprayed and drenched once a month.

Black spot and downy mildew were found on almost all of the rose leaves or canes in the entire Rose Garden. As a fungal disease, the intensity of damage caused by black spot and downy mildew tends to be influenced mostly by weather conditions and the disease resistance of the rose varieties. Many hybrid tea, grandiflora, and floribunda roses are susceptible, whereas many of the shrub roses show more resistance. This observation also shows that the resistance level might be variable in different places and conditions. Nine weeks after planting, which includes four weeks of treatment that took place in early June, the rose plots did not have comparable treatment results in growth, vigor, and performance. The black spot or fungal diseases on the leaves had not significantly changed the growth and performance of the plants.

In order to have better study results, continuing treatment and observation is encouraged until the end of October to determine the percentage of fungal disease present or the percentage of defoliation among the treatments and varieties.

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INTRODUCTION

Consumer demand for organic food has risen quickly over the past decade, triggered in part by the development and success of USDA's organic regulatory program and labeling. As consumer demand for organic products has increased, organic retail sales have spread far beyond the "natural products" market niche in urban areas and college towns and into big-box stores across the country (Greene et al., 2009). The increasing demand for "organic products" is one of the results of a growing concern for this health and environmental problem. It has been found that people not only pay attention to the adverse effects of hazardous chemicals in the foods they eat but also to the pollution to the environment in which they live. Public agencies are facing increasing demands from their employees, their clients, and the general public to explain and justify their use of pesticides (Flint et al., 2003). This awareness has been occurring in many public areas and services including public gardens that often use pesticides to control pests and diseases as part of their pest management program.

A public garden is a mission-based institution that maintains collections of plants for purposes of education, research, conservation, and/or public display. Furthermore, it must be open to the public and provide accommodation for access to all people (Rakow et al., 2011). With the mission of promoting an understanding of the relationship between plants, people, and place through programs that integrate science, art, and the humanities, Morris Arboretum as a public garden attracts people to visit, educates and instantly puts them into contact with plants and the environment. We recognize that the general public and staff deserve to be protected from exposure to hazardous chemicals and pesticides. We also recognize that public gardens should be a model of environmentally responsible practices. For these reasons, most public gardens have been practicing Integrated Pest Management (IPM).

Integrated Pest Management (IPM) is a problem-solving approach to landscape management designed to prevent and control undesirable weeds, pests, and diseases. The main goal of IPM is the development of sustainable ways of managing pests to minimize risks to environmental health and the economy (Rakow et al., 2011). The IPM program at Morris Arboretum was established in 1981 by Dr. Ann Rhoads. A monthly monitoring by the plant pathologist, interns, gardeners, and arborists has been financially beneficial, reducing the use of pesticides and minimizing the health risk to people visiting and working in the garden.

The Rose Garden is one of the horticultural treasures of the Arboretum and one of the most visited destinations. The formal Rose Garden emerged in 1924 after it provided fruit, vegetables, and flower to the mansion for 36 years. The monoculture Rose Garden declined over the years since it opened to public in 1933. In 1994, there was a revitalization of the garden including soil conditioning and introducing diversity into the garden to create an updated and more beautiful garden, and at the same time build an ecologically healthier garden. Adding companion plants to the garden encouraged more beneficial insects, increasing its wildlife value and providing built-in controls for pest and disease problems, while being part of the IPM program.

Growing roses with a lot of chemicals and pesticides has been an accepted practice for the general public. In a formal rose garden, spraying pesticide is commonly used to get rid of

pests and diseases and is an easier way to keep roses looking their best. Before 2010, weekly or biweekly preventive chemical spraying had been scheduled to grow quality roses in the Rose Garden. Alternative controls to pesticide sprays, such as milky spore disease and pheromone traps were used for rose care (Bechtol, 1988).

The Arboretum's IPM program has been striving to reduce pesticide use in the Rose Garden. The IPM program for roses generally includes choosing resistant varieties, keeping good sanitation in the garden, and following proper cultural practices. These include adding compost, mulching, watering, pruning, weeding, adding companion plants, and controlling pests and diseases with chemicals. The use of chemical pesticide is usually considered a last resort in an effective IPM program. If pesticides are needed to control pests, the safest, least harmful product to humans and the environment should be considered first (Rakow et al, 2011).

Organic Rose Garden

The practice of organic rose gardening has become more and more popular in the last decade. Since 2000 there have been a lot studies using compost tea and organic farming practices conducted in Northwest states (Oregon and Washington). In 2000-2001 there was a rose garden compost tea study at University of Washington, followed by a compost tea trial done by the Cascadia Consulting Group for City of Seattle in the Woodland Park Rose Garden, the Jackson Park Golf Course, and at Pritchard Beach. Woodland Park Rose Garden succeeded transforming a 2.5 acre rose garden to a model of organic practices after two years on a diet of compost tea. Brooklyn Botanical Garden, Atlanta Botanical Garden and Lotus Land Rose Garden in California are some public gardens that use sustainable practices to manage their rose gardens organically. Smithsonian Gardens has been practicing selective spraying in its rose garden to reduce the use of chemical pesticide. The Antique Rose Emporium in Texas is a nursery practicing organic rose growing using careful selection of the rose varieties planted and compost tea.

Morris Arboretum had been spraying a total of 2,000 gallons of synthetic chemicals a year in the Rose Garden. In 2010 Justin Jackson, the Rose Garden Section Leader, introduced compost tea to the Rose Garden after attending Dr. Elaine Ingham's Soil Health Workshop.

After three applications of compost tea, both drenching to the soil and leaf spraying, there were some improvements including reduced water use for irrigation. The vegetation appeared greener than plants in the surrounding area, the presence of beneficial insects in the garden was noted, and black spot was suppressed. Problems that persist are the presence of black spot and fungus in the garden and population levels of beneficial bacteria and fungus in compost tea is lower than expected. Improving the quality of the compost tea has been studied. Removing synthetic chemicals from the Rose Garden is going to be a challenge and it is not going to happen in a year. Justin expects that it will take at least a few years of an organic approach before we start to really see a truly healthy rose garden.

PRE-TRIAL PHASE

The intent of this project is to determine what the best organic fungicides for treating black spot on four varieties of roses. The project is divided into two phases: the pre-trial phase and the trial phase. The pre-trial phase, including field observation and plot preparation, was done throughout the fall and winter. The trial phase including planting, maintenance, applying fungicide treatment, observation, and monitoring was done in the spring and summer.

METHODOLOGY

Pre-trial field observation was conducted to study the general condition and diseases in the Rose Garden and collect information that could support the trial methods and materials. The points necessary to study before the trial were the common diseases of the Rose Garden, the resistance of some varieties and type of roses in the field, their availability in the market, and the organic fungicides that could be applied and be effective in the Rose Garden.

To study general conditions and problems in the garden, some interviews with Justin Jackson and photo documentation were done. Some photos of varieties in the garden had been taken in the fall to examine their performance and resistance to black spot. Any supporting information was collected from journals and articles, correspondence, discussion on intern field trips, and meetings with The Philadelphia Rose Society. The nursery area at the farm site was chosen to conduct the trial. The plots were prepared by weeding and digging the soil in October and tilling to loosen the clods in January.

RESULTS & DISCUSSION

1. Disease Incidence

Based on observation, the Rose Garden's main pests and diseases are black spot, downy mildew, rose midge, Japanese beetle, aphids, and rose rosette disease. Black spot is the most important foliar disease of roses and is widespread among all rose species and cultivars. Symptoms are dark brown or black blotches with irregular margins found on the leaves, which often turn yellow and drop as the disease progresses (Davies and Stickland, 2004). Repeated defoliation weakens the plants leading to fewer blooms and greater sensitivity to other stresses.

The fungus, *Diplocarpon rosae* overwinters on diseased canes and fallen leaves. Spores produced on fallen leaves are spread via rain or water splashed on newly emerged leaves and stem tissue in the spring (Wallis and Lewandowski, 2008). The fungus favored warm wet seasons as infection is optimal at 75 °F when leaves have been wet for 7 hours (Davies and Stickland, 2008).



Figure 1: Black spot presence in Rosa ‘Rheinaupark’ and ‘Golden Celebration’.

Black spot is found on almost all of the rose leaves or canes in the entire Rose Garden. As a fungal disease, the intensity of damage caused by black spot tends to be influenced mostly by weather conditions and disease resistance of the rose varieties. Many roses that were attacked by black spot after wet rainy weather in the fall of 2011 showed significant damage in the spring of 2012 particularly some of the hybrid teas. Sometimes symptoms can be seen not only on the leaves but also on petals (red dots, distortion), petioles, fruit, and canes (Wallis and Lewandoski, 2008).

2. Variety Selection

Table 1: Resistance of some roses varieties in the rose garden.

Type	Varieties	AARS Rose	Blackspot / fungal symptoms quantity	Resistance (on the field)
Shrub/Landscape	Care Free Spirit	√	-	Resistant
	Pink Knock Out		-	Resistant
	Rainbow Knock Out	√	-	Resistant
	Winter Sunset		-	Resistant
	Golden Celebration		+	Non-resistant
	Glamis Castle		+	Non-resistant
	Robusta		+++	Non-resistant
Floribunda	Rheinaupark		+	Non-resistant
	Rainbow Sorbet	√	-	Resistant
	Julia Child	√	-	Resistant
	Easy Does It	√	+++	Non-resistant
	Redwood		+	Non-resistant
	Cinco De Mayo	√	+	Non-resistant
Hybrid Tea	Mardigras	√	+	Non-resistant
	Traviata		+	Non-resistant
Grandiflora	Pink Promise	√	++	Non-resistant
	Sunshine Daydream	√	+	Non-resistant
	Wild Blue Yonder	√	++	Non-resistant
	Dick Clark	√	++	Non-resistant

The table shows that all hybrid tea and grandiflora roses observed had black spot or fungal disease symptoms and were considered non-resistant. Many hybrid tea roses are very susceptible, whereas many of the shrub and rugosa roses show more resistance (Wallis and Lewandowski., 2008). Most of the floribunda roses had some black spot. Hybrid tea, floribunda, and grandiflora roses tend to have low resistance levels because most of their hybridization involves flower performance instead of vigor and hardiness like the shrub-type roses. Even though shrub-type roses are the most resistant in the garden some of them had black spot as well.

Some of the roses that we have are the All-America Rose Selections (AARS) winners that are expected to perform well in the garden. AARS is a nonprofit association started in 1938 and dedicated to the introduction and promotion of exceptional roses. Every year the AARS tests new roses in gardens across the U.S. After two years of testing, they select the best varieties for disease resistance, growth qualities, and overall appeal. In fact, some of them apparently still have a visible incidence of black spot in the garden, so being the winner does not always mean they are not susceptible to black spot.

This observation also shows that the resistance level might be variable in different places and conditions. Some of the varieties that claim to have resistance to black spot performed surprisingly different in the garden. A knowledgeable member of Philadelphia Rose Society mentioned that there was no such thing as a 100% resistant rose. Every rose is susceptible to black spot but their vigor in handling black spot makes them different. Some varieties like 'Knock Out' are very vigorous against the defoliation of black spot. Though they look resistant, it is still possible to find black spot infection on their leaves and canes.

Considerations for selecting four varieties for the trial were rose type, resistance, popularity, and availability in the market. They are 'Robusta' (Shrub type), 'Easy Does It' (Floribunda type), 'Chrysler Imperial' (Hybrid tea type), and 'Sunshine Daydream' (Grandiflora type). They were considered as non-resistant based on observation in the Rose Garden. Three of them are AARS winners and all of them are available in the marketplace.

The varieties selected are the same varieties that we have in the Rose Garden. Their performance and resistance in the garden were expected to also happen in the trial. Non-resistant varieties were selected intentionally to easily attract black spot for comparative measurement and efficacy treatments in the trial. AARS winner varieties are prioritized in the selection since they are popular purchases made by the public.



Figure 2: Rosa ‘Robusta’: black spot and downy mildew presence in the fall

‘Robusta’ (*Rosa ‘KORGosa’*) is a modern rugosa rose hybrid that has crimson red single flowers. It was bred by Reimer Kordes in Germany in 1979. Robusta tends to be a big shrub rose. It is very thorny and extremely vigorous, but some mentioned it is also susceptible to black spot. In fact, they are susceptible to black spot in the garden. Most of the leaves were covered with black spot and downy mildew in the fall.



Figure 3: Rosa ‘Easy Does It’: black spot and downy mildew presence in the fall

‘Easy Does It’ (*Rosa ‘HARpageant’*) is a 2010 AARS winner. It is claimed to be excellent in all kinds of climate, a combination of apricot and peach in color, and disease resistant. In the garden, the leaves apparently did not perform really well particularly in the fall. Even though they are still blooming in the fall, most of the plants were badly defoliated by black spot and downy mildew.



Figure 4: Rosa ‘Chrysler Imperial’

‘Chrysler Imperial’ (*Rosa ‘Chrysler Imperial’*) is a strongly fragrant, dark red hybrid tea rose cultivar. It has been around since the 1950’s and is still very popular. It was bred in California in 1952. It was the 1951 Portland Gold Medal winner and the 1953 AARS winner. It is noticeably susceptible to mildew and black spot. It performed reasonably well in the Rose Garden, but like most hybrid tea roses, it was experiencing some black spot. This variety was not included in pre-trial observation, but was proposed by Justin Jackson as a popular hybrid tea rose.



Figure 5: Rosa ‘Sunshine Daydream’ and black spot presence in the fall

‘Sunshine Daydream’ (*Rosa ‘Meikanaro’*) is the latest 2012 AARS winner. It is a grandiflora rose with prolific clusters of light yellow, cuplike flowers that fade to creamy yellow. It has excellent disease resistance, including resistance to black spot and thrived during two years of testing in 21 gardens nationwide. It performs well in the Rose Garden, but had a little black spot in the fall.

3. Treatment Selection

The general recommendations for black spot management are proper watering of the soil, not the foliage, good sanitation, resistant variety selection, and fungicide application (Wallis and Lewandowski, 2008). The treatment includes organic fungicide treatments or the use of non-synthetic chemicals to suppress black spot. The information was gathered from discussion during field trips and also from The Philadelphia Rose Society. By choosing different treatments, they were expected to be able to show comparative results and effectiveness particularly in our area and climate.

Compost tea was chosen as a treatment. It is a represents the treatment program that has been implemented in the Rose Garden during the past two years. Compost tea has been sprayed once a month during the growing season (late spring and summer) in the Rose Garden. For the trial, the compost tea recipe referred to the current recipe for the Rose Garden and was applied once a month. The result of compost tea trials in the Woodland Park Rose in 2011 showed that both the compost tea and conventionally treated beds looked comparable relative to black spot and powdery mildew and the bloom quality and quantity were comparable.

CEASE® is contact biological fungicide that currently has been used in the Rose Garden of the Brooklyn Botanical Garden in New York. It is one of the largest rose collections in North America with over a thousand kinds of roses. In 2010-2011 NYBG's Cranford Rose Garden was renovated because of rosette disease (RRD). They introduced a bright mix of annuals and perennials into the rose beds to provide habitat for beneficial insect that reduce the need for chemical treatment in the garden (Owens, 2011).

Green Cure is a potassium bicarbonate-based (KNO_3) fungicide that has been tested and endorsed by The American Rose Society. It is recommended by Dr. Suni and Rafiq Bolar, members of both The Philadelphia and West Jersey Rose Society. They sprayed Green Cure in the fall to their roses. It worked well on powdery mildew and was somewhat affective against black spot. Another benefit of using Green Cure is that it brought the acidity of soil down, since they had acidic soil.

The four treatments for the trial are control (just water), compost tea, CEASE and Green Cure. CEASE and Green Cure will be sprayed to the leaves once a week as recommended, and compost tea will be sprayed and drenched once a month.

TRIAL PHASE

The Trial Phase was conducted in spring and summer, included ordering the plants, planting, maintaining, applying fungicide treatment, observation, and monitoring.

METHODOLOGY

Four beds (23 x 5 feet, with 8.5 foot spacing) were prepared at the nursery at Bloomfield Farm. Four rose varieties were used: 'Robusta' (V1), 'Easy Does It' (V2), 'Chrysler Imperial' (V3) and 'Sunshine Daydream' (V4). The second factor was fungicide treatment that consisted of four treatments: control (N0), compost tea (N1), CEASE (N3) and Green Cure (N4). Each variety was planted in all beds with five repetitions randomly arranged. There were 20 plants in a plot 3 feet apart, so there were 80 plants in total. One bed got one treatment.

General tilling and turning the soil was done in the fall and winter. No particular treatment was given to the plot before planting. Weeding and mowing the grass were done as needed.

'Robusta' was planted from bare root plants and the others were transplanted from pots in the first week of April. The plots were mulched after planting; watering was done frequently in the first three weeks and continued as needed. Soaking leaves in watering methods referred to sprinklers in the Rose Garden that somehow can attract black spot to the leaves easily.



Figure 6: Planting process

Treatments

Compost tea was brewed every month beginning on May 8. A 250-gallon GEOTEA brewer was used to brew tea for the Rose Garden and the trial every month. The tea was brewed with the following proportion of ingredients: 225 gallons of water, 12 quarts fresh, local compost, 1 quart seaweed extract and 1 bag (5.5 lbs) GeoTea starter. GeoTea starter is a balanced and diverse food resource to encourage the proliferation of naturally occurring microbes present in high quality compost, with an emphasis of fungal development. A tea sample was taken and checked under the microscope to study the microorganism population. Compost tea was sprayed to the leaves and drenched in the soil.

CEASE and Green Cure were sprayed as a solution to the leaves every week. The dosage and timing were recommended in the manufacturer's direction. Both CEASE and Green Cure were diluted in $\frac{1}{4}$ gallon (32 oz.) of water. CEASE was diluted with Therm XTM 70, a

recommended spreader/sticker. The control bed was sprayed with just water every week to create the same condition as in the other treatments. This was applied also to the compost tea bed in the weeks that it did not get the treatment.

Photo Documentation

The trial plot was photographed every week to document the general growth and performance of the roses beginning in early April after planting and continuing throughout the study period. Pictures of each bed will be taken every week beginning in May (after treatment application). Pictures of sample leaves with fungal disease present were taken to see growth performance and presence of black spot and other pests and disease symptoms. By the end of the study, the photos are expected to have significant change and comparable result.

Site Monitoring

The plots were monitored every month through visual evaluation. Justin Jackson, the Rose Garden Section Leader, and I conducted a visual evaluation of the roses in the plots. Scouting was done at the same time to control any pest or insect interfered.

RESULTS AND DISCUSSION

General Growth and Performance

After nine weeks from planting and four weeks in treatment, the rose plot did not appear to be in comparable growth, vigor, and performance. Most roses grow rapidly after the fourth week and get continuously bushier up to the eighth week. While the leaf growth slowed down, it started to bloom abundantly in the eighth and ninth weeks. Four varieties have been continuously blooming after the ninth week, but not as much as the eighth and ninth weeks as the first blooming.



Figure 7: Rose growth in beginning and in the 2nd, 4th, 6th, 8th, and 9th weeks

There were two ‘Robusta’ roses that failed to establish and died. It was expected that bare root roses are more difficult to establish when transplanted compared with roses in pots. There was one sample of ‘Easy Does It’ in the control bed that was determined to be a different variety with purple flower color.



Figure 8: Control plot in treatment period



Figure 9: Compost tea plot in treatment period

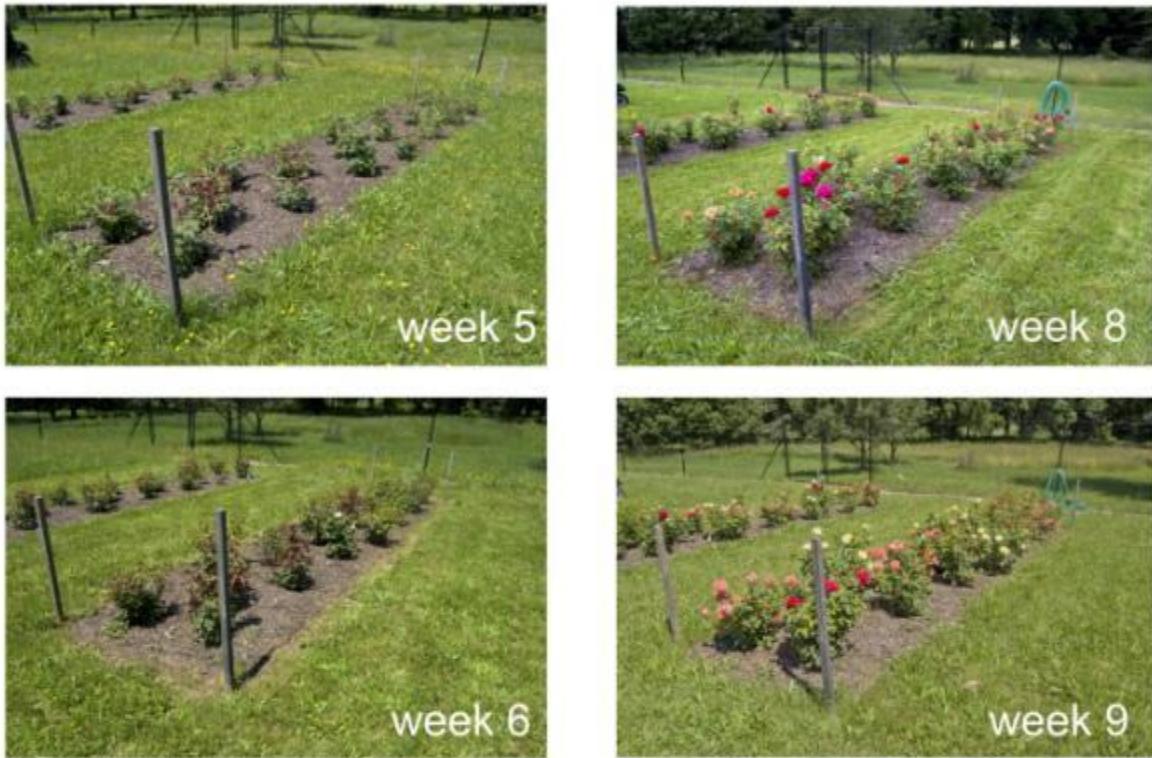


Figure 10: CEASE plot in treatment period

There was no significant difference in either growth or blooming among treatments up to the 9th week. Among the four treatments the compost tea treatments were expected to contribute to the better growth and performance since compost tea mainly acted as source of nutrition and added good microorganisms to the soil.

Until the 9th week the presence of black spot or fungal diseases on the leaves had not significantly changed the growth and performance of the plants. A fourth week of treatments did not affect the growth and performance of the plot.

Foliage Disease

Black spot is one of the most common rose diseases and was monitored during the study. Black spot is easy to identify because of the clearly visible black patches on mature foliage and the premature foliage senescence (Cascadia Consulting Group, 2001). In the plot there were three fungal diseases present on the leaves: black spot, downy mildew, and anthracnose.

During observation until the 9th week downy mildew and anthracnose were more commonly found on the leaves than black spot. This might be because the weather conditions were more ideal for developing both diseases. Anthracnose develops during cool, moist conditions in spring (Mouchett, 2003), and downy mildew appears on garden roses only when these ideal, or at least very favorable, conditions are present: humidity over 85% and temperatures under 80° F (Wyckoff, 2009). Both diseases require similar ideal conditions to

develop, while black spot becomes active during warm ($70\text{-}80^{\circ}\text{ F}$), wet weather and requires water on the leaves for 7 hours at 75° F to germinate (Mouchett, 2003).

There was no significant difference in black spot or fungal disease percentages among treatments up to the 9th week. The percentage of black spot or fungal disease for all treatments was less than 5% based on visual evaluation and there was no significant defoliation to the plant. It was understandable that at the end of spring and early summer fungal diseases start developing and showing the symptoms but seldom result in defoliation. Usually fungal disease becomes more aggressive during the month of August when plants experience some drought stress brought on by high temperatures and no natural precipitation (Cascadia Consulting Group, 2001).

The fungal disease that first infected the plot was downy mildew on ‘Easy Does It’ leaves in 8th week. Each variety had different fungal diseases that primarily infected them. The ‘Robusta’ rose experienced black spot and anthracnose. The Chrysler Imperial had anthracnose symptoms that were slightly different from the symptoms on the ‘Robusta’, while the symptoms on ‘Robusta’ spread more like small black dots, the anthracnose symptoms on Chrysler Imperial were bigger, fuzzy spots. The ‘Easy Does It’ rose experienced downy mildew, which was concentrated on the center-bottom leaves, while ‘Sunshine Day Dream,’ which had one or two dots or almost none of black spot or downy mildew symptoms on the leaves showed the least percentage of fungal diseases on the leaves.



Figure 11: Anthracnose and black spot on 'Robusta' rose

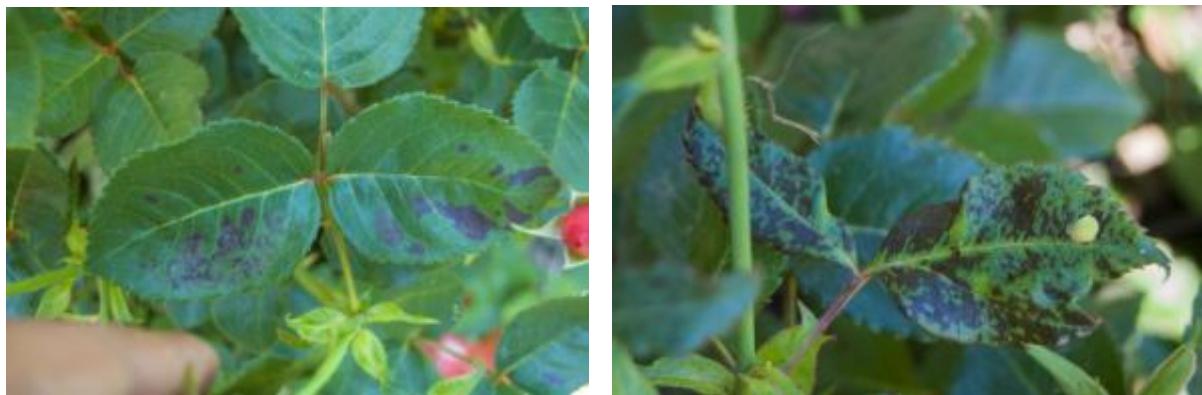


Figure 12: Downy mildew on 'Easy Does It' rose



Figure 13: Anthracnose on 'Chrysler Imperial' rose

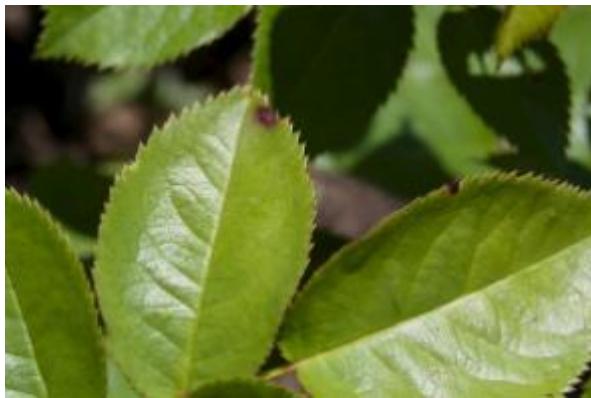


Figure 14: Anthracnose and black spot on ‘Sunshine Daydream’ rose

There were pest problems in the trial plots during the study. There were some young buds eaten by deer in the first week. This was caused by loose gates in the nursery fence. The problem was solved by putting plastic chain on the gates to make sure they would not open easily. There were aphids and midges attacking in about the 5th week. A high population of aphids on the plants attracted lady bugs and praying mantis as biological pest controls. Both of them are beneficial insects that can suppress aphids, mites, and other arthropods. Encouraging beneficial insects by providing suitable living conditions is a pest control strategy often used in organic farming, organic gardening, or IPM. In the 9th week there was a minor rose slug attack. We did not spray any insecticide to the plots since the damage or the pest population was still at a reasonable level.



Figure 15: Deer (left) and rose slug damage (right)



Figure 16: Symptoms of aphid attacks.

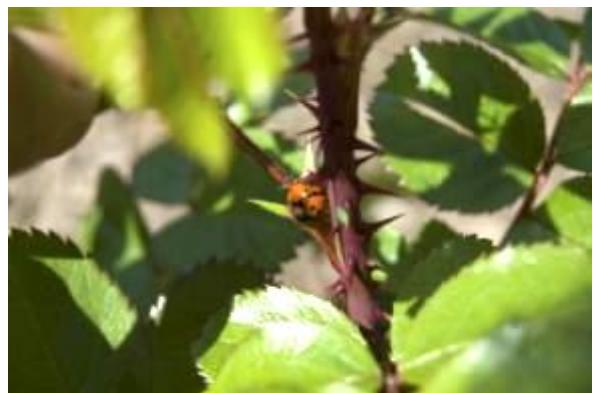


Figure 17: Beneficial insects— praying mantis and lady bug.

CONCLUSION AND RECOMMENDATIONS

Black spot and downy mildew were two common fungal diseases found in the Rose Garden and were the main cause of defoliation for most of the roses regardless of the type (shrub, hybrid tea, floribunda, and grandiflora). Every rose responded differently to the development of fungal disease infection. Some of them, mostly shrub roses were quite tough and resistant, and mostly hybrid tea, floribunda and grandiflora including AARS winners were not resistant. The resistance level might be variable in different places and under different conditions. Some of the varieties that claim to have resistance to black spot or fungal disease performed otherwise condition in the garden.

There are some organic fungicides in the market that can be used for organic rose gardening. Compost tea as the current treatment in the Rose Garden is still facing a challenging future and further study is needed to achieve better results. CEASE and Green Cure are two organic fungicides that were recommended by Brooklyn Botanical Garden and the Philadelphia Rose Society.

After 9 weeks of study there was no significant difference in growth and performance among the treatments. There was also no difference in fungal disease percentage or defoliation among the treatments since the fungal disease just started to develop by the end of study. Based on the visual evaluation, ‘Sunshine Daydream’ was the most resistant variety among other three varieties showing the least fungal disease present on the leaves.

Since the study will achieve better results by the end of growing season in October, continuing treatment and observation is encouraged until the end of October to determine the percentage of fungal disease present or the percentage of defoliation among the treatments and varieties. Furthermore, a cost analysis and biological soil test could be done to add more input or recommendations to the IPM program in the garden.

LITERATURE CITED

- Bechtol, Nancy J. *Guidelines for Establishing an Integrated Pest Management Program in a Public Garden*. Thesis, Longwood Graduate Program, June 1988.
- Cascadia Consulting Group. 2001. *Compost Tea Trials Final Report*. Office of Environmental Management, City of Seattle.
- Flint, Mary L., S. Daar, R. Molinar. *Establishing Integrated Pest Management Policies and Program: A Guide for Public Agencies*. University of California, Division of Agriculture and Natural Resources. Publication 8093. 2003.
- Greene, Catherine, Carolyn Dimitri, Biing-Hwan Lin, William McBride, Lydia Oberholtzer, and Travis Smith. *Emerging Issues in the U.S. Organic Industry*. EIB-55. U.S. Dept. of Agriculture, Economic Research Service. June 2009
- Mouchet, Paulette. *Blackspot? Anthracnose? Rust?*. The Rose Garden Newsletter. May 2003.
- Owens, S. 2011. *Restoration of Cranford Rose Garden*.
www.bbg.org/news/restoration_cranford/
- Rakow, Donald A., and Sharon A. Lee. 2011. *Public Garden Management*. John Wiley & Sons, Inc., Hoboken. New Jersey.
- Wallis, C and D. J. Lewandowski. *Black Spot of Roses*. The Ohio State University, Department of Plant Pathology. 2008.
- Wyckoff, Jeff. *Downy Mildew*. American Rose Society. June 2009.

APPENDIX A : TREATMENTS DETAIL

Compost Tea

Compost tea is a solution created by extracting microorganisms and nutrients from compost. Compost tea is produced by mixing compost with water and culturing it for a defined period, either actively aerating (aerated compost tea, ACT) or not (non-aerated compost tea, NCT) with or without an additive that is intended to increase microbial population densities during production (NOSB, 2004). In the last ten years methods for making aerated compost teas have been determined and it has grown in popularity in the United States, with global interest also increasing (Ingham, 2005). Compost tea has been demonstrated to be an effective source of beneficial organisms and can help restore the natural function of healthy soil, increase available water to plant roots, and protect roots and other plant tissue from pathogens and diseases (Cascadia Consulting Group, 2001).

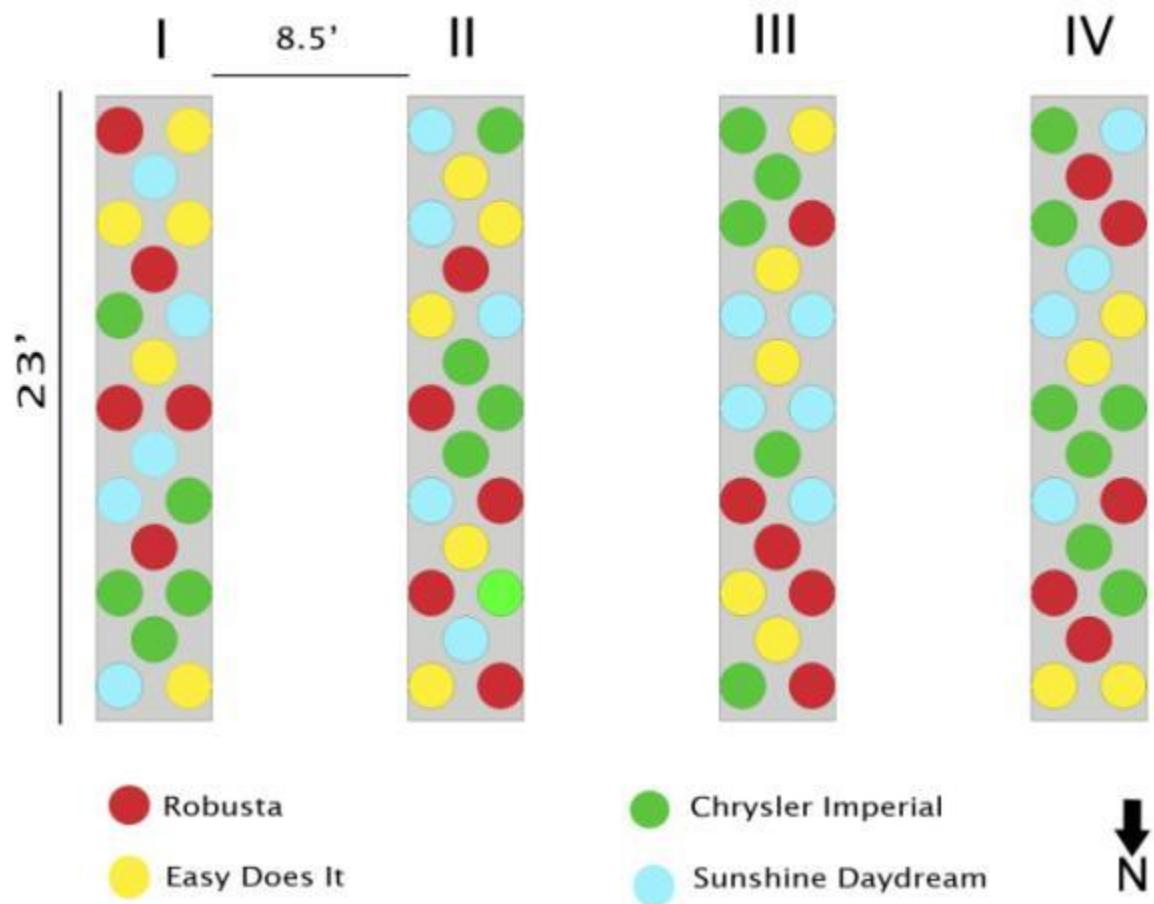
CEASE ®

CEASE is a contact biological fungicide that contains a patented bacterium, *Bacillus subtilis* and is approved by the National Organic Program (NOP) for organic production. It controls common fungal and bacterial diseases on foliage and soil. The bacterial spores occupy space on the plant surface and compete with the pathogens, then active compounds called lipopeptides produced by each bacterium, disrupt the germination and growth of invading pathogens. The benefit of CEASE is its safety. It is exempt from the residue tolerances in food crops, has a 0 day Pre-Harvest Interval, and a four hour Restricted Entry Interval (REI). CEASE can be affected by rain or overhead irrigation, therefore applying it with a spreader sticker (such Therm XTM70) might be needed. It is recommended to spray once a week for prevention when conditions are optimum for disease. The most commonly used rate is 4 quarts per gallon per acre.

Green Cure ®

Green Cure is a potassium bicarbonate-based fungicide that has been proven for 12 years to cure and prevent powdery mildew, black spot downy mildew, blight, mold, and other plant diseases. Potassium bicarbonate is a naturally occurring compound that is widely used in food and is 25 to 35 percent more effective than sodium bicarbonate (baking soda). It is registered for organic production by NOP and provides up to two weeks of preventive protection. It is applicable for indoor plants and has an hour pre-harvest interval. It can be used as a good preventive control for powdery mildew by applying one tablespoon per gallon of water every one to two weeks when environmental conditions are ideal for the disease. One gallon of solution is sufficient to treat approximately 450 square feet.

APPENDIX B : Plot Layout



Plot Treatments

I : Compost Tea

II : Control

III : CEASE

IV : Green Cure

APPENDIX C : Trial Schedule

The schedule was designed for one study period, beginning in April until October 2012. This report covers the observations from beginning up to first week of June 2012.

Month	Week	Control	Compost Tea	CEASE	Green Cure	Documentation	Observation
April	I	PLANTING				✓	
	II						
	III					✓	
	IV					✓	
May	I	✓	✓	✓	✓	✓	✓
	II	✓		✓	✓	✓	
	III	✓		✓	✓	✓	
	IV	✓		✓	✓	✓	
	V	✓		✓	✓	✓	
June	I	✓	✓	✓	✓	✓	✓
	II	✓		✓	✓	✓	
	III	✓		✓	✓	✓	
	IV	✓		✓	✓	✓	
July	I	✓	✓	✓	✓	✓	✓
	II	✓		✓	✓	✓	
	III	✓		✓	✓	✓	
	IV	✓		✓	✓	✓	
Aug	I	✓	✓	✓	✓	✓	✓
	II	✓		✓	✓	✓	
	III	✓		✓	✓	✓	
	IV	✓		✓	✓	✓	
	V	✓		✓	✓	✓	
Sept	I	✓	✓	✓	✓	✓	✓
	II	✓		✓	✓	✓	
	III	✓		✓	✓	✓	
	IV	✓		✓	✓	✓	
Oct	I	✓	✓	✓	✓	✓	✓
	II	✓		✓	✓	✓	
	III	✓		✓	✓	✓	
	IV	✓		✓	✓	✓	
	V	✓		✓	✓	✓	✓

APPENDIX D : Measuring Scale of Black Spot

The measuring scale below is modification of black spot measuring of Conard Pyle Company (Star Roses).

<20% susceptible to black spot	0-19% of the foliage is showing symptoms of black spot or has already defoliated
40% susceptible to black spot	lower 40% of foliage is showing symptoms of black spot or has already defoliated
60% susceptible to black spot	lower 60% of foliage is showing symptoms of black spot or has already defoliated
80% susceptible to black spot	80% of the foliage is showing symptoms of black spot or has already defoliated
100% susceptible to black spot	no foliage

TITLE: **Incentivizing Conservation in the Mid-Atlantic States and Beyond: An Assessment of Conservation Strategies for Private Landowners**

AUTHOR: **Breck Miller**
The John J. Willaman & Martha Haas Valentine Endowed Plant Protection Intern

DATE: **May 2011**

ABSTRACT:

Fragmentation of open land has been a consistently increasing problem in the Mid-Atlantic States and many other parts of the country. The rapid spread of urban areas and the high price of maintaining large areas of open land are putting ever increasing pressure on private landowners to subdivide their properties for sale and subsequent development. Furthermore, the high costs of maintaining land compared with the relatively low economic yields of many farms and working forests compel the owners of those lands to utilize unsustainable management practices that may degrade the integrity of the property and the surrounding landscape as a whole.

While these factors, combined with a depressed economy, make it increasingly difficult for owners and managers of large tracts of land to maintain their properties intact and in an ecologically sustainable manner, there are several opportunities that exist to encourage the maintenance of open space and the use of sound management practices by lessening the costs of land ownership or sharing in the costs of conservation. Funding for these programs comes from federal, state, and private sources. This paper will discuss federal conservation incentive programs, state preferential tax assessment programs in the Mid-Atlantic, conservation easements and land trust organizations, and the future potential of the carbon credit trade. Together, these can provide a strong economic incentive for land conservation and stewardship, and may help to slow the rapid spread of urbanization.

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INTRODUCTION

In this and many other areas of the country, economic pressures are driving landowners to sell their properties for development or pursue unsustainable land management practices, resulting in large-scale parcelization and degradation of the land. For many, the cost of owning large tracts of land can be excessive, and the potential financial gains from selling may be great. In the case of working landscapes such as farms or actively managed forestland, the high costs of land ownership compared to the relatively low yields of the given land use may encourage ecologically unsound but economically practical management practices. According to the Pennsylvania Department of Conservation and Natural Resources, over 100,000 acres of open space and wildlife habitat are lost annually in Pennsylvania alone [1.] According to a study by Rowan University, the rate of urbanization of open land in New Jersey was 16,061 acres per year between 2002 and 2007, with 324,256 total acres urbanized between 1986 and 2007. The current urban footprint in New Jersey covers over 30% of the area of the state [2.] Furthermore, the 2010 census found that New Jersey is the nation's most densely populated state, and Delaware the eighth, with the 11th highest population growth rate [3.]

With growth and development rates such as these, it is clear that open areas in many parts of the Mid-Atlantic are under a continually growing demand and increasing threat. Fortunately, several options exist for landowners that lessen the financial burden of maintaining large undeveloped areas and encourage quality land stewardship over exploitative management practices. While these options generally cannot produce the same economic gains that may be available through sale to developers, they have made it feasible for many property owners who truly value their land to maintain it and treat it in a way that is both ecologically sustainable and beneficial to society.

Among the options available to landowners are federally funded programs, state-run programs, and conservation easements, which can draw benefits both from the government (through tax breaks) and private money from the individual land trust. Another intriguing option is the sale of forest carbon credits—a concept with major potential to incentivize conservation but currently in the developmental stage. The opportunities available to a given landowner vary depending on the size of the parcel, the land use type and cover (agriculture, forest, meadow, etc.,) and the ecological value assigned to the land by the funding agency. Benefits range from tax breaks for simply holding a given acreage of undeveloped land, to payments or cost-share for improved management, to payments and tax breaks for ceding the development rights for a given property. While these programs combined have delivered billions of dollars to landowners either through direct payments or averted costs, many remain underutilized, with the potential for much greater and more efficient use [4.] Reasons for underutilization range from lack of publicity to the complexity of application processes. While many of these programs, especially on the federal level, are in line to lose funding pending the updated 2012 Farm Bill, they remain a very important resource for land owners, land managers, and conservationists, and steps should be made to make them more accessible when necessary.

STATE PROGRAMS

Many states in the U.S. have some form of program to ease the financial burden of owning large tracts of open land. This is especially true when it comes to land used for commercial agriculture or forestry practices, but in some cases, benefits also exist for non-commercial land use. Usually, benefits for landowners on the state level take the form of property tax breaks. When preferential taxation is not applied for, a landowner's property taxes are based on the land's "best and highest use," usually the development value of the land, whether or not the owner has any intentions of actually developing it. Most of the Northeastern states, including Pennsylvania, New Jersey, Delaware, New York, and all of New England, tax breaks for landowners exist in some form [5.] The general idea behind these programs is to reassess the value of a given property for its current use (i.e. undeveloped forest, managed forest, commercial agriculture, etc.) rather than its development value, and adjust property taxes accordingly. The terms for application and the financial extent of breaks varies widely from state to state, with differing requirements for minimum parcel size, land use type, and land cover type. The overall goal of encouraging landowners to maintain their undeveloped land is consistent, however, and plays an important role in slowing the loss or parcelization of open spaces.

PENNSYLVANIA "CLEAN AND GREEN PROGRAM"

In Pennsylvania, the landowner tax relief program is known as "Clean and Green," or Act 319—the Pennsylvania Farmland and Forestland Assessment Act. This act first came into law in 1974, and allows taxes for qualifying land to be assessed based on current use value rather than fair market value. The fair market value reflects a price that would be reasonable to both buyer and seller and reflects not only the current use of the land (undeveloped, for instance,) but also the potential value of the land under its "best and highest use," which often means development. The maximum use value for each county is determined by the Pennsylvania Department of Agriculture on a yearly basis, although counties may apply to administer lower use values than those assigned. There are three basic land classifications eligible for Clean and Green; *agricultural use*, *agricultural reserve*, and *forest reserve*, each with different use values and requirements. For all three designations, the parcel must be a minimum of ten contiguous acres.

AGRICULTURAL USE

Land enrolled in Clean and Green under the heading of *agricultural reserve* must have been devoted to agricultural practices for at least three years prior to enrollment, and failing to meet the ten acre minimum for the program, must produce a gross income of at least \$2,000 per year from agricultural practices. Land is still eligible even if the owner is not the one farming (i.e. the property is being rented.)

AGRICULTURAL RESERVE

Any parcel of open land ten acres or greater is eligible for Clean and Green under the designation of *agricultural reserve*, as long as it remains open to the public, free of charge, for “outdoor recreation or enjoyment of the land’s scenic or natural beauty.”

FOREST RESERVE

Forested parcels ten acres or greater can be enrolled in Clean and Green as *Forest Reserve*, as long as they are capable of producing 25 cubic feet (300 board feet) per acre, per year.

DETERMINATION OF USE VALUE

For *forest reserve* properties, use value is calculated for each county dependent on forest type and based on average timber yield and pricing in the given area. There are six forest types used in the calculation, including softwoods, select oak, oak, northern hardwoods, black cherry, and miscellaneous hardwoods, each with different yields and pricing depending on the region of the state, which is broken into quadrants (northwest, northeast, southwest, and southeast.) The equation used for calculating use value is as follows:

$$\text{Assessed value} = \frac{\left[\frac{(P * Y)}{R} - C \right] * (1 - t_i)}{i + t_m(1 - t_i)}$$

where:

P= stumpage price/ unit of wood based on a ten year average

Y= yield of wood at rotation age

R=rotation age (80 years)

C=average annual management costs (\$4.64/acre in 2008)

Ti=combined state and federal income tax (18.07%)

i=averaged 8-year real interest rate

tm=effective property tax rate

This value is then multiplied by the acreage of the property and the mileage rates for the given county, municipality, and/or school district to determine a landowners property tax. A weighted average of timber values for the six forest types may or may not be used, depending on the county [6.]

A similar process exists for the assessment of property taxes for *agricultural use* and *agricultural reserve* properties, with soil quality and crop yield factors varying by county. The equation used is as follows:

$$V = \frac{N/GR \text{ (VCR) (PRI)}}{r}$$

where:

V=use value

N/GR=10 year rolling average of state crop profit margin percentage

VCR=10 year rolling average of value of crop receipts per acre by county for field crops

PRI=soil index factor adjusted for cost of production by county by 'Land Capability

Class and Yield'

r=10 year rolling average capitalization rate for 15 year fixed loan interest rate for landowners from federal land bank sources or, put more simply, use value/acre=

$$\frac{\text{farm income}}{\text{interest rate}}$$

[7](source: Lancaster County Bureau of Farmland Preservation)

While districts have the right to calculate their own use value rates rather than use the averages supplied by the Department of Agriculture, the labor and technical knowledge required to undertake this task is a deterrent to the majority of counties [6.]

As of 2008, thirteen of the counties in Pennsylvania, including Philadelphia County, had no properties enrolled in Clean and Green [9.] Generally, this is the result of out-of-date property assessment baselines. In each county, the tax on a piece of land not enrolled under Act 319 is calculated in relation to the property values determined by the latest county-wide property value assessment. After the market value of a property is determined in terms of the base year, a predetermined ratio, or assessment ratio, is applied to determine the real taxable value. For instance, if the base year value of a property is \$100,000, and the county's assessment ratio is 40%, then the taxable value of the property is \$40,000. The assessment ratio in a county can range between 20 and 100 percent, and the counties where Clean and Green is not used are those where out of date baseline assessments make taxable value of land lower than the values for land enrolled in the program [10.]

TERMS OF USE

A property remains enrolled in the Clean and Green program for as long as the land use is compliant with the program requirements. Because the main purpose of Act 319 is to avert the subdivision of open land, landowners with property enrolled in the program may be subject to 'rollback' taxes as a consequence for breaking the terms of the agreement. Up to 10% of the enrolled property or a maximum of 10 acres may be removed from the area at a maximum rate of two acres per year without consequence. Divisions exceeding this rate make the owner of the

property subject to repay tax savings on the given area for the last seven years, with an interest rate of 6%. If land is subdivided for sale but remains in a compliant land use with both landowners agreeing to the terms of Act 319, enrollment continues for both properties without any penalty [11.]

Applications for the Clean and Green program are due between January 1 and June 1 to the assessor's office of the given county. Several fees exist for applying and enrolling in the program, totaling around \$150.

NEW JERSEY

New Jersey uses a preferential tax assessment program known as the New Jersey Farmland Assessment Act. The minimum eligible parcel size for enrolled land is 5 acres. The land must have been devoted to agricultural or horticultural uses for at least two years prior to enrollment, and gross sales of products from the land must average at least \$500 per year for the first five acres, plus an additional \$5 per acre for each acre over five acres. In the case of forest land, only \$0.50 per acre over five acres is required [28.]

NEW YORK

New York has a significantly more stringent tax policy for taxation on forested or agricultural lands. Under section 480-a of the NY Real Property Tax Law, owners of forest land may have their property taxes assessed based on use-value only if the property contains a minimum of 50 contiguous acres of forest land that is being actively managed according to the terms of an approved management plan, written by a certified forester. The landowner is liable for continuing management for a given commitment period (specified by the management plan) and is required to pay rollback taxes if the land is sold or converted to an ineligible use during that period. The NY Agricultural Districts law applies to land used for commercial agriculture, and allows owners to receive preferential tax assessment on farm properties where gross agricultural revenue averages \$10,000 per year. Similar penalties exist for converting enrolled farmland to ineligible uses [25.]

CONSERVATION EASEMENTS

Land trusts play an incredibly important role in the conservation of open land in this region, and across the country. According to the 2010 Land Trust Alliance national land trust census, over 47,000,000 acres of land have been conserved by land trusts nationwide—an increase of almost 50% since the 2000 census [12.] Pennsylvania is home to 103 land trust organizations, and as of 2010 has conserved 492,476 acres [13.] New Jersey has 37 land trust organizations, with 233,578 acres conserved. Delaware, with six trusts, has conserved 103,297 acres, and Maryland, with 56 trusts, has conserved 190,640 acres [12.] Areas conserved include important natural areas and wildlife habitat, wetlands, open space, working farms and forests, recreation lands, and areas of historical or cultural significance. In the 2010 census, these were found to be the top priorities for conservation among land trusts in descending order, with natural areas/wildlife habitat considered a top priority by 93% of trusts, and historic/culturally significant areas a priority for 36% [12.]

Most land trusts are considered private charitable organizations, although some are governmental or “quasi-governmental agencies” [14.] Land trusts vary widely in size, and operate on scales from the township level to the entire country. These organizations work to permanently protect land through the use of conservation easements, by buying and maintaining properties, or in some cases by temporarily acquiring them in order to transfer ownership to another entity (usually a state government.) Conservation easements are a voluntary but legally binding agreement between a landowner and the land trust agency, in which the landowner maintains ownership of the property, but gives up the right to certain actions on that land. What rights the landowner cedes or maintains is agreed upon by both the owner and the land trust and will be different for every easement. The main stipulation of most easements is that the owner gives up to rights to development the property. However, the easement may be negotiated to allow limited construction (a house for personal use, for instance,) timber or agricultural management, hunting, etc. Depending on the terms of the easement, the property may remain private, or may be made open to the public.

In addition to benefiting the public and the environment by preserving open space and natural areas, conservation easements can have a significant economic impact for the landowner. In many cases, easements help to lessen the financial burden of owning large tracts of land that forces many people to subdivide their property for development. Depending on the arrangement, financial benefits can include direct payment from the land trust, federal tax benefits, or both.

ECONOMIC BENEFITS FROM CONSERVATION EASEMENTS

Placing your land under a conservation easement is considered a charitable donation by the Federal government, and is therefore tax deductible. Until recently, the tax incentive for donating was quite large. Unfortunately, a temporarily expanded increase in allowable federal tax deductions, which began in 2006, expired in December, 2011, and a bill to reinstate them is pending. In either case, the value of the donation is the difference between the donated property’s appraised value with the easement in place and its value without the easement. Between 2006 and 2011, landowners agreeing to an easement were able to deduct up to 50% of their gross income per year for up to 16 years, with qualifying farmers able to deduct up to 100% of their gross income, making it possible to gain tax savings of close to the original value of the property. With these incentives expired, landowners are able to deduct only 30% of their gross income per year over a period of just six years.

As an example, under the enhanced tax status, an agricultural landowner with a gross income of \$50,000 per year with a property valued at \$1,000,000 could recoup up to \$800,000 in tax deductions, while under the current conditions they will receive no more than \$90,000. While the increased tax incentives for conservation easements are currently expired, there is a great deal of support to have them reinstated, from both land trust organizations and politicians. According to Pennsylvania Congressman Jim Gerlach, there are 300 co-sponsors in the House of Representatives (a majority) supporting a bill that will make the 2006-2011 tax incentives permanent [16.] While the ultimate fate of the bill remains to be seen, its importance is obvious, and its status seems hopeful.

ESTATE TAX BENEFITS

Estate tax policies on conserved land can also be a significant economic incentive for placing land under a conservation easement. Easements can save money for the inheritors of an estate in a few ways. Firstly, because a conservation easement lowers the resale value of a property, the assessed value of the entire estate of the deceased will reflect this loss in value, and therefore lower the overall estate taxes to be paid. Under section 2031(c) of U.S. tax code, an additional 40% of the value of the conserved land (up to \$500,000) may be deducted from estate taxes in addition to the value of the easement. These benefits may also be received by the inheritors of an estate who choose to enroll the property in an easement agreement after the death of the estate owner [26.]

CARBON CREDITS

The sale of carbon credits is an intriguing but so far undeveloped prospect for private owners of large tracts of forest land. The congressional rejection of a proposal for a national cap and trade system for CO₂ in 2009 was a major setback in the development of carbon markets in the U.S. Hope was restored in October of 2011, however, when the California Air Resources Board adopted a state-wide cap and trade system for greenhouse gasses, which as a part of California's climate change law AB 32, is meant to lower the state's atmospheric carbon to 1990 levels [17.] Under this system, greenhouse gas-emitting entities like oil refineries and generators of electricity that produce levels of CO₂ over the given cap will be required to make up the difference between the cap and their CO₂ emissions by buying carbon credits. These may be supplied from a number of sources, including other emitters that have accumulated credits by outperforming the standards, or from individuals or corporations that have accumulated credits by registering sources of carbon sequestration or reduction such as forests, equipment upgrades, or technology like solar or landfill gas-to-energy production.

Compliance with California carbon standards is currently on a voluntary basis, but will become mandatory in 2013. The California Climate Action Registry (CAR) is currently one of the main mediators for carbon exchange in California, and acts as a market place for the sale and purchase of carbon credits from around the country. The CAR is not third party certified, and at this early stage in the development of the carbon trading system, there are no officially sanctioned carbon registries. However, the CAR is considered to be a preliminary model, and will be absorbed by the California Air Resources Board in 2013 after receiving third party verification. Enrollment with the CAR at this point is a way for producers and consumers of carbon credits to ease into the system—current credits are considered “early action” and are pre-approved for the transition to the official Air Resources Board registry.

There are four protocols for registration of carbon credits within the CAR at this point, including forestry, ozone reduction, livestock management, and urban forestry. Under the heading of forestry are three sub-categories—avoided conversion, improved forest management, and reforestation projects, each with different standards for acceptance. *Improved forest management* projects can include any form of management that maximizes the carbon storage

rates or capacity of forests. Practices can include extending rotation ages for harvesting, reducing stocking to increase growth or increasing stocking in under-stocked areas, or avoiding/reducing harvest rates. As the name suggests, *reforestation* projects involve allowing land that was recently, but is not currently forested, to reestablish forest cover. *Avoided conversion* projects require the land to be placed under a conservation easement permanently protecting the land from development and deforestation. To be eligible, the landowner must prove that the land can legally be converted (according to zoning laws, likelihood of development plan approval, etc.) and show that the land has a higher monetary value from its potential converted use than it does in its current state. The sale of the property for agriculture or development must be shown to have a potential yield of at least 40% greater value than the current use. The ownership of the carbon credits granted must be written into the terms of the easement, but it is possible for the landowner to gain both the financial benefits associated with conservation easements and the profits from sale of carbon credits.

The CAR has several forest carbon projects, covering almost three million acres of land. While there are no current reforestation projects, the CAR has 96,000 registered carbon credits from avoided conversion projects, and 2.8 million credits from improved forest management projects, with more in line for verification. One carbon credit is equivalent to one metric ton of CO₂. According to one study, roughly 150 tons of CO₂ equivalent are released per acre of developed forest land in the northeastern U.S. (including Pennsylvania) [27.] While it is not yet clear how the carbon markets will develop in this part of the country, at the current average of around \$10.00 per credit (one ton of CO₂ equivalent,) owners of large forest parcels could stand to make a significant amount of money even if only paid for part of their forest carbon assessment (for instance, only for above ground biomass.) If the market continues to develop, the potential sale of carbon credits could become a significant incentive for landowners to maintain contiguous and functional forest land.

FEDERAL PROGRAMS

The federal government is a major source of funding for conservation projects all around the United States, with several organized programs for administering such funds. These programs are run mostly through the U.S. Department of Agriculture, and organized by individual bureaus within the USDA such as the Natural Resources Conservation Service (NRCS,) the Farm Services Agency (FSA,) and the U.S. Forest Service (USFS.) While the activities encouraged by these programs are diverse, the general structure usually falls into three categories: cost share, land rental, or direct payment for conservation activities. Funding also varies widely depending on the program, but is administered to and distributed by state and/or county offices for the given agency. This paper will cover some, but not all, examples of each federal project type. In most cases, enrollment in these programs can be carried out through local (state or county) NRCS or FSA offices.

DIRECT PAYMENT FOR CONSERVATION ACTIVITIES

CONSERVATION STEWARDSHIP PROGRAM

The Conservation Stewardship Program is administered by the Natural Resources Conservation Service. Under this program, participating landowners—farmers or working forest owners—are paid based on a point system. Under this system, various conservation or environmentally friendly management activities are assigned point values based on their cost to administer and their relative ecological significance. The more points the landowner accumulates, the more they are paid. The payment rate per point depends on what the land use is (cropland, pasture/cropland, pasture, range, or forest) and whether or not the activity being rewarded was in place prior to enrollment (existing) or requires action by the landowner after enrollment (additional.) The price range per point for existing activities is between one cent (range) and five cents (pasture/cropland) per point, per acre, while the prices for additional activities range from about 16 cents (range) to 50 cents (cropland) per point, per acre [19.]

Activities supported by the CSP are numerous, ranging from adjusting chemical spray booms on tractors to reduce wind drift, to leaving grain crops un-harvested to promote wildlife. Other actions include: deriving nitrogen primarily from legumes, livestock and compost to reduce inorganic fertilizer use, no-till crop production, small-scale silvicultural practices to improve forest stand quality and wildlife habitat, integrated pest management plans, organic farming, and many others [21.]

The national budget for the Conservation Stewardship Program for fiscal year 2012 is \$1.15 billion, with a maximum of \$40,000 to be allotted per contract. The average national payment for CSP contracts is \$18.00 per acre. CSP is an important program in Pennsylvania; as of the end of 2010, there were 565 contracts, covering 166,101 acres, paying out \$3,974,217. The average contract value was \$7,034, at an average of \$24.00/acre. Several other Mid-Atlantic States receive significantly smaller CSP funding—FY 2010 funding is as follows: MD: \$741,914, DE: \$349,904 NJ: \$71,225. NY receives funding close to that of PA, totaling \$3,287,632 for FY 2010 [20.]

FEDERAL COST SHARE PROGRAMS

ENVIRONMENTAL QUALITY INCENTIVE PROGRAM (EQIP)

The Environmental Quality Incentive Program is a federal cost share program for agricultural producers (a designation which includes owners of working forests.) Generally, EQIP will pay for up to 75% of the costs for management plans and subsequent activities that lead to improved soil, air, or water quality, wildlife habitat, and surface and groundwater conservation. The FY 2012 budget has yet to be announced, but payments for individual projects are capped at \$300,000. While most projects involving private landowners do not exceed a few thousand dollars, some major NRCS initiatives, like the Chesapeake Bay Watershed Initiative receive funding exceeding the \$300,000 cap; In FY 2010, this project received a total of over \$7 million in EQIP funding, with the PA NRCS contributing the most money, at \$8.37 million, and

WV contributing the least, at \$1.86 million (participating states include DE, MD, NY, PA, VA, and WV [21.]

In the Mid-Atlantic region, project funding on private property range from \$1,000 to \$6,000 per year. There are a wide range of management programs eligible for EQIP funding, including the creation and implementation of forest management plans, grazing management plans, integrated pest management and chemical reduction plans, drainage water management plans, fish and wildlife habitat management plans, and several others.

The EQIP program also includes a feature through which it distributes “conservation innovation grants,” which are given to owners of working farms or forests implementing creative solutions to environmental degradation on their land. \$37.5 million is allocated for conservation innovation grants annually.

WILDLIFE HABITAT INCENTIVE PROGRAM

WHIP is another NRCS cost share program, providing both financial and technical assistance for projects aiding in the creation, protection, or enhancement of fish and wildlife habitat. Generally, WHIP participants sign a 15 year contract agreeing to enhance and protect habitat on their property, with the federal government paying up to 75% of the costs of the project. For contracts exceeding 15 years, the government will pay up to 90% of project costs. In either case, the government contribution to projects is not to exceed \$50,000 per contract.

The Wildlife Habitat Incentive Program is to play a key role in a recently announced, nationwide initiative, known as Working Lands for Wildlife, which will use funding from WHIP and other federal programs to protect wildlife on working farms or woodlands. This initiative will target the protection of several species, including the greater sage-grouse, New England cottontail, bog turtle, golden-winged warbler, gopher tortoise, lesser prairie-chicken and the Southwestern willow flycatcher. WHIP funding in PA and surrounding states will be focused on protecting the bog turtle and the golden winged warbler. While the funding for WHIP under the next farm bill has yet to be announced, funding through FY 2012 has been \$85 million per year nationally [22.]

FEDERAL LAND RENTAL PROGRAMS

CONSERVATION RESERVE PROGRAM (CSP)

The Conservation Reserve Program is a Farm Services Agency program seeking to conserve and improve the soil, water, and wildlife resources by temporarily removing land from agricultural production. Under this program, owners of working farms sign contracts lasting for 10 to 15 years, agreeing to establish cover crops such as native grasses, which will improve wildlife habitat, provide forage, or encourage pollinators. Rented properties can also be planted with native hardwood trees, with contracts exceeding 15 years.

The rental rates for a given property are based on the relative soil quality and projected agricultural yields for the county, as well as current local land rental rates. Payments generally range from \$50 to \$200 per acre, with an average of about \$100 in Pennsylvania. Enrollment for this program is competitive, and priority is given to properties where removal from intensive agriculture is expected to have the most profound impacts. This is based on the potential for creating or improving habitat, reducing erosion, runoff, and subsequent water pollution, improving air quality through reduced wind erosion, and the expected longevity of the impacts of the projects [23.]

THE FUTURE OF FEDERAL PROGRAMS

All of these federal conservation programs, and many more like them, are dictated by the terms of the U.S. Farm Bill, which is updated once every five years or so. Among other things, the Farm Bill determines the overall budgets for the U.S. Department of Agriculture, for the individual agencies within the USDA, such as NRCS, FSA and the U.S. Forest Service, and for the programs administered by those agencies. The 2012 Farm Bill is currently being drafted, and given the major deficit in the U.S., the updated version is likely to include severe budget cuts. While the actual extent of these cuts has not yet been determined, a resolution in the House of Representatives last July proposed cuts of up to \$48 billion.

While most, if not all of the federal conservation programs are likely to be impacted by the new Farm Bill, there are some programs that have already been cut, and several with no baseline funding past FY 2012. Programs that have been cut include the Forest Service's Forest Stewardship Program and Forestry Incentives Program, which were cost share programs for the drafting of forest management plans and the implementation of those plans, respectively. Programs that lack baseline funding past 2012, and are thus unlikely to be renewed, include the Healthy Forest Reserve Program, the Wetlands Reserve Program, the Grassland Reserve Program, and the Small Watershed Rehabilitation Program [24.]

According to a PA NRCS employee interviewed for this paper, these budget cuts will likely mean a restructuring of the way conservation funds are distributed. While several programs are going to either end or lose significant funding, some of the programs that have been found to have the greatest impacts will have funds from discontinued programs diverted to them. According to this representative, the emphasis will be on projects like the Chesapeake Bay Watershed Initiative and the Working Lands for Wildlife Initiative, which focuses funds and efforts on very specific targets, where results are likely to be visible or have an impact on a landscape scale. At this point it is uncertain what will really happen, but it may be that there is less funding for general projects on private land that do not necessarily contribute to a greater and coordinated goal. The programs detailed in this paper are unlikely to lose major funding under the next farm bill, and in the case of programs like WHIP and EQIP may actually stand to gain funding.

REFERENCES

- [1] PA Department of Conservation and Natural Resources, 2001. “Options and Opportunities.” <http://www.dcnr.state.pa.us/wlhabitat/options.aspx>
- [2] Hasse, John et all, 2010. “Urban Growth and Open Space Loss in New Jersey from 1986 through 2007”. <http://gis.rowan.edu/projects/luc/>
- [3] United States Census Bureau, 2010. “2010 Census Data.” <http://2010.census.gov/2010census/data/>
- [4] Jacobson, M., et al, 2009. “Financial Incentive Programs’ Influence in Promoting Sustainable Forestry in the Northern Region.” Northern Journal of Applied Forestry. 26 (2)
- [5] U.S. Forest Service, 2009. “Forest Incentive Services Available from State Sources.” <http://www.srs.fs.usda.gov/econ/data/forestincentives/state.htm>
- [6] Jacobson, Michael, 2009. “Understanding Forest Property Tax Assessment in Pennsylvania.” Penn State: Forest Finance. Vol. 4.
- [7] Lancaster County Bureau of Farmland Preservation. “Agricultural Use and Agricultural Reserve Valuation. http://www.co.lancaster.pa.us/lanco/lib/lanco/propertyassessment/ag_formula.pdf
- [9] PA Legislative and Budget Finance Committee, 2010. “Fiscal Impact of Preferential Assessment of Farm and Forest Land (Clean and Green Program.”) <http://lbfc.legis.state.pa.us/reports/2010/37prs.PDF>
- [10] State of PA, 2007. “Real Estate Assessment Process in Pennsylvania, an Overview.” Pennsylvania Legislator’s Municipal Deskbook, vol. 3.
- [11] Lancaster County Board of Commissioners. “Act 319- the Clean and Green Program: General Questions and Answers.” http://www.co.lancaster.pa.us/lanco/lib/lanco/act_319_guidelines_156.pdf
- [12] Land Trust Alliance, 2010. “National Land Trust Census 2010 Final Report.” <http://www.landtrustalliance.org/land-trusts/land-trust-census/national-land-trust-census-2010/2010-final-report>
- [13] PA Land Trust Association, 2010. “PA Land Trusts Protect 57,087 Acres in Two Years.” <http://conserveland.org/articles/42>
- [14] PA Land Trust Association 2012. “Conservation 101: Intro to Land Trust Work.” http://conserveland.org/conservation_basics/con101/intro
- [16] Bedminster Regional Land Conservancy, 2012. “Donating Development Rights: The Tax Benefits of Conservation Easements.” <http://bedminsterlandconservancy.org>

[17] Hart, Julie (October 21, 2011.) “California Becomes First State to Adopt Cap and Trade Program.” The Los Angeles Times

[19] U.S. NRCS, 2012. “Environmental Quality Incentives Program.”

<http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip>

[20] U.S. NRCS, 2010. “Contracts and Dollars Obligated on Active Contracts, FY2010.”

<http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/?ss=16&navtype=SUBNAVIGATION&cid=stelprdb1045143&navid=100120300000000&pnavid=100120000000000&position=Not%20Yet%20Determined.Html&ttype=detailfull&pname=Contracts%20and%20Dollars%20Obligated%20On%20Active%20Contracts%20-%20Contract%20Fiscal%20Year%202010%20%20NRCS>

[21] U.S. NRCS, 2011. “Conservation Stewardship Program Conservation Activity List.”

http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1046211.pdf

[22] PA NRCS, 2006. “PA 517.12 Pennsylvania State WHIP Plan.”

http://www.pa.nrcs.usda.gov/programs/whip/Documents/PA_State_WHIP_Plan.pdf

[23] PA Game Commission, 2010. “Conservation Reserve Enhancement Program.”

<http://www.portal.state.pa.us/portal/server.pt?open=514&objID=622399&mode=2>

[24] Monke, Jim, 2010. “Previewing the Next Farm Bill: Unfunded and Early-Expiring Provisions.” Congressional Research Service Report for Congress.

[25] NY State Department of Taxation and Finance, 2012. “Agricultural Assessment Program-Overview.” http://www.tax.ny.gov/research/property/assess/valuation/ag_overview.htm

[26] Land Trust Alliance, 2012. “State and Local Tax Incentives.”

<http://www.landtrustalliance.org/policy/tax-matters/campaigns/state-tax-incentives>

[27] Ingerson, Ann L. 2007. *U.S. Forest Carbon and Climate Change*. Washington, D.C.: The Wilderness Society.

[28] Hitzche, Peter, 2009. “An Introduction to New Jersey’s Farmland Assessment Act.” Rutgers Cooperative Extension Fact Sheet FS1100

TITLE: An Analysis of Local Honey: Foraging Effects and Colony Fitness of Philadelphia Honeybees (*Apis Mellifera* L.)

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ABSTRACT:

Pollen, the primary dietary source of proteins, lipids, vitamins, and minerals, is essential to the physiological development of adult honey bees (*Apis mellifera* L.). A varied pollen diet is vital to immune system maintenance, organ development, and colony succession via brood production. The reasons for the recent decline in honey bee populations are wide-ranging but include a lack of diverse nectar and pollen resources. Resource deficiency and colony fitness is well understood within natural and agricultural landscapes; few studies have determined the importance of a polyfloral diet for bees existing in areas of intense development. Focusing on honey bees in the city of Philadelphia, we investigated the range of plants utilized as pollen sources and if there are significant colony-level benefits to foraging diversity. We examined the pollen content of honey samples collected from 15 Philadelphia hives from August to November 2011. Late season fitness of colonies was assessed by measuring hive-area covered by brood found in sampled hives. The findings presented here shed light on taxa visited by honey bees in an urban ecosystem. Identification and selection of plants shown to be principal pollen sources can be used to promote effective pollinator restoration programs in developing cities.

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INTRODUCTION

In most ecosystems bees (Hymenoptera: Apiformes) are the primary pollinators of flowering plants (Buchmann and Nabhan 1996, Kearns et al. 1998, Aizen & Feinsinger 2003, Ashman et al. 2004). Of particular social interest is the reliance of fruit, seed, and nut crops on apiformes, particularly managed honey bee (*Apis mellifera* L.) populations (Klein et al. 2007). Estimates place the annual global value of pollination services, including those of wild and managed bees, at \$216 billion per year, or 9.5% of the worldwide annual crop value (Gallai et al. 2009). Of course these fruits of labor do not go unrewarded. Reciprocally, from flowering plants bees derive all nutritional elements necessary for survival, growth, and reproduction.

For the adult honey bee, carbohydrates derived from nectar meet the daily cost of flying and foraging. An adult worker needs approximately four mg of useable sugar per day for survival (Barker & Lehner 1974). While nectar satisfies quotidian energetic requirements, the long term growth and reproduction of the honey bee colony is dependent on pollen intake. As the only natural protein source for honey bees, pollen is necessary for brood and young worker development. To rear one larvae 25-37.5 mg protein are needed (Hrassnigg and Crailsheim 2005) and colonies of about 50,000 individuals typically have an annual pollen budget of 20 kg (Seeley 1995). Within the hive, foraged-pollen is mixed with regurgitated nectar and glandular secretions to produce brood food, a substance of high protein value that is fed to developing larvae. Other pollen-derived nutrients include lipids, amino acids, starch, sterols, vitamins, and minerals (Roulston and Crane 2000). The nutritive importance of pollen makes it one of the primary factors influencing colony longevity. For the non-reproducing worker caste of social insects, colony growth and reproduction through increased brood rearing are the principal sources of fitness (Sagili & Pankiw 2007). Colonies without pollen supply maintain brood rearing for a limited time. During an extreme pollen dearth, bees will attempt to supply the protein demand of brood first by depleting pollen reserves and then by cannibalizing other broods. By some accounts colonies will terminate brood rearing rather than produce malnourished larvae (Imdorf et al. 1998).

Colony malnutrition may also arise from constrained foraging diversity. No other chemical constituent of pollen influences as many aspects of bee nutrition as protein. Nonetheless, not all pollen is created equal and protein concentrations range from 2.5%-61% depending on the floral source (Roulston et al. 2000). Studies cite that the reasons for recent honey bee losses include a lack of diverse nectar and pollen resources, especially within intensively farmed agricultural landscapes (Kearns et al. 1998, Winfree et al. 2007, DeCourtay et al. 2010). Naug 2009 points out that current colony declines might simply be the breaking point where nutritional stress due to habitat loss and/or homogenization is significantly contributing to the synergistic effect of numerous other stressors being experienced by bees.

For example, deficient nutrition can impair immune function and increase honey bee colonies' susceptibility to disease. Alaux et al. 2011 tested whether dietary protein quantity (monofloral pollen diets of varying protein concentrations) and diet diversity (polyfloral pollen diets) influenced the immunocompetence of honey bees raised *in situ*. They found that polyfloral diets induced higher levels of glucose oxidase, a hypopharengeal gland enzyme that enables bees to sterilize brood food. Their results show that diversity in floral resources confers increased hive

antiseptic protection. In addition to impaired immune response, non-diverse pollen diets can affect the development of young brood. Honey bees require ten amino acids for development: arginine, histidine, lysine, tryptophane, phenylalanine, methionine, threonine, leucine, isoleucine, and valine (De Groot 1953). Dandelion (*Taraxacum officianale*) pollen lacks tryptophane and phenylalanine and is deficient in arginine. Honey bees raised solely on *T. officinale* pollen will fail to rear brood (Herbert et al. 1970), but supplementation of L-tryptophane L-phenylalanine and L-arginine restored brood rearing (Herbert 1992).

The importance of polyfloral foraging (polylecty) for honey bee development and survival draws a distinct connection between habitat heterogeneity and colony fitness. Human disturbance, particularly the loss of natural and semi-natural habitats, is regarded as a primary cause of pollinator decline (Kearns et al. 1998, Kremen et al. 2002, Aizen and Feinsinger 2003, Goulson et al. 2008, Winfree et al. 2009). A deficiency in nectar and pollen resources will lead to demographic decreases in bee colonies for reasons listed above. Recognizing that species may have to survive in human modified areas if they are to survive at all necessitates work to understand how pollinators function in highly disturbed environments. Studies have shown that urban and residential areas provide suitable habitat for native bees (Frankie et al. 2005, Cane et al. 2006, Winfree et al., 2007). There is anecdotal evidence suggesting that honey bees perform well in highly developed landscapes, yet no studies have examined specifically the floral resources this species utilizes in urban environments. Elucidation of causal relationships between plant community composition and habitat characteristics may provide information useful for bee conservation, especially as it applies to urban and residential habitats (Hernandez 2009). Due to the cottage beekeeping industry, it is doubtful that honeybees will disappear from urban areas. Nonetheless, determining the flora utilized by bees in areas of high anthropogenic disturbance may reveal specific plants suitable for landscape enhancement of floral resources for other pollinators in urban, semi-natural, and agricultural ecosystems.

This study utilizes the techniques of mellissopalynology, or the study of pollen found in honey, to determine the plant taxa providing urban honey bees with pollen. Specifically, I asked (1) what is the relative colony fitness of honey bee hives located in Philadelphia, PA? (2) Is there a positive relationship between colony fitness and the diversity of pollen types (representing foraging effort) found in corresponding honey samples? (3) What are the plant taxa visited by urban honey bees? I expected that the high level of disturbance present in Philadelphia would result in honey bees visiting many weedy, non-native species. Additionally, due to the positive benefits of broad diet breadth, I propose that pollen type diversity found in honey samples would be positively correlated with hive brood levels.

METHODS

Investigation into the effects of foraging diversity on colony fitness necessitated both lab and field work. By measuring the relative amount of brood in each sample hive I calculated an index of hive reproductive potential. This measure was compared to the number of observed pollen types as determined by qualitative mellissopalynological analysis.

Study Area. The study site was Philadelphia County ($40^{\circ} 00' N$ and $75^{\circ} 09' W$). A city of 1,526,006 occupants, Philadelphia has an average of 11,380 persons per square mile (U.S. Census 2011). Of the 84,420 acres that comprise the municipality, 20% (16,884 acres) are covered with tree canopy. An additional 24% of the area (20,821 acres) is designated as grass and shrub-covered (O’Neil-Dunne 2011). Potential forage habitats fall under the 5 land type categories typical of urban environments as designated by Hernandez et al. (2009). Remnant or seminatural habitats, managed gardens, unmanaged weedy sites, parks, and home gardens are all common in Philadelphia. The Flora of Pennsylvania Database has collection records for 1751 species in Philadelphia County (Flora of Pennsylvania Database, May 2012).

Brood Level Measurement. I visited over 20 *A. mellifera* hives for brood analysis. For the purpose of this study only Langstroth hives with standard hive boxes (henceforth “supers”) and frames were analyzed and therefore some hives were excluded. Super size varied among beekeepers; shallow, medium and deep frames were encountered with average area values of 80.75, 95.63, and 144.50 in² respectively. Hive area was determined as the summation of the surface area of each frame present in the hive during the sampling period. Sample hives were inspected and each frame containing brood was photographed for image analysis. Using ImageJ the total brood area of each sample hive was summarized. As a measure of hive reproductive potential, the Brood Index (BI) was determined as the *quotient of total brood area and total hive area*:

Mellissopalynological Analysis. Honey bees possess a crop in which nectar and pollen mix, and therefore honey is an effective sample of the bees foraging output (Roulston & Cane 2000). I collected 16 honey samples from August to November 2011. Most Philadelphia beekeepers extract honey only once a year, and these honey samples are representative of the season’s yield to date. The geographic distribution of hives sampled is shown in Appendix 1.

Chemical treatment of samples adopted the methods recommended by the International Commission for Bee Botany (Louveaux et al., 1978). Five grams of honey were dissolved in 10 ml of distilled water and centrifuged (10 minutes, 7000 r/min). The resulting supernatant was discarded and the remaining residue was again diluted and centrifuged (10 minutes, 7000 r/min). After the second wash, 5 ml of acetolysis mixture (9:1 acetic anhydride to sulfuric acid 95%) was added to the residue. Samples were incubated at $70^{\circ} C$ in a heatblock for 10 minutes. The acetolyzed pollen was again centrifuged and the supernatant was discarded. Due to high corrosivity, the residual acetolysis mixture was diluted and centrifuged again. The final residue was transferred onto 75 x 25 mm microscope slides using a Pasteur pipette and left to dry. The

sample area was covered with glycerine jelly with basic fuchsin and a cover slip. The pollen present in representative honey samples was observed with a Zeiss Axioskop microscope at 400x.

Restricted time and resources did not allow for full species-level identification of pollen types observed. Nonetheless, a relative measure of foraging diversity was obtained by differentiating palynomorphs, or pollen types. Based upon the morphological classification system of Traverse (2007) palynomorphs were distinguished by their size, aperture number, aperture type (pore, sulcus, colpus), aperture ornamentation (operculum, annulus, margos), exine surface structuring (psilate, pitted, foveolate, fossulate, scabrate, gemmate, clavate, verrucate, baculate, echinate and/or regulate). For each hive a linear regression was run between the colony BI and the number of palynomorphs found in a corresponding honey sample.

RESULTS

Hive size varied considerably ($M = 1,1240.69$, $SD = 4831.11$) within the 16 hives chosen for mellissopalynological analysis, with total areas ranging from $24,862.50 \text{ in}^2$ to $5,737.50 \text{ in}^2$ (Table 1). The range of measurements is the result of differing hive arrangements. Beekeeping practices within Philadelphia varied in number of hive supers, super size, and number of frames per super. Brood area varied considerably ($M = 469.40$, $SD = 284.16$) among the different hive arrangements (Table 1). For instance the highest brood area (*A-19148*: ca. 951 in^2) was recorded in a hive constructed of 4 medium size supers with 2 supers containing 9 frames each and 2 supers containing 10 frames each. The hive with the lowest brood area (*P-19144*: ca. 19 in^2) was recorded in a hive with 2 deep supers and 1 shallow each with 9 frames. Linear regression analysis indicated no interaction between hive size and brood amount, $r(14) = 0.04$, $p = 0.42$. In two instances (*N-19130* and *I-19103*) honey samples were extracted from two hives. Under these circumstances the hive areas were combined, in this way foraging effort and brood amount were treated as if from a single colony.

Table 1 Comparison of hive measurements including hive area, brood area and the resulting BI for each of the 16 hives sampled across Philadelphia. The number of palynomorphs observed in corresponding honey samples is also shown.

Hive & Zip Code	Total Hive Area (in ²)	Brood Area (in ²)	Brood Index (%)	# of palynomorphs
A-19148	7159.00	951.42	13.29	53
B-19119	6885.00	836.82	12.15	49
C-19147	9562.50	784.18	8.20	32
D-19104	9605.00	605.15	6.30	54
E-19129	7650.00	475.78	6.22	46
F-19143	13317.00	814.22	6.11	73
G-19129	11857.50	592.57	4.99	50
H-19104	11857.50	491.82	4.15	68
I-19103	13311.000	541.40	4.07	78
J-19119	11560.00	384.25	3.32	46
K-19102	5737.50	154.59	2.69	55
L-19125	11517.50	241.98	2.10	70
M-19147	10115.00	148.27	1.47	78
N-19130	24862.50	274.53	1.10	40
O-19144	18198.50	178.00	0.98	57
P-19144	6655.50	19.47	0.29	67
AVERAGE	11240.69	468.40	4.84	57.25
STDEV	4831.11	284.16	3.82	13.72

The resulting Brood Indices offer an individually normalized measure of hive reproductive potential (Table 1). Percentage values were based on the total area of the hive, representing potential brood space, and the current level of brood during the sampling period. Accordingly, percentage values varied ($M = 4.84$, $SD = 3.82$). For each hive the number of palynomorphs from a corresponding honey sample was determined ($M = 57.25$, $SD = 13.72$). Counts of different pollen types ranged from 78 (I-19103 & M-19147) to 32 (C-19147) for honey samples (Table 1). Linear regression analysis revealed no significant positive correlation between hive BI and the number of palynomorphs found in a corresponding honey sample $r(14) = 0.12$, $p = 0.20$ (Figure 1). Additionally, there was no significant causal relationship between brood area and the number of observed palynomorphs $r(14) = 0.08$, $p = 0.30$.

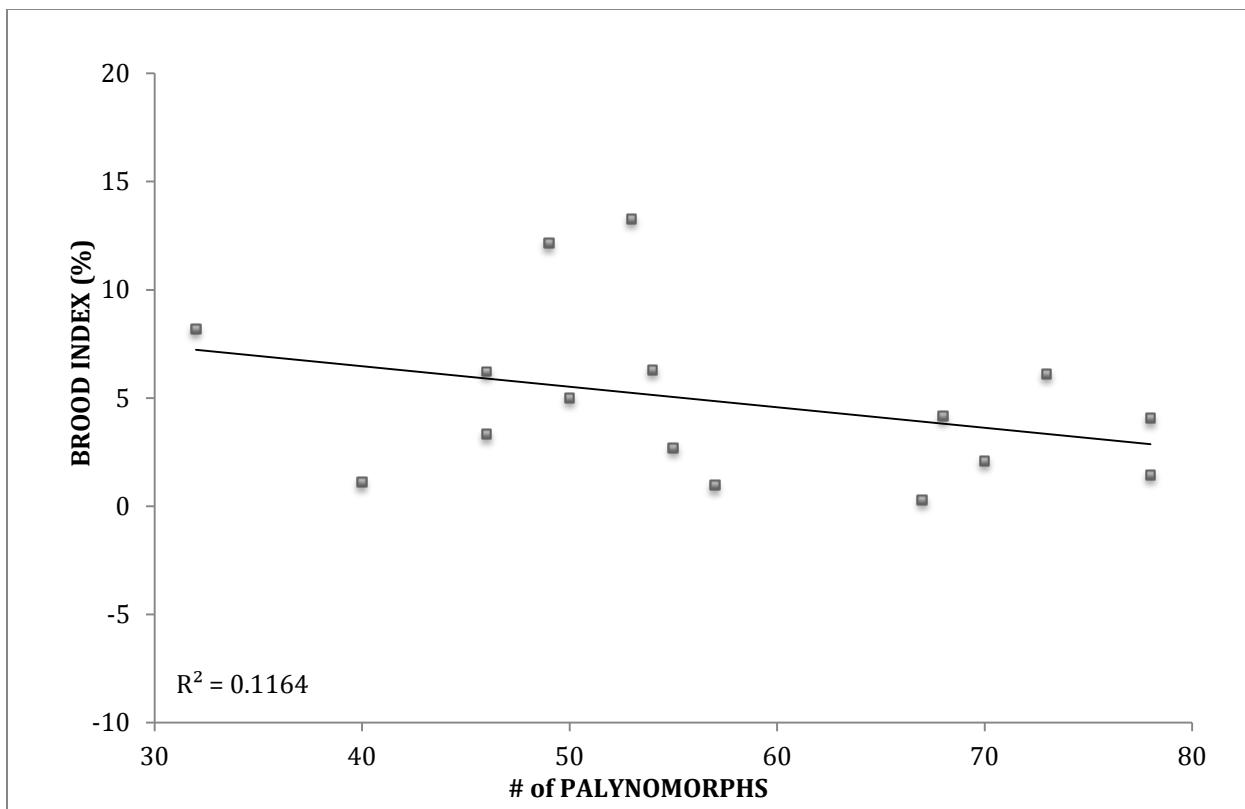


Fig 1 Regression analysis of the influence of foraged-pollen diversity and colony fitness as measured by Brood Index.

Although few pollen types were identifiable to species, many possessed morphological characters that enabled family level identification. Cross analysis with The Flora of Pennsylvania Database revealed those locally represented species from identified families. For instance, pollen from the Vitaceae is typically radially symmetrical, 20-25 μm across and tricolporate with a faveolate or faveolate-reticulate exine. Members of the Vitaceae commonly found in Philadelphia include: *Vitis vulpina*, *V. riparia*, *V. labrusca*, *V. aestivalis*, *Parthenocissus tricuspidata*, *P. quinquefolia* and *Ampelopsis brevipedunculata* (Flora of Pennsylvania Database, March 2012). Pollen types from the 16 honey samples analyzed were identified to 28 families and from these families 154 candidate genera were determined (Appendix 1).

DISCUSSION

A positive interaction between foraged-pollen diversity and honey bee colony fitness was not found (Figure 1). The nutritional benefits of polyfloral foraging could not be confirmed. Although reports show that monofloral diets can improve larval production (Tasei & Aupinel 2008), the results presented here likely suffer from faulty sampling. This is not surprising; as privately managed hives exhibit great variability. Beekeepers in Philadelphia practice a range of management techniques (I.E. pest control, supplemental feeding, colony subdivision) and the lack of a standardized hive confounded results considerably. As a metric to assess colony fitness, Brood Index proved to be methodologically successful, but its validity as an accurate representation of reproductive potential requires further study. All brood was measured during autumn months when honey bees decrease their larval output in preparation for winter. The levels reported here are thus only representative of late season colony fitness and do not accurately portray the overall health of a hive.

Similarly, mellissopalynology techniques offered a novel approach to understand pollinator visitation, yet yielded questionable results. Visually recording floral visitation does not provide an accurate measure of cumulative foraging effort; pollen analysis triumphs with its elimination of observation bias and its potential to understand foraging frequency through pollen counts. However, the use of honey as a medium to observe pollen foraging is not completely representative and pollen contamination can occur. Instances of pollen from anemophilous species such as *Pinus*, *Betula*, or *Ulmus* were observed (Appendix 1). The use of pollen traps placed at the entrance to hives is an alternative method that would provide a direct representation of pollen intake. Unfortunately, the use of privately owned hives did not allow for this.

In the present study pollen types were analyzed from honey that was extracted from hives from June to October and are therefore only representative of the foraging to date. The disjunction between honey sampling and brood sampling times affected the outcome of this study. Future palynology-based foraging studies would benefit from standardized hive setups, routine brood analysis throughout the season, and regular sampling of pollen collected via pollen traps.

Honey from Philadelphia had an average of 57.25 ± 13.72 palynomorphs per sample (Table 1); representing a higher degree of polylecty than previously reported. In Finland 116 different pollen types were analyzed from honey samples, with an average of 27.3 different pollen types per sample (Salonen et al. 2009). The broader diet breadth exhibited by urban honey bees is likely the result of proximate habitat construction. Whereas in Finland samples were collected from hives near low diversity agricultural land, pollen counts from the present study are representative of the surfeit of ruderal species typical to areas of high anthropogenic disturbance. Of the 28 families observed in this study, palynomorphs encountered frequently belonged to Fabaceae type, Brassicaceae type, Polygonaceae type, Anacardiaceae type, and Vitaceae type pollen. Also of note is the utilization of urban street trees as a floral resource; *Tilia spp.* pollen was predictably frequent among all samples. Species level identification for Fabaceae type palynomorphs was not achieved, but field observations indicate that *Gleditsia tricanthos*, *Robinia pseudoacacia* and *Styphnolobium japonicum* are utilized by honey bees and contribute pollen. Likewise, identification of Rosaceae type pollen proved challenging, but *Prunus spp.* and

Pyrus calleryana occur commonly within Philadelphia and are probable pollen sources. Again, it should be noted that these results represent only the foraging effort of the hive to the date of honey extraction. The number of pollen types encountered would change with local floral phenology. An increase in family representation was observed in feral honey bees foraging perennially in a Texan coastal prairie plain. A total of 95 different pollen types, including 43 families, 66 genera and 29 unknown taxa were recorded with seasonal fluctuations in pollen frequency (Baum et al. 2004). Seasonal fluctuations in floral resources are another aspect of honey bee foraging that should be analyzed through routine sampling of pollen traps.

Understanding specifically the composition of local apiflora has important implications for bee conservation. Selecting plants identified through palynological analysis to be principal pollen sources can ameliorate the problem of reconnecting plants and pollinators in ecological restoration efforts. Pollinator conservation literature stresses the importance of establishing ‘framework’ and ‘bridging’ plants (Dixon 2009, Bluthgen & Klein 2011, Menz et al. 2011). Investigation of pollen frequencies will help identify with greater specificity strong candidate ‘framework’ plants, while analyzing seasonal fluctuations of pollen intake will elucidate exactly the ‘bridge’ taxa visited during otherwise resource limited periods. Although honey bees provide only the insight of a non-native generalist, determining the extent of foraging behaviors in an urban environment demonstrates how pollinator systems continue to function in areas of high disturbance. After habitat protection, the most intuitive conservation action to improve the livelihood of pollinators is the addition and preservation of those plants shown to be floral resources. Pollen analysis coupled with field observations comprise a methodology that could indicate precisely, and without observational bias, the flora providing bees with pollen.

REFERENCES

- Aizen, M. A. and P. Fensinger. 1994. Habitat fragmentation, native insect pollinators and feral honey bees in Argentine “chaco serrano.” *Ecological Applications* 4:378-392.
- Ashman, T. et al. 2004. Pollen limitation of plant reproduction: ecological and evolutionary causes and consequences. *Ecology* 85:2408-2421.
- Baum, K. A., W. L. Rubnik, R. N. Coulson and V. M. Bryant. 2004. Pollen selection by feral honey bee (Hymenoptera: Apidae) colonies in a coastal prairie landscape. *Environmental Entomology* 33:727-739
- Barker, R. J. and Y. Lehner. 1974. Acceptance and sustenance value of naturally occurring sugars fed to newly emerged adult workers of honey bees (*Apis mellifera* L.). *Journal of Experimental Zoology* 187:277-285.
- Bluthgen, N., and A. Klein. 2011. Functional complementarity and specialization: The role of biodiversity in plant-pollinator interactions. *Basic and Applied Ecology* 12:282-291.
- Cane, J. H., R. L. Minckley, L. J. Kervin, T. H. Roulston and N. M. Williams. 2006. Complex responses within a desert bee guild (Hymenoptera: Apiformes) to urban habitat fragmentation. *Ecological Applications* 16:632-644.
- Dixon, K. W. 2009. Pollination and restoration. *Science* 325:571-573.
- Decourtye, A., E. Mader, N. Desneux. 2010. Landscape enhancement of floral resources for honey bees in agro-ecosystems. *Apidologie* 41:264-277
- De Groot, A. P. 1953. Protein and amino acid requirements of the honey bee. *Physiological Entomology* 8: 167-171.
- Frankie, G W., R. W. Thorp, M Schindler, J. Hernandez, B. Erter and M. Rizzardi. 2005. Ecological patterns of bees and their host ornamental flowers in two northern California cities. *Journal of the Kansas Entomological Society* 78: 227-246.
- Gallai, N., J. M. Salles, J. Settele, and B. E. Vaissiere. 2009. Economic valuation of the vulnerability of world agriculture confronte with pollinator decline. *Ecological Economics* 68:810-821.
- Goulson, D., G. C. Lye, and B. Darvill. 2008. Decline and conservation of bumble bees. *Annual Review of Entomology* 53:191-208.
- Herbert E. W. J. 1992. Honey bee nutrition. In: Graham, J. M. (ed.) *The Hive and the honey bee*. Dadant & Sons, Hamilton, IL, pp. 197-233.

Herbert, E., W. Bickley, and H Shimanuki. 1970. The brood rearing capability of caged honey bees fed dandelion and mixed pollen diets. *Journal Economic Entomology* 63: 215-218.

Hernandez, J. L., G. W. Frankie and R. W. Thorp. 2009. Ecology of urban bees: A review of current knowledge and directions for future study. *Cities and the Environment*. 2:1-15.

Brassnigg N. and K. Crailsheim. 2005. Differences in drone and worker physiology in honeybees (*Apis mellifera* L.). *Apidologie* 36: 255-277.

Imdorf A., M. Rickli, V. Kilchenmann, S. Bogdanov and H. Wille. 1998. Nitrogen and mineral constituents of honey bee worker brood during pollen shortage. *Apidologie* 29:315-325.

Kearns, C. A., D. W. Inouye, and N. M. Waser. 1998. Endangered mutualisms: the conservation of plant-pollinator interactions. *Annual Review of Ecology and Systematics* 29:83-112.

Klein A. M., B. Vaissiere, J. H. Cane, I. Steffen-Dewenter, S. A. Cunningham, C. Kremen, and T. Tscharntke. 2007. Importance of crop pollinators in changing landscapes for world crops. *Proceedings of the Royal Society of London Series B-Biological Sciences* 274:303-313.

Kremen C., N. W. Williams, and R. W. Thorp. 2002. Crop pollination from native bees at risk from agricultural intensification. *Proceedings of the National Academy of Sciences* 99:16812-16816

Matteson, K. C., J. S. Ascher and G. A. Langellotto. 2008. Bee richness and abundance in New York City Urban Gardens. *Annals of the Entomological Society of America*. 101: 140-150.

Mattila H. R., and G. W. Otis. 2006. Influence of pollen diet in spring on development of honey bee (Hymenoptera: Apidae) colonies. *Journal of Economic Entomology* 99: 604-613.

Menz, M. H. H., R. D. Phillips, R. Winfree, C. Kremen, M. A. Aizen, S. D. Johnson, and K. W. Dixon. 2011. Reconnecting plants and pollinators: Challenges in the restoration of pollination mutualisms. *Trends in plant science* 16:4-12

Naug, D. 2009. Nutritional stress due to habitat loss may explain recent honeybee colony collapses. *Biological Conservation* 142: 2369-2372.

O'Neil-Dunne, J. 2011. A Report on the City of Philadelphia's Existing and Possible Tree Canopy. University of Vermont Spatial Analysis Laboratory.

Roulston, T. H. and J. H. Cane. 2000. Pollen nutritional content and digestibility for animals. *Plant Systematics and Evolution* 222: 187-209.

Roulston, T. H. and S. L. Buchmann. 2000. A phylogenetic reconsideration of the pollen starch-pollination correlation. *Evolutionary Ecology Research* 2:627-643.

Roulston, T. H., J. H. Crane, and S. L. Buchmann. 2000. What governs the protein content of pollen grains: pollinator preferences, pollen-pistil interaction or phylogeny. *Ecological Monographs* 70:617-643.

Seeley, T. D. 1995 The Wisdom of the Hive. Harvard University Press, Cambridge, MA.

Sagili, R. W., and T. Pankiw. 2007. Effects of protein-constrained brood food on honey bee (*Apis mellifera*) pollen foraging and colony growth. *Behavioral Ecology and Sociobiology* 61:1417-1478

Salonen, A., T. Ollikka, E. Gronlund, L. Ruottinen, and R. Julkunen –Tiitto. 2009. Pollen analysis of honey from Finland. *Grana* 48:281-289.

Tasei, J. N. & Aupinel, P. 2008 Nutritive value of 15 single pollens and pollen mixes tested on larvae produced by bumblebee workers (*Bombus terrestris*, Hymenoptera: Apidae). *Apidologie* 39, 397–409.

The Pennsylvania Flora Database. (2011, October 20). University of Pennsylvania. Retrieved May 09, 2012 from <http://www.paflora.org/>

Traverse, A. 2007. Paleopalynology. Topics in Geobiology, Volume 28. Springer, Dordrecht, Netherlands.

U.S. Census Bureau. (2012, January 31). *State & county Quickfacts: Philadelphia County, P.A.* Retrieved May 09, 2012 from <http://quickfacts.census.gov>.

Winfree, R., R. Aguilar, D. P. Vazquez, G. LeBuhn, and M. A. Aizen. 2009. A meta-analysis of bees' responses to anthropogenic disturbance. *Ecology* 90: 2068-2076.

Winfree, R., T. Griswold and C. Kremen. 2007. Effect of human disturbance on bee communities in a forested ecosystem. *Conservation Biology* 21: 213-223.

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APPENDIX

Appendix 1 Distribution of sample hives (orange hexagons) throughout Philadelphia County



Potential Apiflora of Philadelphia County, PA

Amaranthaceae

<i>Amaranthus spp.</i>	amaranth
<i>Atriplex littoralis</i>	Seashore orach
<i>Atriplex patula</i>	Spreading orach
<i>Atriplex prostrata</i>	Halberd-leaved orach
<i>Chenopodium spp.</i>	Goosefoot

Anacardiaceae

<i>Toxicodendron radicans</i>	Poison-ivy
<i>Rhus typhina</i>	Staghorn sumac
<i>Rhus glabra</i>	Smooth sumac
<i>Rhus copallina var. latifolia</i>	Shining sumac
<i>Cotinus coggygria</i>	Smoke-tree

Aquifoliaceae

<i>Ilex verticillata</i>	Winterberry
<i>Ilex opaca</i>	American holly
<i>Ilex crenata</i>	Japanese Holly

Araliaceae

<i>Aralia spinosa</i>	Hercules'-club
<i>Aralia racemosa</i>	Spikenard
<i>Aralia nudicaulis</i>	Wild sarsaparilla
<i>Aralia elata</i>	Japanese angelica-tree

Asteraceae

<i>Eupatorium spp.</i>	Eupatorium
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<i>Solidago spp.</i>	Goldenrod
<i>Symphyotrichum spp.</i>	Aster
<i>Taraxacum spp.</i>	Dandelion

Bignoniaceae

<i>Catalpa speciosa</i>	Northern catalpa
<i>Catalpa bignonioides</i>	Southern catalpa
<i>Campsis radicans</i>	Trumpet-vine

Betulaceae

<i>Betula lenta</i>	Black birch
<i>Betula nigra</i>	River birch
<i>Betula populifolia</i>	Gray birch
<i>Betula pubescens</i>	Downy birch
<i>Carpinus caroliniana</i>	Hornbeam

Brassicaceae

<i>Brassica juncea</i>	Brown mustard
<i>Brassica nigra</i>	Black mustard
<i>Brassica rapa</i>	Field mustard
<i>Cardamine spp.</i>	Bittercress
<i>Lepidium spp.</i>	Cress
<i>Rorippa palustris</i>	Marsh watercress
<i>Rorippa sylvestris</i>	Creeping yellowcress
<i>Sinapis alba</i>	White-mustard
<i>Sinapis arvensis</i>	Charlock
<i>Thlaspi arvense</i>	Field pennycress

Celastraceae

<i>Celastrus orbiculatus</i>	Oriental bittersweet
<i>Celastrus scandens</i>	American bittersweet
<i>Euonymus alatus</i>	Winged euonymous
<i>Euonymus americanus</i>	Hearts-a-bursting
<i>Euonymus atropurpureus</i>	Burning-bush
<i>Euonymus europaeus</i>	European spindletree
<i>Euonymus fortunei</i>	Wintercreeper

Caprifoliaceae

<i>Lonicera tatarica</i>	Tartarian honeysuckle
<i>Lonicera standishii</i>	Honeysuckle
<i>Lonicera sempervirens</i>	Trumpet honeysuckle
<i>Lonicera morrowii</i>	Morrow's honeysuckle
<i>Lonicera japonica</i>	Japanese honeysuckle

Cornaceae

<i>Cornus racemosa</i>	Gray dogwood
<i>Cornus florida</i>	Flowering dogwood
<i>Cornus amomum</i> ssp. <i>obliqua</i>	Oblique Silky dogwood
<i>Cornus amomum</i> ssp. <i>amomum</i>	Silky dogwood
<i>Cornus alternifolia</i>	Alternate-leaved dogwood

Adoxaceae

<i>Sambucus canadensis</i>	American elder
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Fabaceae

<i>Amorpha fruticosa</i>	False-indigo
<i>Gleditsia triacanthos</i>	Honey-locust

<i>Medicago lupulina</i>	Black medic
<i>Medicago sativa</i>	Alfalfa
<i>Melilotus albus</i>	White sweet-clover
<i>Melilotus officinalis</i>	Yellow sweet-clover
<i>Robinia hispida</i>	Bristly locust
<i>Robinia pseudoacacia</i>	Black locust
<i>Robinia viscosa</i>	Clammy locust
<i>Styphnolobium japonicum</i>	Japanese pagoda-tree
<i>Trifolium arvense</i>	Rabbit's-foot clover
<i>Trifolium aureum</i>	Large yellow hop-clover
<i>Trifolium campestre</i>	Low hop-clover
<i>Trifolium hybridum</i>	Alsike clover
<i>Trifolium incarnatum</i>	Crimson clover
<i>Trifolium pratense</i>	Red clover
<i>Trifolium reflexum</i>	Buffalo clover
<i>Trifolium repens</i>	White clover
<i>Vicia americana</i>	Purple vetch
<i>Vicia hirsuta</i>	Vetch
<i>Vicia sativa ssp. nigra</i>	Black garden vetch
<i>Vicia sativa ssp. sativa</i>	Garden vetch
<i>Vicia tetrasperma</i>	Slender vetch
<i>Vicia villosa ssp. varia</i>	Winter vetch
<i>Vicia villosa ssp. villosa</i>	<i>Vicia villosa</i> ssp. <i>villosa</i>
<i>Wisteria floribunda</i>	Japanese wisteria
<i>Wisteria frutescens</i>	American wisteria
<i>Wisteria sinensis</i>	Chinese wisteria

Lamiaceae

<i>Glechoma hederacea</i>	Gill-over-the-ground
<i>Lamium amplexicaule</i>	Henbit
<i>Lamium purpureum</i>	Purple dead-nettle
<i>Lycopus americanus</i>	Water-horehound
<i>Lycopus europaeus</i>	European water-horehound
<i>Lycopus rubellus</i>	Gypsy-wort
<i>Lycopus uniflorus</i>	Northern bugleweed
<i>Lycopus virginicus</i>	Virginia water horehound
<i>Prunella vulgaris</i> ssp. <i>lanceolata</i>	Lance selfheal
<i>Prunella vulgaris</i> ssp. <i>vulgaris</i>	Common selfheal

Lythraceae

<i>Lythrum alatum</i>	Winged loosestrife
<i>Lythrum hyssopifolia</i>	Hyssop loosestrife
<i>Lythrum salicaria</i>	Purple loosestrife

Malvaceae

<i>Tilia americana</i> var. <i>americana</i>	Basswood
<i>Tilia americana</i> var. <i>heterophylla</i>	White basswood

Paulowniaceae

<i>Paulownia tomentosa</i>	Empress-tree
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Phytolaccaceae

<i>Phytolacca americana</i>	Pokeweed
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Plantaginaceae

Polygonaceae

<i>Fallopia convolvulus</i>	Black bindweed
<i>Fallopia japonica</i>	Japanese knotweed
<i>Fallopia sachalinensis</i>	Giant knotweed
<i>Fallopia scandens</i>	Climbing false-buckwheat
<i>Persicaria spp.</i>	Smartweed
<i>Polygonum aviculare</i>	prostrate knotweed
<i>Polygonum aviculare</i>	Knotweed
<i>Polygonum aviculare</i>	Doorweed
<i>Polygonum erectum</i>	Erect knotweed
<i>Polygonum ramosissimum</i> ssp. <i>ramosissimum</i>	Bushy knotweed
<i>Polygonum tenue</i>	Slender knotweed
<i>Rumex spp.</i>	Dock

Rhamnaceae

<i>Rhamnus cathartica</i>	Common buckthorn
<i>Rhamnus frangula</i>	Alder buckthorn
<i>Ceanothus americanus</i>	New Jersey tea
<i>Rhamnus cathartica</i>	Common buckthorn
<i>Rhamnus frangula</i>	Alder buckthorn

Rosaceae

<i>Photinia parviflora</i>	Photinia
<i>Photinia pyrifolia</i>	Red chokeberry
<i>Photinia villosa</i>	Oriental photinia
<i>Potentilla spp.</i>	Cinquefoil
<i>Prunus americana</i>	Wild plum

<i>Prunus avium</i>	Sweet cherry
<i>Prunus cerasus</i>	Pie cherry
<i>Prunus mahaleb</i>	Mahaleb cherry
<i>Prunus padus</i>	European bird cherry
<i>Prunus persica</i>	Peach
<i>Prunus serotina</i>	Wild black cherry
<i>Prunus subhirtella</i>	Higan cherry
<i>Prunus virginiana</i>	Choke cherry
<i>Pyrus calleryana</i>	Callery pear
<i>Rubus spp.</i>	

Sapindaceae

<i>Acer rubrum</i>	Red maple
<i>Koelreuteria paniculata</i>	Golden rain-tree

Scrophulariaceae

<i>Verbascum blattaria</i>	Moth mullein
<i>Verbascum lychnitis</i>	White mullein
<i>Verbascum phlomoides</i>	Orange mullein
<i>Verbascum sinuatum</i>	Wavyleaf mullein
<i>Verbascum thapsus</i>	Common mullein

Simaroubaceae

<i>Ailanthus altissima</i>	Tree-of-heaven
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Ulmaceae

<i>Ulmus americana</i>	American elm
<i>Ulmus parvifolia</i>	Chinese elm

Ulmus pumila Siberian elm

Ulmus rubra Red elm

Verbenaceae

Verbena spp. Vervain

Vitaceae

<i>Ampelopsis brevipedunculata</i>	Porcelain-berry
<i>Parthenocissus quinquefolia</i>	Virginia creeper
<i>Parthenocissus tricuspidata</i>	Boston ivy
<i>Vitis aestivalis</i>	Summer grape
<i>Vitis labrusca</i>	Fox grape
<i>Vitis riparia</i>	Riverbank grape
<i>Vitis vulpina</i>	Frost grape

TITLE: **The Edible Woody Plants of the Morris Arboretum**

AUTHOR: **Lauren Pongan**
The Hay Honey Farm Endowed Natural Lands Intern

DATE: **April 2012**

ABSTRACT:

Discussions about food systems and food sources are symptomatic of a larger shift of focus for the U.S. population. The Morris Arboretum has an opportunity to capitalize upon this burgeoning field of interest by highlighting our holdings that are edible. This project aimed to select and highlight twenty edible plants through the creation of a printable walking guide to the edible woody plants of Morris Arboretum.

In addition to an analysis of the Arboretum's current edible holdings, this project researched, identified, placed orders for, and designed planting for selected plants that the Arboretum lacks, but that are of interest and value to it. Research was conducted through on-site visits to peer gardens and arboreta, and consultations with fruit and nut specialists in the region.

Utilizing the energy behind the local food movement, this project seeks to help more Arboretum visitors establish an understanding of our universal dependence on plants.

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INTRODUCTION

Discussions about food systems and food sources have become a focus of popular culture in the United States. The nomenclature of food systems such as food miles, CSAs, fair trade, biodynamic, and organic are now commonplace in the media and increasingly so in conversations. Programs in agroecology, ethnobotany, food-studies culture, and food systems have crept up at institutions of higher education nationwide. Though it is difficult to quantitatively describe this movement, the appearance of news articles covering foods, farmers, and gardens; the increase in urban farming and gardening; the increasingly diverse offerings of permaculture and homesteading classes; as well as the successes and pervasiveness of Whole Foods Markets and Trader Joes stores across the country are symptomatic of a larger consumer awakening surrounding food. People are becoming increasingly curious about the methods used in food production, but also about the plants that produce their food.

This burgeoning interest in edible plants offers the Morris Arboretum an opportunity to engage a new set of visitors or potential visitors. One of the most concrete ways to connect visitors with plants is by educating them about the plants that we rely on as food sources. Instead of focusing on vegetable gardening and agricultural production, the scope of this project will encompass perennial plants including woody plants such as fruit and nut trees, nut shrubs, berry bushes, and fruiting vines. Selected plants should expose homeowners to new ideas and concepts surrounding gardening and agriculture in their own homes. A goal is for these visitors to leave the Arboretum with a new curiosity about or a continued interest in what types of perennial, edible plantings would make sense in their own gardens.

Additionally, the Morris Arboretum, both on its public garden side and on Bloomfield Farm, has traditionally been a place in which edible plants were cultivated for food. Bloomfield Farm was initially utilized for agricultural production, though such pursuits had long since been abandoned when the property was incorporated into the Morris Arboretum's holdings.

On the public garden side, historically, the Morries had an elaborate fruit and vegetable garden. Currants, Raspberries, and vegetables were grown in and around the present day rose garden, green house, and hoop houses. Though it's unknown whether the intention in edible plantings was self reliance and subsistence, or novelty, the intentional reintroduction of edibles to the living collection is in keeping with the Arboretum's dedication to its history.

Personal Interest

My personal interest in this project comes from my agricultural background. I have spent several growing seasons working on farms in Pennsylvania and Maine. Agriculture was the vehicle through which I initially learned about plants; farming engendered my enthusiasm and interest in horticulture, and my experience with it was inspiration to apply for the natural lands internship. With the exception of experience with apple trees, pear trees, and raspberries, my knowledge was primarily rooted in vegetables and annuals.

This project offered me an opportunity to expand my familiarity to encompass perennial edibles that are hardy in the Philadelphia area. While initially I was only interested in native edibles, I realized that the collection here at Morris is conducive to the study of woody edibles

from all over the world, notably Asian varieties. Though this project benefits me by allowing me to study something I am passionate about, I believe it will also benefit the Arboretum by enabling us to engage a more diverse range of visitors.

RESEARCH AND CONSULTING

The most narrowed aim of this project is to connect Arboretum visitors with edible plants and to pique their curiosity about growing food. This specific goal fits into the broadest aim of this project, which is to help Arboretum visitors to establish personal connections with plants. To begin to formulate the most effective method of establishing this connection, an examination of methods used by peer gardens and arboreta to the same effect was necessary. This examination included meetings and tours of peer public gardens with similar goals, as well as research about specific hardy edibles.

In addition to interviewing local specialists in fruits, nuts, and berries to help identify plants that fall under the scope of my project, I made site visits to relevant institutions, met with knowledgeable area specialists, and attended the Morris Arboretum's Annual Landscape Design Symposium, which focused on *Conversations across Fields: Interdisciplinary Approaches to Ecological Landscape Design*. Two relevant presentations at the symposium were "A Laissez-faire Approach to the Edible Residential Landscape" and "Farmscape Ecology: Agriculture Joins Restoration."

Visits to peer public gardens included the Brooklyn Botanic Garden (BBG) and Bartram's Garden in Philadelphia. BBG primarily used traditional vegetable gardens and children's gardens as demonstration gardens for visitors. In the children's garden specifically, hands-on educational programming was their preferred method for making connections with visitors. Unfortunately I did not see this model as applicable at the Morris Arboretum, because vegetable gardening of annuals did not fall under the scope of this project. It did, however, give me insight into potential future class offerings and interpretive signage.

Bartram's Garden, however, recently installed an orchard as part of a larger food justice project. In addition to their community gardens and a recently installed small farm on the property, the installation of an orchard was both an historically enriching horticultural component of their property and a practical food access programming tool. There were several parallels between Bartram's Garden's interests and those of the Morris Arboretum. These included the commitment not only to horticulture, but also to preserving and engaging the historical aspects of the property. For Bartram's Garden this was manifested in the reintroduction of an orchard, as there had been one (though at a different location) on the property historically.

A visit to longtime Arboretum member and horticulture volunteer Oliver William's house was my first experience seeing fruiting pawpaws, as the Arboretum's specimen of *Asimina triloba* was stripped of its fruit by visitors before I could see it last fall. A later foraging expedition with Sam Councilman, longtime forager and Lancaster County native, allowed me to see pawpaws growing in their native habitat as understory trees in groves, often near riverbanks. It was helpful to see this not only to determine what might make a cultivar ideal, but also to

understand the best places to plant additional pawpaws. I also learned that outcrossing is needed to bear fruit, and since the Arboretum had, at the time, only one specimen, fruiting was highly unlikely.

My visit to Rutgers University yielded information from a hazelnut specialist, Dr. Tom Molnar. “We work with mostly with *[Corylus] avellana* (European hazelnut) but also its hybrids with *C. americana* and some *C. colurna*,” wrote Dr. Molnar in an email. His work primarily consists of isolating *Corylus avellana* individuals, procured via collection in eastern Europe, that exhibit resistance to Eastern Filbert Blight, a fungus that has decimated *Coryls americana*, or American hazelnuts, in North America. By isolating individuals with resistance, Dr. Molnar will be able to reestablish a population of hazelnuts in United States, making way for selections for commercial production and sale. His work demonstrates the importance of researching edible plant selection to know about potential (or, in the case of *Corylus americana*, probable) disease or insect-related susceptibility. An example he used was that *Corylus avellana L. 'Contorta'*, a cultivar of European hazelnut with attractive, contorted branching and a short growing habit, is often sold commercially in the United States, in spite of its susceptibility to Eastern Filbert Blight. In most cases these ornamental cultivars will succumb to blight within the first five years of their planting. At any given time, Dr. Molnar has 30,000 trial trees in the ground.

Although not on-site at an orchard, my meeting with Phil Forsyth of Philadelphia Orchard Project (POP) and Forsyth Gardens was the most informative, as his experience relates directly to my stated goals. Through POP and Forsyth Gardens, Forsyth has created a list of edible plants that are hardy in Philadelphia. His projects include orchard installations in Philadelphia through community partnerships and residential gardening. I used this list as a starting point for identifying potential plants. The list was broken down into the categories of trees, shrubs, vines, and groundcovers. Symbols after each plant name likewise designated the ability to be grown in containers; ability to be espaliered; requirement of an additional plant or variety for out-crossing; ability to produce fruit in the shade; and requirement of shelter from cold weather if they are tender plants.

Forsyth was able to answer general questions about permaculture planting design principles, and to make specific suggestions with regard to edible plant cultivars. He made some suggestions that aren’t appropriate for the Arboretum, but that encapsulate some essential principles of permaculture that are useful to bear in mind as I designed my project, such as a spiral herb garden, rain barrels with irrigation, water gardens with edible plants, and vermicompost demonstrations. These ideas may become more useful if, in the future, the Arboretum opts to install a vegetable garden or a demonstration garden for home gardeners.

SELECTION CRITERION AND PROCESS

Narrowing the Catalogue

I began with an assessment of the woody edibles currently held in the Morris Arboretum’s collection. I manually analyzed the entire plant catalogue in order to narrow the database to include only edible plants. I accomplished this by crosschecking our plants by genus

(and then later species) with a variety of online sources to determine edibility, practicality, and palatability of the plants in the collection.

A plant not being edible was the first cause for deletion from my list. Second to edibility, I considered practicality of fruit collecting and palatability. For example, some plants provided sustenance, but were unpalatable, such as the bark layer of fir trees. Likewise, some fruits were both edible and palatable, but were unpractical to include. An example of this case was *Cephalotaxus fortunei*, or the Chinese plum yew, which produces small fruits with poisonous seeds. While the fruit flesh itself was edible, it would not be practical to highlight this as a fruit producing plant since its collection is tedious and the danger of accidentally ingesting a poisonous seed.

After narrowing the plant catalogue from 7902 individual plants to 1292 individuals that fall under the category of edible (some of these listings are likely neither palatable nor practical to obtain) I began to further narrow the selections by identifying certain key plants. After discussions with Tony Aiello, head curator, we determined that I would be able to highlight approximately 20 plants on a self-guided map. From our Living Collections sessions and from prior study, investigation and exposure, I knew that there were certain plants I wanted to include on the tour before examining the catalogue. Examples of these selections included *Diospyros virginiana* (American persimmons), *Asimina triloba* (pawpaw), *Acer saccharum* (sugar maple) and something from the *Amelanchier* genus (serviceberry).

My meeting with Phil Forsyth proved to be highly informative with regard to selection. The majority of plants are being ordered from One Green World Nursery, in Portland, Oregon, at Forsyth's suggestion. Their nursery offers a wide variety of cultivars for edible plants, which is of special interest to the Arboretum. As the plants I selected are intended as demonstration plants, rather than fruit-production plants, they will preferably be both ornamental and edible.

SELECTIONS

Ordered Selections

Table A:

Plant	Unit Cost	#	Total	Nursery	Destination	Notes
Spring 2012-- Project Order						
Lauren Pongan x180						
<i>Pyrus communis</i> 'Lady Petre'		1	25.00	POP	greenhouse	Lauren will pick up
<i>Passiflora incarnata</i>	16.95	3	50.85	One Green World	Plaza in Iana's section	
<i>Lonicera caerulea</i> 'Blue Sea'	21.95	1	21.95	One Green World	Widener	outcross
<i>Lonicera caerulea</i> 'Blue Bird'	19.95	1	19.95	One Green World	Widener	outcross
<i>Lonicera caerulea</i> 'Blue Forest'	19.95	1	19.95	One Green World	Widener	outcross
<i>Ziziphus jujuba</i> 'Black Sea'	32.95	1	32.95	One Green World	Crab Apple Slope	outcross
<i>Ziziphus jujuba</i> 'Lang'	32.95	1	32.95	One Green World	Crab Apple Slope	outcross
<i>Ribes uva-crispa</i> 'Friend'	9.95	1	9.95	One Green World	green house bed next to stone wall	better yield crosspolinated
<i>Ribes uva-crispa</i> 'Red George'	9.95	1	9.95	One Green World	green house bed next to stone wall	better yield crosspolinated
<i>Ribes uva-crispa</i> 'Jewel'	9.95	1	9.95	One Green World	green house bed next to stone wall	better yield crosspolinated
<i>Ribes rubrum</i> 'Gloire des Sablons'	9.95	2	19.90	One Green World	green house bed next to stone wall	self-fertilizing

<i>Asimina triloba</i> 'Potomac'	27.95	1	27.95	One Green World	Sculpture Garden	
<i>Asimina triloba</i> 'Pennsylvania Golden'	24.95	1	24.95	One Green World	Sculpture Garden	outcross--pick up?
<i>Rubus</i>		2		Bartram's Garden		
Subtotal			306.25			
Shipping	15 % of total	45.94				
Grand Total			352.19			

It was necessary to order six species of plants that I selected for this project that are new introductions to the Arboretum. Table A depicts the adapted order list that I generated for this project. Cultivars were selected to provide a variety of ornamental aesthetics, synchronized flowering time for cross pollination, taste and/or texture variability, and variety of growth habits. The common names for the above selections are, in order, Lady Petre pear, maypops, blue honeysuckle or honeyberry, Chinese jujube, gooseberries, currants, and pawpaws. Elinor Goff, Plant Recorder, will assist in the accessioning process.

As previously stated, the currants (included in the above chart) as well as raspberries (to be obtained from Bartram's Garden) are selections that prove historically relevant to the Morris Arboretum. Similarly the Lady Petre Pear is likewise steeped in history. According to the verbal accounts of Todd Greenberg, Bartram's Garden's head gardener, John Bartram received seed from this butter pear tree from Lord Petre in England. He successfully germinated and planted this seed and one surviving tree was still growing on the property until fairly recently.

After this tree died, a Germantown resident contacted Bartram's to inform them that she had a pear tree on her property that was propagated from cutting from the Lady Petre Pear that had grown on Bartram's property. In 2004 Phil Forsyth of POP assisted in creating four grafts from this tree, to be reintroduced to Bartram's at a later date. Graciously, Forsyth has allowed Morris Arboretum to purchase the fourth, though admittedly weakest, graft of the batch. The Arboretum will benefit from holding this historically rare plant that is relevant to both the Philadelphia area and the history of horticulture in the city. Likewise, we are obtaining a red raspberry that was cultivated by William Bartram from Bartram's Garden.

Final Selections List:

Table B:

Plant	Latin
Sugar maple	<i>Acer saccharum</i> 'Bonfire'
Lady Petre Pear	<i>Pyrus communis</i>
Serviceberry	<i>Amelanchier</i>
Pecan	<i>Carya illinoensis</i>
Black Walnut	<i>Juglans nigra</i>
Sweet birch	<i>Betula lenta</i>
Maypops	<i>Passiflora incarnata</i>
Elderberries	<i>Sambucus nigra</i>
Blue honeysuckle	<i>Lonicera caerulea</i>
Chinese Jujube	<i>Ziziphus jujuba</i>
Pawpaws	<i>Asimina triloba</i>
Hazelnuts	<i>Corylus fargesii</i>
Persimmons	<i>Diospyros virginiana</i>
Pine nuts	<i>Pinus cembra</i> ('Columnaris' or Armandii)
Szechuan Pepper	<i>Zanthoxylum simulans</i>
Raspberries	<i>Rubus</i> 'odorata'
Gooseberries	<i>Ribes grossularia</i>
Dead Man's Fingers Tree	<i>Decaisnea fargesii</i>
Cornelian Cherry	<i>Cornus mas</i> 'Golden Glory'
Red Currants	<i>Ribes rubrum</i>

Interpretive Signage

Ten to twelve of these selections will be accompanied by interpretive signage that will provide visitors with more information about this edible plant. The content of these signs will be both horticultural as well as ethnobotanical, and will include a simple line drawing of the branching pattern, leaves, and fruit if possible. Examples of things that might be relevant to include on these signs are nativity, hardiness, edible parts, products made from the plant, history, and interesting facts. See Figure 1 to view an example of interpretive signage for *Asmina triloba*.

Downloadable Walking Guide

Using the printable maps available on the Morris Arboretum's website as a guide, I have developed a format for a self-guided walking map. Of the maps currently available the *Great Trees Tour* most closely resembles the use and layout of the edible plants map I will create. Aspects of this map that make it a useful model, which includes a map designating the rough location of each highlighted plant, room for a small graphic of the fruit or edible portion of each tree plant, bulleted points that include facts about each plant, and room for a brief introduction to the topic of edible hardy plants. In the introduction I will also include a specific note that the tour is designed to demonstrate specimen plants, and that people should refrain from sampling the plants, and should instead consider how they might be able to integrate these or similar plantings onto their own property. I hope to create a press release and to write an article in *Volunteer* about this new online interface to publicize the plantings and to drive more online traffic to the Morris Arboretum website.

CONCLUSIONS

Obstacles

There were several unanticipated obstacles that arose during the completion of this project, all primarily pertaining to plant selection for the map. One obstacle included the unexpected unsuitability of certain edibles for an Arboretum setting. For example, red mulberries, or *Morus rubra*, seed in far too easily to be planted in the public garden section of the Arboretum. Likewise, *Actinidia arguta*, or hardy kiwi, though already accessioned in two places in the Arboretum, grows far too vigorously to be trained. Section leaders instead cut hardy kiwi back throughout the summer to keep it under control, therefore making it nearly impossible for the vine to bear fruit.

Other factors that needed to be taken into account were plant locations and plant health. Some of my intended selections were already accessioned by the Arboretum, but they were planted in areas that would be difficult for visitors to find, such as in copes or in remote corners of the Arboretum that were far from the path. Sometimes, the individual plants that I selected via Plant Locator were weak, or poorly producing specimens upon examination. Additionally, some plants that I had hoped to order and plant singly required or produced more fruit when other species or cultivars were available for outcrossing. Finally, I also learned that many of the plantings that will be made this year will not produce fruit for at least two years after they have become established. Hopefully these plantings become increasingly valuable for the Arboretum both as specimens and as a foundation for potential educational experiences including a woody edibles class and a fruit tree pruning class.

REFERENCES

- Boyd, James. 1929. A History of the Pennsylvania Horticultural Society, 1827-1927. Printed for the Society, Philadelphia, PA. <http://pennhort.libanswers.com/a.php?qid=96373>
- Bush, Carroll D. 1953. Nut Grower's Handbook: A Practical Guide to the Successful Propagation and Planting
- Cultivation, Harvesting and Marketing of Nuts. Orange Judd Publishing Company, New York, NY.
- Fishman, Ram. 1986. The Handbook for Fruit Explorers. North American Fruit Explorers, Inc., Chapin, IL.
- Jacke, Dave and Toensmeier, Eric. 2005. The Edible Forest Gardens: Ecological Vision and Theory for Temperate Climate Permaculture. Volume One: Vision & Theory. Chelsea Green Publishing Company, White River Junction, VT.
- Jacke, Dave and Toensmeier, Eric. 2005. The Edible Forest Gardens: Ecological Vision and Theory for Temperate Climate Permaculture. Volume Two: Design & Practice. Chelsea Green Publishing Company, White River Junction, VT.
- Rosengarten, Jr., Frederic. 1984. The Book of Edible Nuts. Walker and Company, New York, NY.
- Wilkinson, Albert E. 1945. The Encyclopedia of Fruits, Berries & Nuts and How to Grow Them. The New Home Library, Philadelphia, PA.

ACKNOWLEDGEMENTS

Sites Visited

Brooklyn Botanic Garden; Brooklyn, NY
Bartram's Garden; Philadelphia, PA
Philadelphia Orchard Project/Forsyth Gardens; Philadelphia, PA
PA Nut Growers Association; Harrisburg, PA
Rutgers University; New Brunswick, NJ
Tucquan Glen Nature Preserve; Lancaster, PA
Private Residence of Oliver Williams; Mount Airy, PA

Knowledgeable People:

Aiello, Tony; Director of Horticulture
Clarke, Louise; Natural Areas Section Leader
Greenberg, Todd; Head Gardener, Bartram's Garden
Forsyth, Phil; Founder and Orchard Director, Philadelphia Orchard Project and Forsyth Gardens
Molnar, Ph.D., Tom; Assistant Professor, Rutgers Department of Plant Biology and Pathology
Sam Councilman; Forager, Lancaster County
Williams, Oliver; Horticulture Volunteer, Morris Arboretum

Figure 1



Pawpaw Tree

Asimina triloba

Native to the United States, pawpaws are a little-known but nutritious fruit. Thomas Jefferson planted them at Monticello and in written accounts Clark and Lewis subsisted on pawpaws and nuts when other provisions ran low on their journey.

Pawpaws flower in the spring and the fruit falls from the tree in early fall upon ripening. They have a relatively short shelf life compared to other commercially grown fruits. This pawpaw fruit has a custardlike texture, and its flavor is often compared to tropical fruits such as a mixture of banana, mango, and pineapple. Plant breeding has led to cultivars producing larger fruits with fewer seeds.

Pawpaws prefer filtered sunlight, as they are an understory tree. To bear fruit, pawpaws need to outcross with other pawpaws. In nature, they often appear in groves and/or along riverbanks.

65-064*C



TITLE: Springfield Township Tree Canopy Study

AUTHOR: Nina Safavi
The Martha S. Miller Endowed Urban Forestry Intern

DATE: May 2012

ABSTRACT:

Urban forests provide environmental, economic, and aesthetic value to society. Reduction in stormwater runoff, energy savings, improvements in air quality, as well as their visual aesthetic are among the benefits of including trees as a part of the urban and suburban fabric. To safeguard tree resources into the future, municipalities can determine the percentage of their canopy cover and establish appropriate goals.

The Urban Forestry team's mission is to connect people and plants through outreach, education, and consulting both locally and regionally. With that mission in mind, the goal of this project was to help Springfield Township better understand its tree resources by conducting a tree canopy study using GIS (Geographic Information Systems) and LiDAR (*Light Detection and Ranging*) mapping technology.

Our planet's geography was poorly defined until the dawn of aerial photography following WWI. In today's modern age, maps are a precise and powerful tool used for presenting and analyzing spatial information. More advanced data are now being collected by aerial flyover. Montgomery County, Pennsylvania acquired a LiDAR dataset in 2008. These data can dramatically improve the ability of municipalities to make tree-related decisions because of more detailed and accurate measurements of their tree canopy.

Using LiDAR data, Springfield Township was found to have a 32.4% tree canopy cover. The resulting canopy cover map will be used in Springfield Township's Natural Resources section of their decennial Comprehensive Plan. The Township can now consider and set an appropriate canopy goal and next determine which areas to be targeted for future tree plantings.

To supplement the study, a proposal was developed to conduct a more in-depth analysis of Springfield Township's tree resources by inventorying and assessing trees under its jurisdiction. Additionally a marketing brochure was designed to promote the study to other municipalities and has evolved into a campaign to help additional townships understand their urban forest in its current form and plan feasible approaches to increasing tree canopy cover to benefit their citizens.

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BACKGROUND

Benefits of Urban Trees

Beyond their visual beauty, trees sequester carbon, reduce stormwater runoff, moderate the urban heat island effect, save energy, improve air quality, and increase property values illustrated in Figure 1 (Staley, 2004). Much of the literature on the benefits of urban trees comes from the United States Department of Agriculture Forest Service. From the Northern and Western Research Stations, David Nowak and other research foresters have quantified urban and suburban tree canopy cover and the benefits they offer.

In March of 2003, American Forests, Inc. and the U.S. Forest Service presented a report titled "Urban Ecosystem Analysis: Delaware Valley Region." The report's findings indicated that the 2.4 million acres that make up the Delaware Valley had suffered a loss of 8% of heavy tree cover (-34,000 acres) in 15 years, translating into a reduction in benefits offered by those trees (Urban Ecosystem Analysis, 2003). The analysis looked at changes in land use over time and calculated the monetary value of the environmental impact trees have on the region.

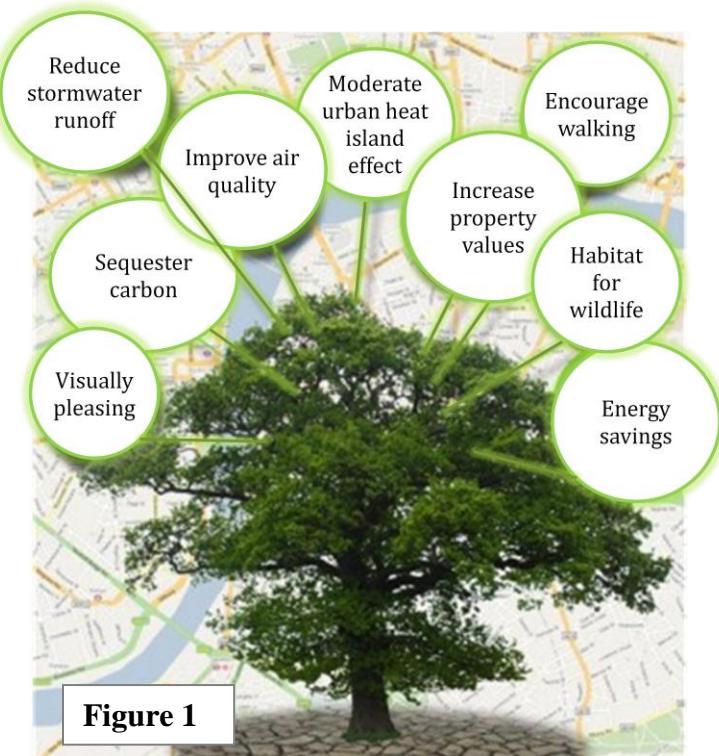


Figure 1

Stormwater Runoff

Trees are particularly beneficial to watersheds. Springfield Township's Wissahickon Creek Watershed and its receiving streams are negatively affected by a rise in impervious surfaces resulting from development where trees once stood. During a rain event water runs off hard surfaces and travels towards streams gaining speed, collecting pollutants, and increasing the volume of water that flows into streams. This process is exacerbated with a diminished forested landscape. Stormwater runoff peak and total flows are increased by this process and cause flooding, erosion, widening of stream banks, sedimentation, and a loss in water quality (Cotrone, 2008).

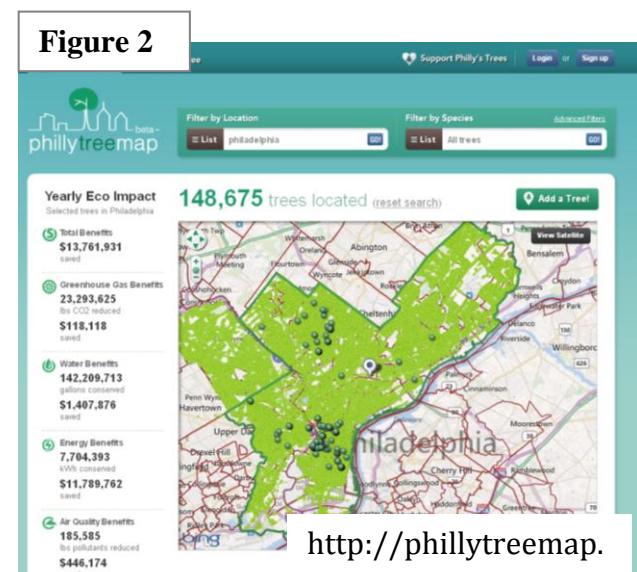
Most of the benefits derived from the urban forest come from the trees' leafy canopy. The canopy intercepts rain water, slows stormwater runoff, and reduces runoff volume. Interception is a way to calculate runoff mitigation by trees, and accounts for stormwater that fails to reach the ground surface. Studies have found that interception can reduce runoff from an average of 10-40% depending on species, season, and the precipitation rate. A deciduous tree in an urban or suburban setting can intercept 500 to 760 gallons of water per year. The volume is greater for evergreen trees, intercepting over 4,000 gallons per year, due to their foliage enduring over colder seasons (Cotrone, 2008). A Forest Service study found that a small nine-year-old Callary pear (*Pyrus callaryana*), intercepted 67% of the rain that fell within its canopy (58

gallons of stormwater from a ½-inch rainfall). However, large canopy trees planted over urban impervious surfaces are up to eight times more effective at intercepting stormwater (Cotrone, 2008).

Regional Urban and Suburban Foresting Efforts

Reacting to a declining urban forest, TreeVitalize was introduced by the Department of Conservation and Natural Resources (PADCNR), with a campaign to “Plant One Million” trees in three states, (Pennsylvania, New Jersey, and Delaware) and is currently run by the Pennsylvania Horticultural Society (PHS). Moreover, they have a goal to train 10,000 volunteers in tree biology and tree care to serve as community stewards in establishing and maintaining new plantings. Ultimately the goal of TreeVitalize is to establish strong urban forestry partnerships in the region, and to build local capacity for sustaining the urban forest resource (www.treevitalize.net).

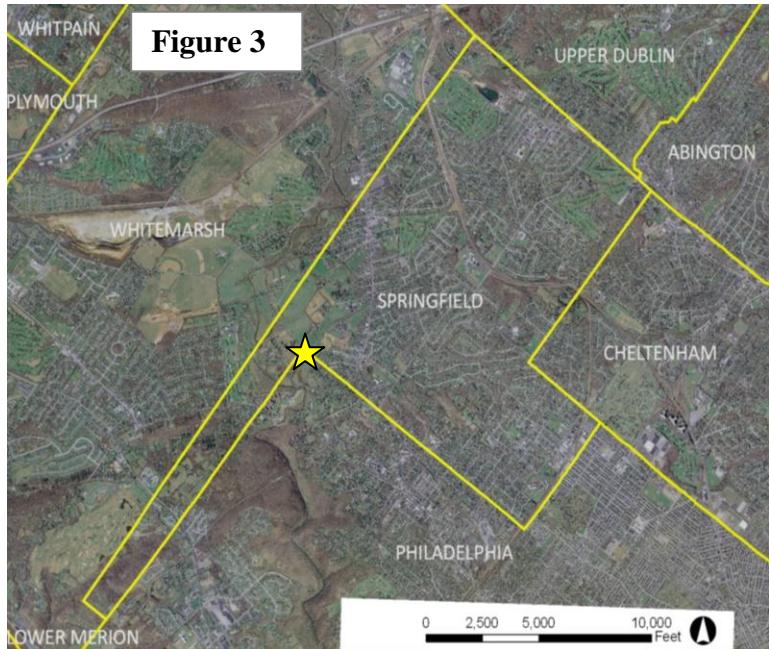
A number of collaborative initiatives by other organizations have since been introduced. Philadelphia Parks and Recreation recently launched TreePhilly, a tree giveaway program for private property home owners. All regional planting efforts count towards the “Plant One Million” goal. To track and analyze urban trees a number of inventory and analysis software programs are available including iTree and CityGreen. Additionally, to encourage public engagement and ease the data collection loads, a local mapping consulting company, Azavea, has developed Philly Tree Map represented in Figure 2. This open source website allows anyone to enter data for species, location, and size and see the calculated benefits of the urban forest.



Springfield Township and the Morris Arboretum

Springfield Township, located in Montgomery County, Pennsylvania, recognizes the benefits of their urban forest. The updated decennial Comprehensive Plan will include a new subsection on Tree Canopy Cover within its chapter on Natural & Historic Resources, demonstrating that the township values trees as an important part of their green infrastructure. The township stretches across over 16 square miles of mostly suburban community with a population of about 19,500 (www.springfieldmontco.org). To ensure a sustainable healthy urban forest, the township can benefit from further analysis of their canopy cover.

Springfield Township is home to the Morris Arboretum's Bloomfield Farm, where the Horticultural Center accommodates about a quarter of the Arboretum staff. Figure 3, represents Springfield Township and the Morris Arboretum, which is represented by a star. The Arboretum's Director of Public Programs, Robert Gutowski, serves as Chairman of the Springfield Township Planning Commission, and has established a close and active relationship between the township and the Arboretum. Former Arboretum projects included updating Springfield Township's approved plant materials list.



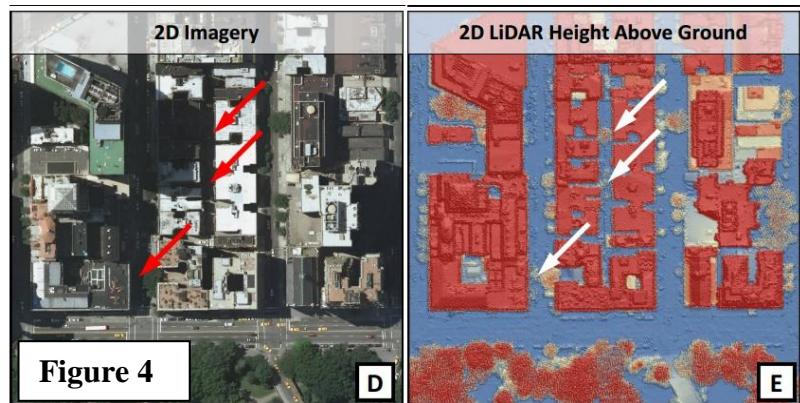
METHODOLOGY

Tree canopy studies are a necessary part of natural resource planning and management. Recognizing the importance of the urban forest, researchers have explored ways to more accurately and efficiently determine canopy cover. While conducting an inventory and assessments of individual trees is useful for assessing the health and potential hazard of urban trees, it can be timely and costly. For large scale sites tree canopy mapping can be determined using aerial data.

The Spatial Analysis Laboratory (SAL) at the University of Vermont's (UVM) Rubenstein School of the Environment and Natural Resources developed a methodology for determining tree canopy cover using Light Detection and Ranging (LiDAR) data. The methodology has been used for determining canopy cover for a number of American cities. Based on 2008 data and the USDA Forest Service's tree canopy protocol, the UVM analyzed Philadelphia's tree canopy. This project was made possible by an America Recovery and Reinvestment Act (ARRA) grant through the USDA Forest Service's Northern Research Station, in collaboration with Philadelphia Parks & Recreation (O'Neil-Dunne, 2011).

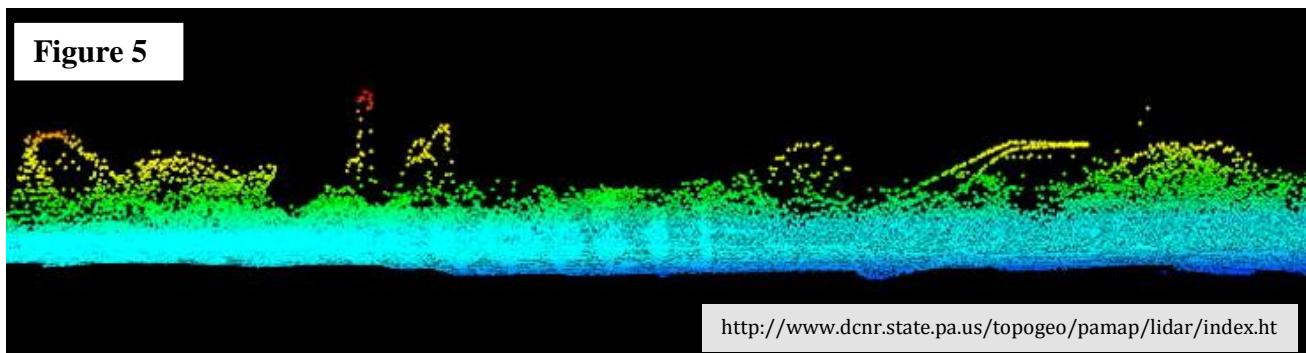
In 2008, Montgomery County also acquired LiDAR data through the PAMAP program by the Pennsylvania Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey. The data are made available for free through the Pennsylvania Spatial Data Access (PASDA) website, a hub for spatial information. To determine canopy cover, these data were extracted for Springfield Township, and processed using a methodology similar to that of UVM and documentation from the Environmental Sciences Research Institute (ESRI). The geographic information system used for processing was ArcGIS.

Prior to the availability of LiDAR data, the only comprehensive remotely-sensed estimates of tree canopy for the region were from the 2001 National Land Cover Database (NLCD 2001). NLCD 2001 is derived from relatively coarse, 30-meter resolution satellite imagery. Using LiDAR acquired in 2008, land cover can be mapped with greater accuracy than NLCD 2001, due to closer intervals of data points and the absence of shadows. Figure 4 from the UVM protocol illustrates this difference between LiDAR over NLCD.

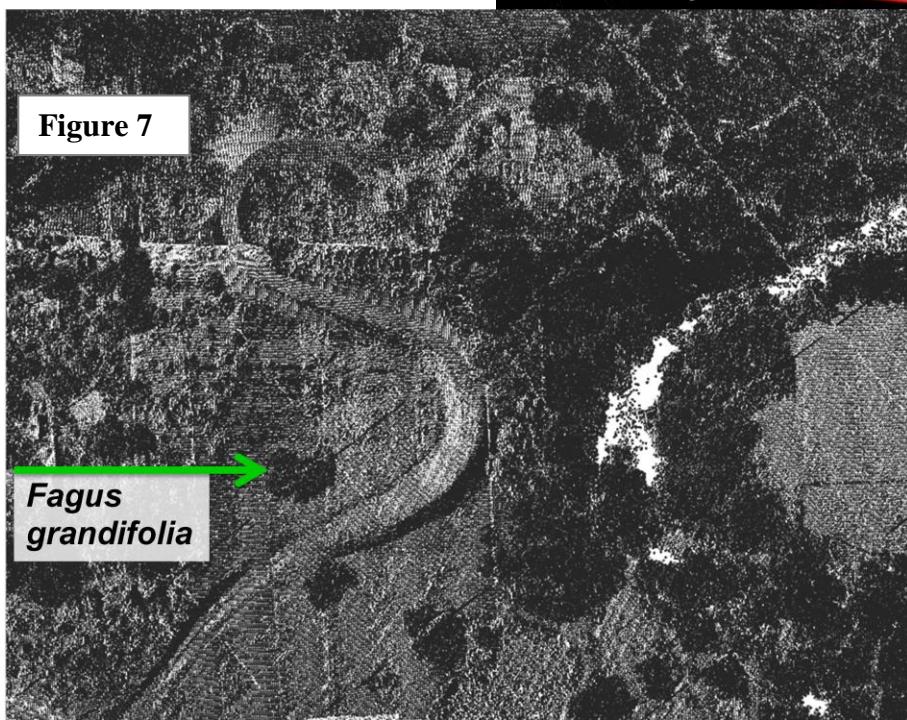
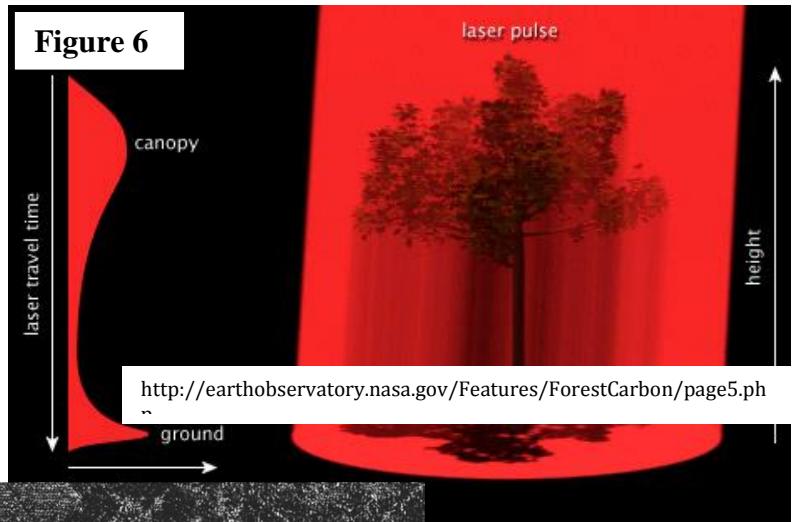


<http://nrs.fs.fed.us/urban/utc>

LiDAR is captured by flyover in which the plane illuminates the target with light using laser pulses. Capturing the distance it takes for each pulse to bounce back, a corresponding x, y, and z coordinate point is created. All the captured points form a point cloud that illustrates the volumetric shape of the given site. Figure 5 represents the point cloud for an amusement park in section view.

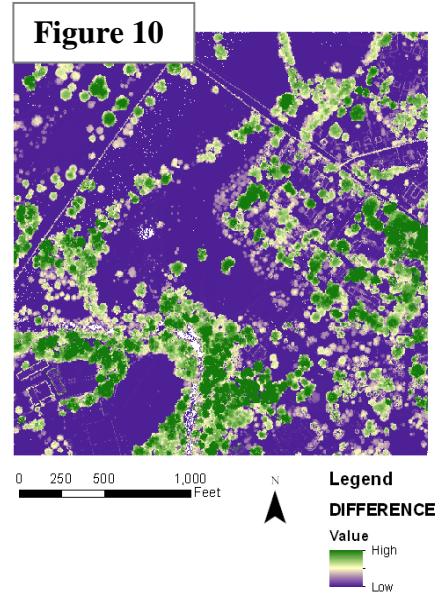
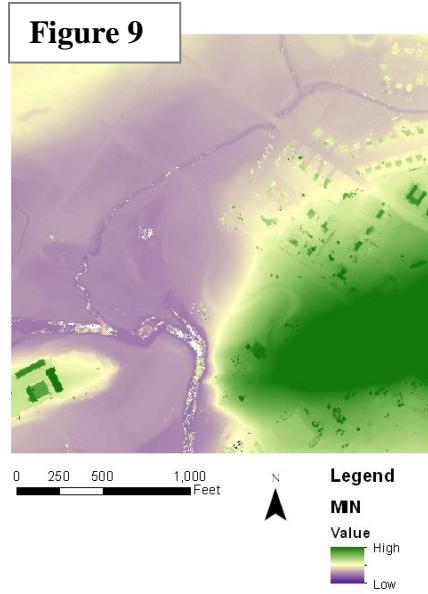
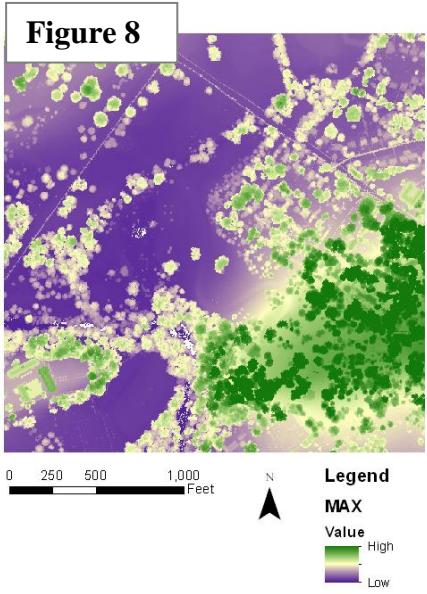


Tree canopy is the layer of leaves, branches, and stems that cover the ground when viewed from above. Trees have a unique spatial characteristic due to the height variation associated with each tree's shape. LiDAR points are determined for the ground as gaps between leaves and branches allow for ground penetration. Figure 6 illustrates how light contacts trees and captures height values. Moreover, maximum height is captured as light contacts the top of the crown. Similarly, values are captured for light contacting branches, foliage, and trunk between the ground and the crown. Figure 7 shows a LiDAR point cloud representation for the Morris Arboretum's "S" shaped driveway up the Magnolia Slope with the big *Fagus grandiflora* marked for scale. This section of the Morris Arboretum will be used to illustrate the following steps for creating a tree canopy map.



The data points were interpolated to create a smooth surface presenting minimum and maximum surface points. Where data points were not captured, the values were estimated through extrapolation. The absolute height, adjusted for variations in ground elevation is attained by subtracting the minimum value from the maximum. The resulting map of the difference

represents canopy cover. Most groundcover and infrastructure that has the same maximum as minimum will cancel each other out since their difference is zero. Minor adjustments, selecting the minimum height to display, can then be made to determine tree canopy. Maps for interpolations of minimum, maximum, and difference are represented below by Figures 8, 9, and 10.



The difference map was next overlaid on aerial imagery and is illustrated in Figure 11 to roughly show that the canopy cover map does fit the site very well.

Figure 11: Morris Arboretum Sample Site Canopy



RESULTS

Comparison to other Municipalities

The preceding steps from the described methodology were followed for Springfield Township and revealed a total canopy cover of 32.4%. Springfield Township's canopy cover is below American Forests' recommendations: of 40% for overall canopy; 50% in suburban residential; 25% in urban residential; and 15% in central business districts (Urban Ecosystem Analysis Delaware Valley Region). Across the country, many municipalities are determining their canopy cover and are setting tree canopy goals for the future. Philadelphia, learning it had a canopy of 20% in 2008, is planning to expand their urban forest to 30% by 2015 (O'Neil-Dunne, 2011). Similarly, Washington D.C. has a goal of 40% by year 2035, from a 2002 canopy cover of 34% (www.caseytrees.org/programs/policyadvocacy/utc). Figure 12 represents other municipalities and their corresponding canopy cover and goals.

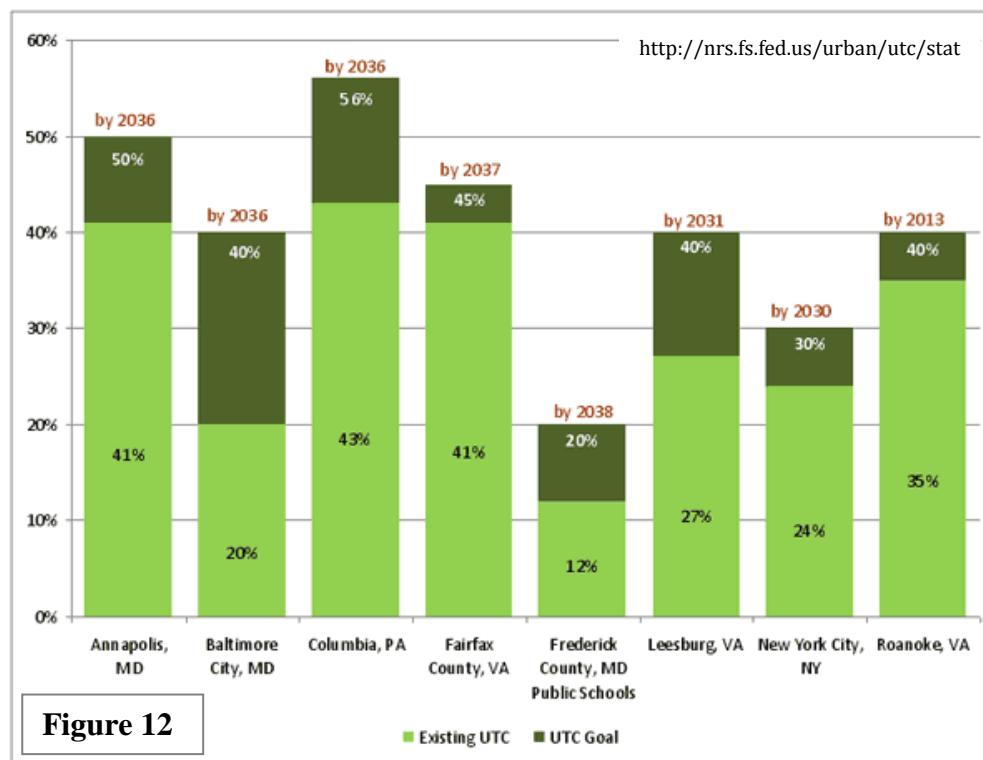


Figure 12

Springfield Township Stormwater Runoff Implications

Canopy cover offers many benefits, some of which can be quantified financially. Springfield Township's planners are especially concerned with stormwater management. Infrastructure used to manage stormwater is costly. Using values determined by the Urban Ecosystem Analysis for the Delaware Valley Region in 2003 stormwater mitigation benefits by canopy cover were extrapolated for Springfield Township. Given an average 2-year, 24-hour rainfall of 3.25 inches, with a 32.4% canopy cover (1,395 acres of total canopy) the construction cost of building additional stormwater infrastructure at \$2 per cubic foot would be \$4,356 per acre. Canopy cover for Springfield Township provides a benefit of about \$6,000,000 in

infrastructure cost savings from runoff. The estimated cost savings is for stormwater runoff alone, and neglects all the other benefits offered by trees.

Potential for Tree Planting

To ensure future generations of trees, it is important to maintain existing trees and plant new trees. Taking a closer look at land use can reveal opportunities for tree plantings. The resulting canopy cover map was overlaid on a Land Use category map, shown in Figure 13, provided by Montgomery County to determine the percentage of canopy cover for each land use category.

Figure 13

Springfield Township
Montgomery County
Pennsylvania

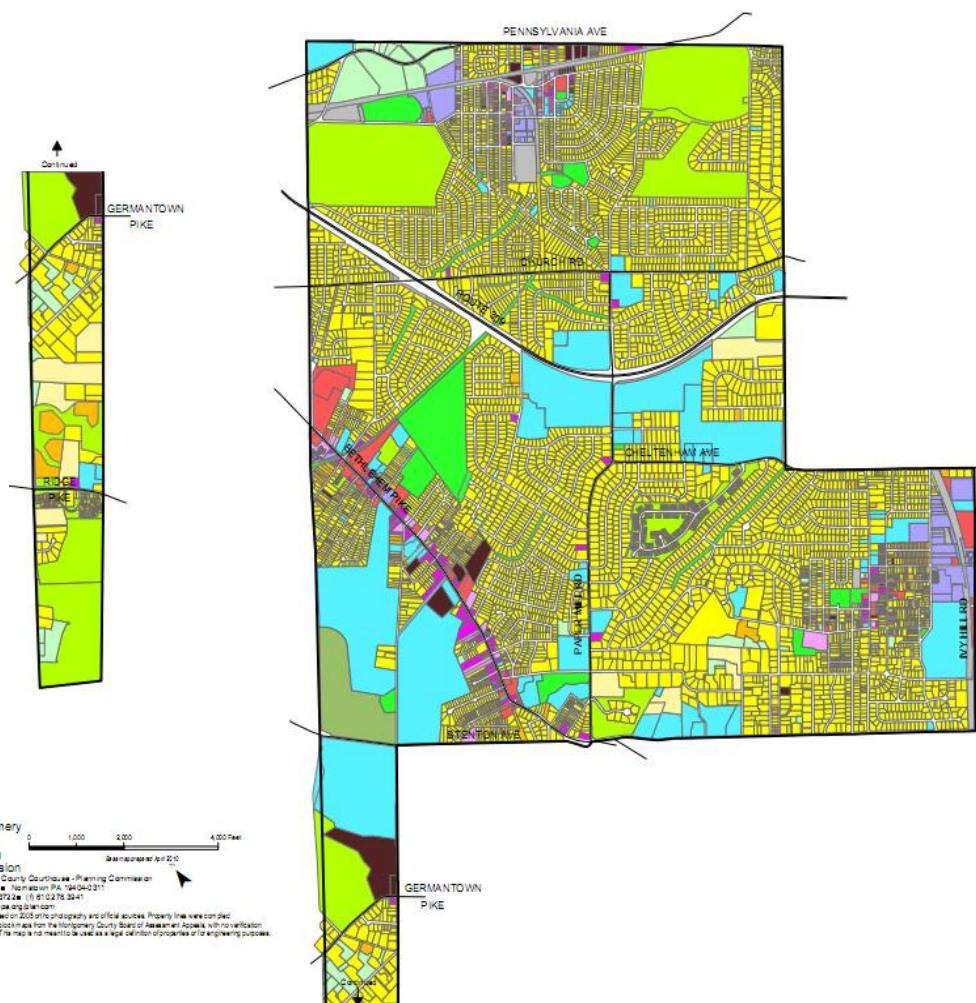
Figure ?

Existing Land Use

- Multifamily
- Single Family Attached
- Twin / Duplex
- Single Family Detached
- Country Residence
- Mixed Use
- Retail
- Office
- Industrial
- Institutional
- Utilities
- Undeveloped
- Public Open Space
- Private Open Space
- Agriculture

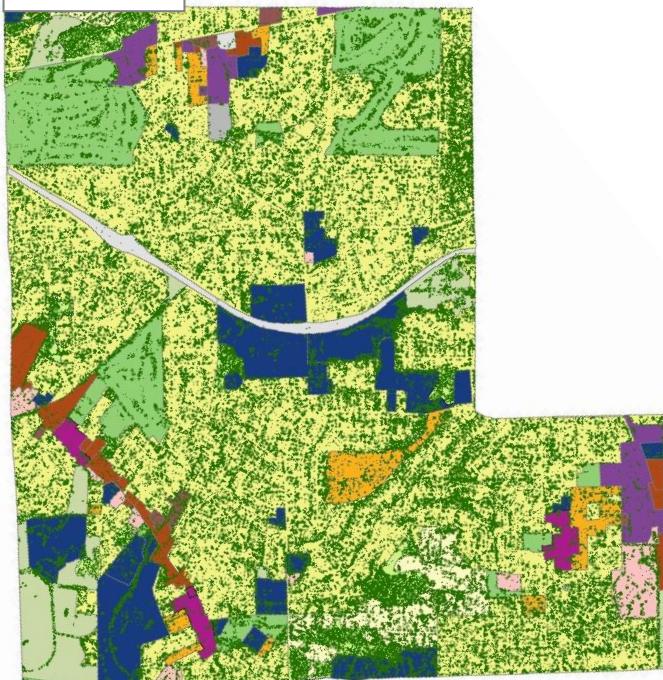
Source: Montgomery County Board of Assessment Appeals, April 2010

MCPC Montgomery
County
Planning
Commission
Montgomery County Comprehensive Planning Commission
100 North Broad Street, P.O. Box 20371
(412) 274-3722, (412) 274-3247
www.montcopa.org/plann委
This map is for planning purposes only. It is not a survey or legal map. Property lines were compiled from the 2010 Board of Assessment Appeals property records. This map is not meant to be used as a legal definition of property lines for engineering purposes.



Among land use categories there is room for improvement for “Single Family Attached” areas, which has a calculated canopy cover of 26%. Not surprisingly, the “Wooded” category has the highest percentage (71%) of canopy cover. Amongst residential areas, “Single Family Detached Low Density” has the highest canopy cover with 43%. All categories and their corresponding canopy cover are represented in Figures 14, 15 and 16 in map, tabular, and graph formats.

Figure 14



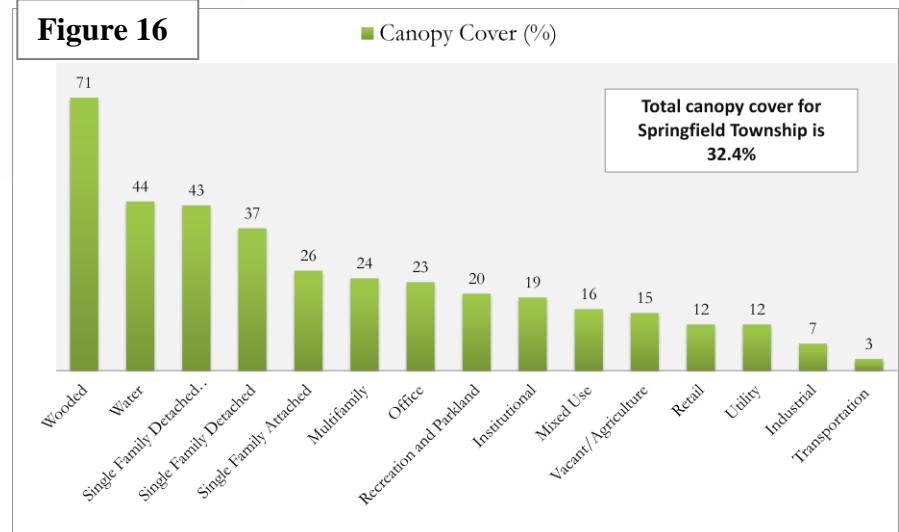
Legend

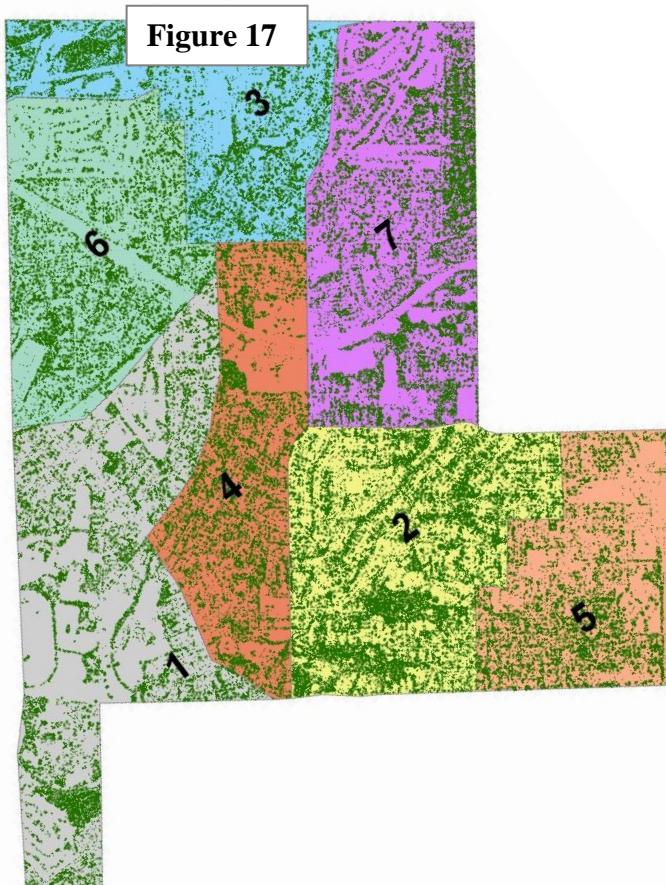
2010 Land Use	
Industrial	
Institutional	
Mixed Use	
Multifamily	
Office	
Recreation and Parkland	
Retail	
Single Family Attached	
Single Family Detached	
Single Family Detached low Density	
Transportation	
Utility	
Vacant/Agriculture	
Water	
Wooded	

Figure 15

Land Use	Land Use #	Area (acres)	Canopy Cover (%)
Wooded	14	266	71
Water	16	3	44
Single Family Detached Low Density	2	179	43
Single Family Detached	1	2355	37
Single Family Attached	4	116	26
Multifamily	3	25	24
Office	10	66	23
Recreation and Parkland	13	493	20
Institutional	11	361	19
Mixed Use	9	39	16
Vacant/Agriculture	15	190	15
Utility	7	9	12
Retail	8	76	12
Industrial	12	83	7
Transportation	6	46	3

Figure 16





Additionally, canopy cover was broken down by Voting Wards, shown in Figure 17. Ward 2, accounting for the general Wyndmoor area, had over 10% more canopy cover than the others, with a total of 44%. Given this condition, potential for improvement lies in the top left corner of the yellow area. Ward 6 had the least cover with 27%. Ward 1, Flourtown, with 32%, has the second most coverage, but it too but could be improved since much of the canopy is designated in the protected natural panhandle area of the ward.

LIMITATIONS TO THE STUDY

There are a number of limitations to this study. First, related to the data, the tree canopy map represents conditions at the time the LiDAR data was collected (2008). It is unlikely that the canopy has changed significantly since then and the more meaningful question is when can this data be collected again? The PAMAP program has flyovers planned for every three years. However, budgetary constraints have restricted abiding to the schedule. It can be anticipated that LiDAR flyover will resume in the future as this type of data continues to become more precise and popular. Ultimately Springfield Township can expect to have the data capacity to reassess its tree canopy in the future for comparison to 2008.

Furthermore, the data was captured at intervals of 3.2 feet. For areas between points that were not collected, canopy cover was determined by extrapolation algorithms. Since 2008, LiDAR has become even more precise. The city of Philadelphia is expecting to acquire a 4 inch interval dataset.

Finally, knowing that tree canopy encompasses 32.4% of Springfield Township is helpful, but does not provide any information about the health and longevity, like a tree inventory and assessment would provide. Moreover, the canopy cover map layer can be more beneficial for determining planting locations if supplemented with other map layers such as impervious surface, slope, sidewalk planting pits, etc.

DISCUSSION

Springfield Township now has baseline information allowing planners to understand and quantify their canopy cover. They can use the tree canopy map as a planning tool for determining planting locations. To supplement this study Springfield Township would benefit from a planting targeting study to detail specific potential planting locations and a tree inventory and assessment. While these services fall outside of the scope of this study, a proposal addressing these issues is in Appendix I.

The general mindset of Springfield Township residents is that development has reached its peak, and no further investment in green infrastructure planning is needed. Residents may be uncompromising when it comes to the use of their tax dollars on canopy planning efforts as well as being advised on what to do on their private property. For instance, after paying a few thousand dollars to remove a hazardous tree in their yard, it is understandable that someone may not want to plant a new one. Educating people about the benefits of trees can start to shift residents' thinking.

Finally, while this study is restricted by the geographic boundaries of Springfield Township, nature knows no boundaries. Stormwater runoff and retention is not confined within municipal borders. A larger campaign aimed to help other municipalities understand their canopy cover and set appropriate goals is necessary for larger scale benefits. Whitemarsh Township has already expressed a strong interest in the study and is reviewing a proposal submitted by the Urban Forestry Consultants. To promote canopy cover studies region-wide, a marketing brochure was developed and is included in Appendix II.

REFERENCES

- Coltrane, Vincent. "The Role of Trees & Forests in Healthy Watersheds." Penn State Extension. http://www.dcnr.state.pa.us/ucmprd2/groups/public/documents/document/dcnr_009116.pdf.
- Dwyer, Mark C. & Robert W. Miller. 1999. "Using GIS to Assess Urban Tree Canopy Benefits and Surrounding Greenspace Distributions." Journal of Arboriculture. v25, n2 (March 1999).
<http://www.treelink.org/joa/1999/march/08_USING_GIS_TO_ASSESS_CANOPY_BE_NEFTS_dwyer.pdf>
- Grove, J. Morgan; O'Neil-Dunne, Jarleth. "Urban Tree Canopy Analysis Helps Urban Planners with Tree Planting Campaigns." U.S. Forest Service Northern Research Station. 2011 No. 11. <http://nrs.fs.fed.us/news/review/review-vol13.pdf>.
- Jensen, Ryan. "Using Remote Sensing and Geographic Information Systems to Study Urban Quality of Life and Urban Amenities." Ecology and Society. Vol 9, No. 5.
- Keating, Janis. "Trees: The Oldest New Things In Stormwater Treatment? How Much Do Tree Canopies Really Affect Runoff Volume?" Stormwater. v3, n2 (March/April 2002). http://www.forester.net/sw_0203_trees.html.
- Lidar Analysis in ArcGIS 10 for Forestry Applications: An Esri White Paper*. Jan 2011.
<http://www.esri.com/library/whitepapers/pdfs/lidar-analysis-forestry-10.pdf>
- McPherson, E. Gregory, James R. Simpson, Paula J. Peper, Scott E. Maco, and Qingfu Xiao. 2005. "Municipal Forest Benefits and Costs in Five U.S. Cities." Journal of Forestry. v103n8 (Dec 2005): 411-416.
- McPherson, E. Gregory, James R. Simpson, Paula J. Peper, and Qingfu Xiao. 1999. "Benefit-Cost Analysis of Modestos Municipal Urban Forest." Journal of Arboriculture, v25n5 (Sep 1999): 235+. <<http://www.treelink.org/joa/1999/sep/02mcpherson.pdf>>
- Nowak, David J. "Tree and Impervious Cover Change in U.S. Cities." USDA Forest Service, Northern Research Station. vol:11, Issue:1, 2012, Pages 21–30.
http://nrs.fs.fed.us/pubs/jrnls/2012/nrs_2012_Nowak_001.pdf
- O'Neil-Dunne, Jarlath. "A Report on the City of Philadelphia's Existing and Possible Tree Canopy." 2011. University of Vermont Spatial Analysis Laboratory.
http://www.fs.fed.us/nrs/utc/reports/UTC_Report_Philadelphia.pdf.
- Rains, Michael. 2010. "*Preserving and Restoring Tree Species Disappearing From Our Forests.*" U.S. Forest Service Northern Research Station. No. 9.
<http://www.fs.fed.us/nrs/news/review/review-vol09.pdf>
- Springfield Township Comprehensive Plan Update Draft, Montgomery County, 2011

Springfield Township Comprehensive Plan, Montgomery County, 2009

Staley, Dan. "Benefits of the Urban Forest Literature Review." Casey Tree White Paper. May 2004, .<http://www.hiway410.com/dstaley/Draft%20Casey%20Trees%20White%20Paper.pdf>.

Urban Ecosystem Analysis Delaware Valley Region: Calculating the Value of Nature. 2003. American Forests.

Varela, C. Sebastian. 2008. *Urban Biological Corridors and Their Socio-Environmental Implications: A Plan to Establish a Green Infrastructure in Northwest Philadelphia, PA.* State University of New York, College of Environmental Science and Forestry.

The Wissahickon Roundtable: Land Development Practices to Protect the Wissahickon Creek. 2010. Pennsylvania Environmental Council.

Xiao, Qingfu, E. Gregory McPherson, James R. Simpson, and Susan Ustin. 1998. "Rainfall Interception by Sacramento's Urban Forest." Journal of Arboriculture, v24, n4 (Jul 1998): 235-244.

Additional Resources:

Montgomery County Planning Commission

Springfield Township

City of Philadelphia, GSG office of Innovation and Technology

City of Philadelphia, Enterprise GIS

For their help and support, a special thank you to:

Robert Gutowski, Director of Public Programs & Chairman of Springfield Township Planning Commission

Jason Lubar, Associate Director of Urban Forestry

Robert Wells, Associate Director of Arboriculture Outreach

TITLE: **From the Canopy: An Arborist's Perspective**

AUTHOR: **Daniel Weitoish**
The Walter W. Root Endowed Arboriculture Intern

DATE: **April 2012**

ABSTRACT:

The goal of this project is to enhance the visitor experience at the Morris Arboretum in the pursuit of fostering a stronger conservation ethic through the use of smartphone technology. Quick Response (QR) Codes placed on a tree identification tag will link a visitor to the created tree profiles where one can explore tree metrics, in-depth horticultural information, and multimedia content acquired in the canopy highlighting a tree climber's perspective.

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INTRODUCTION

The foundation of this project is built upon a single premise: an enhanced connection to trees will foster a stronger conservation ethic. Therefore, the goal is to deliver materials to Arboretum guests that will give them the opportunity to explore our trees in a manner not typically available.

Arborists are afforded a unique perspective on trees since their work often requires climbing into the canopy. The privilege to observe a tree from the canopy delivers a point of view entirely unlike the ground level perspective. Whether it's observing the distinctive ecology of canopy lichens or being awestruck by the view at 110 feet in the air, being in the canopy permits appreciation of the tree orders of magnitude greater than simply walking by it and it is this viewpoint, exploration, and wonder that I hope to provide for our guests.

Clearly, it is impractical to physically bring guests into the canopy with less than large capital investments like our *Out on a Limb* exhibit. To complete this goal with little or no cost, use of smartphone technology will be combined with QR Coding on tree identification tags to link a guest to our website. Each QR tag will encode for a URL that directs a guest's smartphone to a plant profile page containing useful information, pictures, and links to videos. Furthermore, generated plant profiles and associated content will be accessible from our website for any individual interested in exploring our garden remotely or studying it in a classroom.

METHODS OF CONTENT GENERATION

Plant Profile

A guest's first experience with this project will involve interacting with the plant profile page (Appendix D) that is coded with a given QR Code. This page will deliver both quick access material (tree metrics and images with seasonal interest) as well as a more in-depth, horticultural profile modeled after the "Issues in Arboretum Management" Living Collections information sheet (Appendix A).

The living collections sheet contains generalized information for one plant species. To better illustrate the individual characteristics of a specific tree, data were collected for the height, spread, and circumference at breast height (CBH). This data corresponds to trees targeted for photography, as well as nearby trees so as to keep our accession data as up-to-date as possible (Appendix B). The height measurement method employed was indicated by a letter where: (M) reflects a direct measurement using a dropped tape measure from the canopy of a tree. An advisable approach for future use of this method should involve attaching the tape measure to a 12 to 20 foot pole saw/hook and lifting it to the highest part of the canopy to increase the speed of the endeavor and decrease the danger of climbing on the thinnest branches in the upper canopy. This method is by far the most accurate but requires substantially more time. A (S) designated height assessed with the "stick trick" as advised on the Pennsylvania Big Trees website ([1](#)); refer to their site for a description of this method. Significant advantages of this method include the ability to use it from the ground, the few pieces of necessary equipment required, and the speed of execution. However, accuracy is diminished with variables like

observer error and changing topography and the method requires an open area around the measured tree, making it not feasible in forested areas. Finally, the (E) designation indicates an estimated average for two observers. Admittedly, this estimate can be highly variable but when the other two methods were impossible or impractical to apply, this can provide relatively accurate information with a pair or group of practiced observers.

Pictures and Videos

Images captured during the course of this project focused on photographing both seasonal features of a given tree and attractive vistas at several heights. Images were captured with a Canon Powershot Sx230HS point-and-shoot camera. Firstly, the camera, in its protective case, was attached to the rope below the climber using a clove hitch. The targeted tree was climbed and examined for attractive vistas and interesting features. After reaching the top, the attached camera was pulled up, removed from the line, and attached to the climbing harness. Pictures were then captured from each targeted vista as the climber descended the tree.

The intent behind the videos is to provide the viewer with the sensation of both existing in a stationary position in the tree as well as moving up or down. To capture the stationary perspectives, the climber either filmed a vista with no movement so as to best capture sound and subtle tree movement, or slowly panned the camera side to side in a steady course over a duration of 30-120 seconds to gather a wider perspective. Many of the videos that used panning were rejected as a result of camera shake that resulted from free-hand shooting. Vertical transition often occurred over a distance of 5 to 7 feet where the climber slowly raised or lowered the camera, capturing the trunk of the tree along the way, and finally panning out to one side when the ascent/descent was complete. These videos provide the truest sensation of traveling up and down the tree given the fixed position on the trunk during the motion.

IMPLEMENTATION

QR Code Generation and Placement

QR Codes are two dimensional matrix codes that, when incorporated into this project, represent a website URL in a format that is easily scanned by a visitor's smartphone (Appendix C). After the completion of a given tree's profile, a QR Code generator will be utilized to generate a code for placement in the garden. This code will be printed, waterproofed, and attached to either the back of a highly visible copper tree tag, or to a freestanding stake when this approach is preferred.

Smartphones and Software

The use of smartphones is essential to the execution of this project. A smartphone is defined as a cell phone with more advanced computing capability and connectivity than a traditional cell phone. The "advanced" hardware features required for this project are a working camera to scan QR Codes, internet connectivity to access website plant profiles, as well as the computing and video power to play videos and show pictures.

Possession of the appropriate software to scan QR Codes is also critical to this project. This software, given that QR Coding and use is mostly in its infancy, is not a common part of

pre-loaded software packages and, therefore, must be downloaded from the user's application store. Many applications to achieve this end are available in both free and paid versions.

Guest orientation to QR Coding and the existence of this project will be necessary after implementation. This will take the form of an informative display in the gift shop where a visitor is guided to download appropriate QR Code scanning software and is provided with a map identifying scanable plants in the garden.

CHALLENGES AND ADJUSTMENTS

Panorama Failure

As previously stated, the goal of the project was to provide our guests with a way to deepen their interaction with the Arboretum's collections. Earlier pursuits of this goal focused on the creation of 360° panoramas that would be viewable on a smart phone. The intent was to deliver to the guests some measure of control so that they might manipulate the panorama. This control was to provide the ability to pan vertically and horizontally with the hope that increased control would translate to enhanced visitor engagement.

Ultimately, this approach proved fruitless due to the lack of proper photography equipment. Using a simple point-and-shoot camera with a standard lens, combined with the inability to effectively mount a tripod in most trees, resulted in images that failed to stitch properly in several photo stitching softwares (Photoshop, Easypano, Ptgui, Panomonkey, and Panoweaver). Further investigation revealed that, despite the claims of most stitching software, only images shot with a fish-eye lens yield the sort of 360 ° spherical panoramas that were necessary for the design of the project. It is my belief that using the correct DSLR camera with a fish-eye lens while shooting freehand from a tree top can create these images in the future. However, this failure was formative to the project, leading to the incorporation of videos as a substitute and potentially improving the quality of the project overall.

A Luddite's Quandary

On another note, I think it is important to address the philosophical implication of promoting the use of technology at an institution that seeks to deliver exposure to nature. One of the greatest merits of the Morris Arboretum is that, despite residing within the city of Philadelphia, our garden contains natural areas, forested trails, and open meadows that provide guests with an ecological setting not commonly granted to those living in an urban environment. If the Arboretum serves this unique function, why then would I promote the use of technology that will mar the essential immersive experience in our natural world?

I argue that it is incorrect to assume that the immersive experience of nature is innate to all humans. Not only is this argument most well illustrated by individuals raised and/or residing in an urban setting, the technological accessibility and pervasiveness of our present culture nearly mandates constant access to cell phones, computers, and the internet. The "Information Age" is aptly named, being indicative of how many in our culture orient themselves to their world. Providing these individuals with the option to gather more information about a tree through the use of their technology may be the best option to open the door to a true natural

immersion and promote an ethic of conservation. A maxim that has proven true in my own horticultural education provides a succinct summation to this point: “the more you learn, the more you can see”. Therefore, it is my conclusion that, despite some arguments to the contrary, promoting the use of technology in our garden will not detract from a visitor’s experience.

Seasonal Constraints

As previously stated, an important intent of this project was the inclusion of images that featured seasonal interest of particular plants. Plants are often valued for their seasonal interest. When one encounters them outside of this limited time period, they may be curious to see why this plant is valued. Capturing seasonal interest was hampered by both the weather and time frame in which the project took place. Opportunities to use snow to showcase winter interest were very limited as a result of the few snowfall events and the lack of accumulation over the entire winter of 2012. In addition, considering that the project was fully developed by November 2011 and the publication of this document occurred in April 2012, only a short window of time was available to capture seasonal interest. Expansion or continuation of this project over an entire year or over successive years will be sufficient to mitigate these limitations.

FUTURE WORK

The major product of this project is the structural foundation for designing plant profiles, making them available online, and permitting mobile access within the garden. Additionally, with the inclusion of more images, videos, and profiles, expansion to other plants, garden features, exhibits, and historical structures is easily achievable. It is my goal to complete as many tree profiles as possible before the end of this internship, but the addition of content can be supplied by any staff member or intern seeking to enhance a visitor’s experience.

CONCLUSIONS

Rarely does one have the opportunity to explore and create a more fun and interesting product than this one; for this I am exceedingly thankful. Capturing each tree required climbing it and by doing this I had the privilege of exploring each one more completely than most individuals will ever have a chance to. I hope that by making the product of these climbs available to others they will gain my perspective and, through doing so, will develop a stronger connection to our trees and seek their conservation well into the future.

Finally, special thanks to my project supervisor Andrew Hawkes for his patience, training, advice, and guidance throughout this project. Additionally, Zac Brooks, Arboretum Web Master, deserves credit for all website coding and design; without either of these individual this project could never have been completed.

References

1. <http://www.pabigtrees.com/Measure.aspx>

APENDICES

Appendix A: Living Collections Data Sheet Living Collections Sessions

Plant Description

Plant Scientific and common names: *Acer nigrum* - black maple

Scientific name and translation: *Acer nigrum*

Acer is the Latin name for this genus. The word also means sharp and refers to the hardness of the wood, which Romans used for spear hafts. *Nigrum* means black

Common name: black maple – perhaps because of the darkness of the foliage

Family and how it relates to this species: *Aceraceae (Sapindaceae)* – maple family (soapberry family); you can tell this because it has opposite, palmately compound leaves and samaras as fruits

Native Range and Horticultural Adaptability

Origin: Northeastern and north-central United States, including Iowa

USDA Hardiness: 3b to 7b, north of Minneapolis to Atlanta, Georgia

Horticultural Interest and Uses

Landscape uses and Characteristics (size):

Upright oval to rounded tree, 60-75 feet at maturity, useful as large-scale shade tree, boulevard tree

Cultural requirements: well-drained, moist, fertile soil; full sun

Identification traits: opposite, simple leaves, leaves three (to five) lobes, droopy, pubescent leaves, persistent stipules, long pointed buds

Seasonal interest (where appropriate):

Spring:

Summer:

Fall: excellent fall color, ranging from yellow-orange to orange-red

Winter:

Cultivars and related taxa: 'Greencolumn'

Other background

Acer nigrum is closely related to *Acer saccharum*, the sugar maple, and some people consider it a subspecies of sugar maple. It differs mostly because of the shape and pubescence of its leaves. Its range overlaps with that of sugar maple, except that sugar maple does not grow west of the Mississippi and black maple grows west of the Mississippi into Iowa and Minnesota. As a result it shows broader adaptability than sugar maple.

Appendix B: Tree Metrics Data Sheet

#	Acc. Number	Latin Name	CBH (inches)	Height (feet)	Spread (feet)
1	56-239	<i>Fagus engleriana</i>	at ground 256	60' (M)	103
2	32-0068*A	<i>Aesculus flava</i>	173	85 (M)	70
3	64-751-A	<i>Acer griseum</i>	at 2' 48	30	27
4	64-760-A	<i>Stewartia pseudocamelia</i>	31	26	23
5	32-1106-A	<i>Ulmus glabra cv. horizontalis</i>	85	22	38
6	32-0052-A	<i>Ulmus parvifolia</i>	at 2' 209	76 (S)	87
7	32-0424*A	<i>Pinus strobus cv. Nana</i>	39	23 (S)	24
8	32-0672-A	<i>Tsuga canadensis f. pendula</i>	94	31 (S)	43
9	32-0407	<i>Taxodium ascendens "Morris"</i>	78	58 (S)	23
10	32-0697-A	<i>Abies cilicica</i>	95	102 (S)	23
11	95-174-A	<i>Zelkova sinica</i>	47	55 (S)	39
12	35-6324-B	<i>Juniperus rigida</i>	56	63 (S)	22
13	35-6483-A	<i>Thuja occidentalis cv. DT#2</i>	70	60 (S)	23
14	35-5345-A	<i>Chamaecyparis pisifera 'Squarrosa'</i>	80	65 (S)	37
15	47-131-A	<i>Cunninghamia lanceolata</i>	55, 56, 41, 42, 53, 4	65 (S)	43
16	74-008-A	<i>Rhamnus lanceolata</i>	23, 27, 25, 33, 16, 17,	26 (S)	37
17	86-020-A	<i>Celtis choseniana</i>	28	17 (S)	30
18	54-0533-A	<i>Thuja occidentalis</i>	33, 20, 26, 22, 25	35 (S)	27
19	32-1122-A	<i>Chamaecyparis nootkatensis 'Glauca'</i>	54	45 (S)	23
20	32-0671-A	<i>Thuja occidentalis 'Vervaeana'</i>	42		17
21	47-323-C	<i>Cedrus atlantica</i>	112	82 (S)	49
22	2000-110-A	<i>Thuja occidentalis 'emerald'</i>	15		4
23	32-832-A	<i>Pinus strobus cv. Nana</i>	132	46 (S)	43
24	94-490-C	<i>Zelkova schneideriana</i>	46	42	33
25	84-073-A	<i>Acer triflorum</i>	28	27	27
26	32-0090-A	<i>Larix kaempferi</i>	89	76 (S)	68
27	95-164-A	<i>Carpinus japonica</i>	21	28	20
28	32-0145 A	<i>Quercus x benderi</i>	262	85 (S)	89
29	32-0021	<i>Ginkgo biloba</i>	123	69 (S)	58
30	32-2385-A	<i>Quercus rubra</i>	180	95 (S)	66
31	32-0409-A	<i>Fagus sylvatica f. pendula</i>	114	42 (E)	29
32	32-0696-A	<i>Abies cephalonica</i>	133	102 (S)	34
33	48-022-D	<i>Sequoiadendron giganteum</i>	89	69 (S)	26
34	53-4330-A	<i>Sequoiadendron giganteum</i>	88	59 (S)	30
35	48-022-C	<i>Sequoiadendron giganteum</i>	124	73 (S)	28
36	53-194-B	<i>Acer griseum</i>	at 2': 57	45 (E)	34
37	32-0589-A	<i>Cercidiphyllum japonicum</i>	306	79 (S)	101
38	32-0864-A	<i>Cedrus atlantica cv. aurea</i>	108	59 (S)	57
39	32-0303-A	<i>Cedrus atlantica cv. glauca</i>	123	52 (E)	72
40	63-001	<i>Magnolia grandiflora</i>	at 2': 81	48 (S)	33
41	44-057-B	<i>Cedrus libani var. stenocoma</i>	101	82 (S)	32
42	32-0398-A	<i>Cedrus libani var. stenocoma</i>	150	80 (S)	56
43	32-2455-A	<i>Abies cilicica</i>	99	103	27
44	32-0697-A	<i>Abies cilicica</i>	95		25
45	49-549-A	<i>Metasequoia glyptostroboides</i> ¹⁵³	130		34
46	49-549-B	<i>Metasequoia glyptostroboides</i>	99		26
47	49-549-C	<i>Metasequoia glyptostroboides</i>	143		31
48	49-549-D	<i>Metasequoia glyptostroboides</i>	107		38

44	32-0697-A	<i>Abies cilicica</i>	95		25
45	49-549-A	<i>Metasequoia glyptostroboides</i>	130		34
46	49-549-B	<i>Metasequoia glyptostroboides</i>	99		26
47	49-549-C	<i>Metasequoia glyptostroboides</i>	143		31
48	49-549-D	<i>Metasequoia glyptostroboides</i>	107		38
49	49-549-E	<i>Metasequoia glyptostroboides</i>	89		30
50	49-549-F	<i>Metasequoia glyptostroboides</i>	108		33
51	75-035-A	<i>Metasequoia glyptostroboides</i>	130		40
52	53-257-E	<i>Metasequoia glyptostroboides</i>	104		33
53	53-257-D	<i>Metasequoia glyptostroboides</i>	174		47
54	53-257-B	<i>Metasequoia glyptostroboides</i>	140		35
55	53-257-A	<i>Metasequoia glyptostroboides</i>	172		36
56	94-093-A	<i>Metasequoia glyptostroboides</i>	51		25
57	94-091-B	<i>Metasequoia glyptostroboides</i>	50		30
58	94-093-B	<i>Metasequoia glyptostroboides</i>	28		25
59	94-093-C	<i>Metasequoia glyptostroboides</i>	53		26
60	92-194-A	<i>Metasequoia glyptostroboides</i>	87		29
61	92-194-B	<i>Metasequoia glyptostroboides</i>	58		25
62	2003-174-A	<i>Metasequoia glyptostroboides</i>	39		21
63	32-1676-A	<i>Acer buergerianum</i>	135		73
64	32-1366	<i>Pteroceltis tartarinowii</i>	57, 62, 42, 41, 56, 70	65 (E)	71

Appendix C: QR Code



Appendix D: Online Tree Profile



GREAT TREES

[**< Previous**](#)[**See all Trees**](#)[**See Map**](#)[**Next >**](#)

Scientific Name:

***Cedrus atlantica* cv. 'Glauca'**

Common Name:

Blue Atlas Cedar

Accession Number

32-0303*A



[**See more pictures and videos...**](#)

Height

56'

CBH

10'3"

Spread

70'

Naming and family

Scientific Name and Translation: *Cedrus atlantica* cv. 'Glauca' – 'Cedrus' is derived from the Greek word "kedros", a term formally applied to both cedars and junipers, while 'atlantica' refers to the tree's native mountain range in Algeria and Morocco. 'Glauca' is derived from the ancient Greek word "glaukos" meaning "blue-grey" or "blue-green".

Common Name: Blue Atlas Cedar – The common name is accurate indicating the tree is a true cedar, originating from the Atlas mountain range. The "blue" modifier refers to the leaf color as the color is more blue/grey than the true Atlas cedar.

Family and how it relates to this species: Pinaceae- members are usually monoecious, resinous, evergreen trees (except *Larix* and *Pseudolarix*), with subopposite or whorled branches with spirally-arranged needles, and seeds with 3-24 cotyledons.

Native Range and Horticultural Adaptability

Origin: Turkey

USDA Hardiness: Zone 6-9

Horticultural Interest and Uses

Landscape uses and Characteristics (size): In cultivation, this tree typically grows 40'-60' tall and spreads 30'-40'. In the wild, it has the capacity to reach 120' tall and spread 90'-100'.

Cultural requirements: Prefers deep, well-drained, loamy soil with an acidic pH and full-sun exposure

Identification traits: 30-40 needle-like leaves per spur, often pointed, quadrilaterally compressed, and lustrous. Older trees develop branches with flat, shelf-like growth habit. Cones grow upward.

Seasonal interest:

Spring: growth habit, bark, evergreen foliage, beautiful and scented wood

Summer: growth habit, bark, evergreen foliage, beautiful and scented wood

Fall: growth habit, bark, evergreen foliage, beautiful and scented wood

Winter: growth habit, bark, evergreen foliage, beautiful and scented wood

Cultivars and related taxa: This is a cultivate variety of *Cedrus atlantica*. Others include 'Argentea', 'Glauca pendula', 'fastigiata', and 'Aurea'

Other background:

- Pine family has most diversity (220-250 species, 11 genera) for any conifer and the second largest geographic range (next to Cupressaceae).
- In his song "Beware the Darkness", George Harrison makes reference to this tree
- In 1995, a witches broom formed on 32-03033*A. Propagates from this formation yielded a dwarf specimen that is on display in our dwarf conifer collection located behind the greenhouses

Other pictures and videos:



A video player interface showing a landscape scene. The video frame shows a hillside covered in dense green vegetation, likely a forest. A large white play button is centered in the middle of the frame. At the top right of the video frame, there is a "More info" button with a downward arrow. Below the video frame, there is a standard YouTube-style control bar with icons for play, volume, and search.