

FINAL INDEPENDENT PROJECT REPORTS

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Morris Arboretum Internship Program

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TITLE: WEED IDENTIFICATION AND MANAGEMENT AT MORRIS ARBORETUM

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DATE: March 2014

ABSTRACT:

There are a number of unwanted, invasive, non-native plants at the Morris Arboretum. The horticultural staff and volunteers are constantly battling these weeds in every section of the property. Correct identification poses a challenge, as well as choosing the most effective control techniques for each plant. Weed control requires a considerable allocation of time and money during the growing season. Efficient identification and eradication are of utmost importance. The purpose of this project was to create a weed identification and management guidebook specific to Morris Arboretum. Only the most common and problematic weeds on the property were covered. Emphasis was placed upon photographing and explaining all significant identification features, reproductive methods, problems caused, and management techniques. The reference guide is intended as a resource for interns, seasonal staff, volunteers, and interested members of the public.

Weed Identification and Management at the Morris Arboretum

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INTRODUCTION

One of the most considerable elements of gardening is weeding. Weeds are a constant pressure in the managed landscape. Before the act of weeding, the gardener must decide what is, in fact, a “weed”. Merriam-Webster defines a weed as “a plant that is not valued where it is growing and is usually of vigorous growth.” This definition expresses that the term “weed” is ambiguous. Plants considered weeds in a formal garden may not have the same designation in the natural landscape. Deciding what is or is not a weed is a human or personal classification. Fortunately, most plants considered weeds are agreed upon across the board by professional horticulturists. Plants that consistently overgrow or choke out more desirable plants are almost always regarded as weeds.

The ability to identify weeds in the landscape is an essential skill for all gardeners. It is also one of the most challenging aspects of the trade. For those new to horticulture, weeding can be an intimidating prospect. Differentiating between weeds and desired plants is difficult until a gardener gains confidence through experience. There are a large number of unwanted and invasive plants present at the Morris Arboretum of the University of Pennsylvania. The horticultural staff and volunteers are constantly battling these weeds in every section of the property. Correct identification poses a challenge, as well as choosing the most effective control techniques for each plant. Weed control requires a considerable allocation of time and money during the growing season. Efficient identification and eradication are of the utmost importance.

Although the full-time horticulture staff is very comfortable with weed identification, a vast amount of labor at the Arboretum comes from seasonal staff, interns, and volunteers, many of whom are new to gardening. The aim of this project was to create a weed identification and management guidebook specific to the Morris Arboretum. Many other weed guides are available, but all of these contain information about numerous weed species that are not found in the Arboretum. These guides can lead to confusion and misidentification. The guide produced by this project includes only the most important weed pests at the Morris Arboretum. This guide will streamline the identification process for those that are unfamiliar with weeding. It is meant as a quick and easily accessible reference.

METHODS

The main goal of this project was to create a weed identification reference for volunteers and staff. The first step was to establish which weeds to include. All horticulture section leaders were asked to identify the top 5 to 10 problematic weeds in their area of the property. This garnered a list of 20 weed species. An additional 10 weeds were selected based on suggestions from horticulture volunteers and personal observations by the author. In some cases, there are multiple related species belonging to the same genus. Since the differences between these species are minor in regard to identification and management, they are simply listed by their genus followed by spp. (i.e. *Oxalis corniculata* and *O. stricta* are listed as *Oxalis* spp.) The following is a total list of the selected weed species.

Aegopodium podagraria, goutweed
Alliaria petiolata, garlic mustard
Allium vineale, field garlic
Ampelopsis brevipedunculata, porcelain berry
Artemisia vulgaris, mugwort
Calystegia sepium, hedge bindweed
Cardamine hirsuta, hairy bittercress
Celastrus orbiculatus, oriental bittersweet
Cirsium arvense, Canada thistle
Cyperus esculentus, yellow nutsedge
Euphorbia maculata, spotted spurge
Fallopia japonica, Japanese knotweed
Fatoua villosa, mulberry weed
Glechoma hederaceae, ground ivy
Humulus japonicus, Japanese hop

Lonicera japonica, Japanese honeysuckle
Lonicera spp., shrub honeysuckles
Microstegium vimineum, Japanese stilt grass
Oxalis spp., wood sorrel
Persicaria perfoliata, mile-a-minute
Persicaria spp., smartweed
Phalaris arundinaceae, reed canary grass
Phragmites australis, common reed
Phytolacca americana, common pokeweed
Pilea pumila, clearweed
Pinellia ternata, crow-dipper
Ranunculus ficaria, lesser celandine
Rosa multiflora, multiflora rose
Toxicodendron radicans, poison ivy
Urtica dioica, stinging nettle

After determining the list of the most common and problematic weeds, those plants were scouted and identified in the field. All weeds were photographed with a point-and-shoot camera on site. A majority of the photographs were taken within the Morris Arboretum property. However, in order to photograph some plants and their important life-stages, pictures were taken at other locations, including: Wissahickon Valley Park, Awbury Arboretum, and Mount Tammany (Delaware Water Gap). A minimum of twelve pictures were taken of each weed species. Image quality was assessed based on focus, contrast, lighting, and content. Effort was made to only include the highest quality pictures depicting important stages. The reference guide was intended to be concise. Each weed was given one page on which to fit all of the information and photographs. A maximum of three photographs were selected to represent each species in the guide. Color images are the most important part of the reference guide. Even though written descriptions were included, the photographs provide a higher level of clarity.

The next step was to decide what information to include in the guide. The categories decided upon were: botanical family, identification, propagation, origin and habitat, problem caused, and management. These categories generally coincide with topics covered in published weed guides. The identification category was broken into seven sub-categories: growth habit, size, leaves, stem, roots and underground structures, flowers, and fruit. Effort was made to keep the information in each category as clear and concise as possible. Thus, information for each weed species was kept on a single page.

MANAGEMENT

Effective weed management requires specific goals. Early weed detection and rapid response are manageable goals for the Arboretum. With the help of this management guide, volunteers, seasonal workers, and interns should be able to monitor all areas of the Arboretum for new weed infestations and respond quickly with control efforts. Although it will be impossible to eliminate all weeds from the property, at least this new guide will help workers become better scouts. Early detection and rapid response are the best ways to reduce weed populations at Morris Arboretum.

There are two “types” of weeds included in this reference guide: aesthetic weeds and those that pose a threat to the maintenance of broad-scale biodiversity. Most of the aesthetic weeds only affect the formal plantings of the Arboretum including mulch rings around trees and perennial borders. Aesthetic weeds include: *Cardamine hirsuta*, *Euphorbia maculata*, *Pilea pumila*, and *Oxalis* spp. These species do not pose a threat to overall biodiversity, but rather represent an annoyance to the gardener. They reproduce quickly and make plantings look unkempt if left uncontrolled. Other weeds, particularly those that inhabit the natural areas of the Arboretum, are a threat to overall biodiversity (i.e. *Alliaria petiolata*, *Fallopia japonica*, and *Microstegium vimineum*). These plants are almost all non-native and invasive. They disperse readily and grow aggressively. Invasive plants have few natural controls in the environment. There are not many forces that keep the growth of these plants in check. Thus, invasive species out-compete native plants, which have evolved to a very specific niche. Most native plants have a whole host of natural predators and diseases that keep them in balance in the ecosystem.

No single management technique is inherently better than another, nor will a single management technique be adequate for all situations in a management program. Each site needs to be evaluated and weed management goals established based on the level of control desired, keeping in mind environmental and budgetary restrictions. In most cases, it is more cost effective to remove small infestations by hand. Large weed populations are often more efficiently controlled with herbicides. Many weed guides include both chemical and organic control methods. However, this new Morris Arboretum reference guide only includes organic methods of control. This approach was taken in order to protect the health of workers. Chemical control is not inherently bad, but herbicide exposure raises human health and environmental concerns. Safely handled chemicals can be of great use to the gardener, but many mechanical and cultural management techniques can be just as effective given enough time. Morris Arboretum volunteers and employees can achieve weed control with organic methods that pose fewer risks.

Mechanical and cultural weed control techniques were included in the reference guide. Mechanical techniques are those that act directly on plants. Mowing is a good example of a mechanical control technique. Mulching is a mechanical control technique that works by shading out light-sensitive seeds and seedlings. Cultural control involves manipulating the environment of a plant, which, in turn, acts upon the plant. For example, densely planting a garden bed limits the amount of bare soil for weeds to colonize. Every weed in the reference guide has at least one organic control method that will help curb its population.

Wildlife Considerations

The large white-tailed deer (*Odocoileus virginianus*) population on the Morris Arboretum property is likely exacerbating problems with invasive species. Historically, the land was able to support smaller deer populations. Now, with few natural predators, white-tailed deer populations have swollen to an unsustainable size. Human development has left very little natural land for deer to graze on. Small patches of undeveloped land are overrun with deer. White-tailed deer preferentially feed on native plants. As deer browse native vegetation, they leave gaps in the landscape that are filled with non-native invasive species. Non-native plants are great at utilizing disturbed land and vacant niches. Many non-native plants are not palatable for deer and are avoided. High deer pressure complicates efforts to maintain healthy native plant communities.

Many fruit-eating bird species are considered the major dispersal agents of invasive plants. The Morris Arboretum hosts many frugivorous bird species including:

- Cedar waxwing, *Bombycilla cedrorum*
- Northern cardinal, *Cardinalis cardinalis*
- Gray catbird, *Dumetella carolinensis*
- Northern mockingbird, *Mimus polyglottos*
- Eastern bluebird, *Sialia sialis*
- European starling, *Sturnus vulgaris*
- American robin, *Turdus migratorius*

Fleshy fruits are produced by a number of invasive plants such as: *Ampelopsis brevipedunculata*, *Celastrus orbiculatus*, *Rosa multiflora*, and *Lonicera* species. Fruit passes through birds' digestive tracts, and the seeds are subsequently deposited in new areas. The invasive species listed above are often dispersed by birds. Although these plants contribute to the diets of many frugivorous birds, they negatively impact the ecosystem in other ways. For example, non-native invasive plants are often unpalatable to native insects. Many birds depend on insects for the main part of their diet. Areas dominated by non-native plants will have less insect diversity than healthy, functioning ecosystems. Thus, bird territory sizes must be larger during nesting season in order to provide enough insects for breeding birds. Although invasive, fleshy-fruit bearing plants should be removed, consider the bird species that utilize their fruit. Planting native species with fleshy fruit will take the place of invasive non-natives. A few good options are winterberry (*Ilex verticillata*), silky dogwood (*Cornus amomum*), black tupelo (*Nyssa sylvatica*), and serviceberry (*Amelanchier canadensis*).

A few native plant species that have wildlife benefits are considered weeds in the garden. Poison ivy (*Toxicodendron radicans*) and common pokeweed (*Phytolacca americana*) both produce fruit that is a part of the diet of many songbirds and mammals. While these plants are considered nuisances in formal plantings, they are very valuable plants in the ecosystem. Pokeweed should be conserved in natural areas. Poison ivy should be left growing in areas where humans will not easily come in contact with it. Marginal natural areas are good places to let poison ivy grow and serve wildlife.

CONCLUSION

Weeds will inevitably remain a part of the Morris Arboretum landscape. It is hoped that this new weed identification and management guide will help staff and volunteers recognize unwanted plants in the gardens, farm, and natural areas. The management techniques specified in the reference guide will give workers ideas on how best to control the plant.

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Weed Identification AND Management

At the Morris Arboretum of the
University of Pennsylvania



EMMA E. ERLER

Mugwort

Artemisia vulgaris

FAMILY: Asteraceae (Aster Family)

IDENTIFICATION

- ◇ **Growth Habit:** Herbaceous perennial
- ◇ **Size:** 2-5 feet tall
- ◇ **Leaves:** Simple, alternate, lobed, and pointed.
Upper leaf surfaces are lightly hairy; bottoms densely covered with silvery-white hairs.
Crushed leaves are fragrant.
- ◇ **Stem:** Upright and branched in the upper 1/3 of the stem. Older plants are woody. Stems are red, brown, or purplish.
- ◇ **Roots and Underground Structures:** Horizontal rhizomes are long and white/tan. Rhizomes creep outwards to form large colonies.
- ◇ **Flowers:** Composite flower heads are borne in clusters at the ends of stems. Flowers are greenish white or yellowish. June-October
- ◇ **Fruit:** Oblong achenes; rarely viable

PROPAGATION

Mugwort primarily reproduces by spreading rhizomes. It is spread when rhizomes are fragmented in cultivation or transported in topsoil. Mugwort occasionally spreads by seed.

ORIGIN AND HABITAT

Native to Eurasia. Mugwort is a weed of gardens, fields, roadsides, and turf grass. It is very tolerant of mowing and cultivation. Mugwort thrives in sunny areas with poor, well-drained soil.

PROBLEM

Mugwort forms dense stands that outcompete native or desirable vegetation. Tough rhizomes make it hard to eliminate in perennial beds and turf.



MANAGEMENT

Mugwort is easiest to remove in spring and early summer when it is still small. Use a soil knife to dig up as much of the root and rhizome system as possible. Rhizome fragments will resprout, so revisit affected areas. Vigilant removal will eventually exhaust the rhizome system.

Large patches can be repeatedly mowed to the ground to stop the spread of the plant.



TITLE: **THREE YEAR STRATEGIC PLAN FOR THE
URBAN FORESTRY CONSULTANTS AND
SCHOOL OF ARBORICULTURE**

AUTHOR: **Andrew J. Kirkpatrick
The Martha S. Miller Endowed Urban Forestry Intern**

DATE: **February 2014**

ABSTRACT:

This project's goal was to develop an actionable three year strategic plan for Morris Arboretum's Urban Forestry Consultants and the School of Arboriculture. The strategic plan explores ways to increase net revenue and raise the profile of both entities in the region as a resource for urban forestry and arboriculture and considers Morris Arboretum's vision and mission and how the entities support it. The methodology included reviewing three years of historical time and billing data to establish a baseline from which trends could be derived.

Analysis of the past three fiscal years for the Urban Forestry Consultants reveals that revenue has been supported by grant funding from the William Penn Foundation which came to an end in Fiscal Year 2014, the current fiscal year. Therefore, next year there will be a gap in revenue that will need to be addressed either with new grant funding or increased billable time for contracted projects. Large-scale projects like the Princeton Borough tree inventory completed in FY13 produced the most net revenue for project hours invested. Pursuing more large-scale projects will be integral for maintaining revenue streams for the Urban Forestry Consultants as well as ensuring that hourly billing rates remain competitive.

On average the School of Arboriculture has been breaking even for the last three fiscal years, unless indirect expenses are considered. When indirect expenses, salary and benefits expenses for support from the education department are factored into calculating performance, the picture begins to change; trends show that the school has been operating on a small deficit. The deficit increases when the loss of Tree Risk Assessment Certification (TRACE) training is factored in for coming years. The School of Arboriculture needs to consider the true costs of operations when planning future course offerings to ensure that expenses balance with gross revenue.

Three Year Strategic Plan for the Urban Forestry Consultants and School of Arboriculture

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INTRODUCTION

The Urban Forestry (UF) Consultants and the School of Arboriculture (School) at the University of Pennsylvania's Morris Arboretum provide non-profit arboricultural services, education and training in the Philadelphia region. The mission of the Morris Arboretum is *to promote an understanding of the relationship between plants, people, and place through programs that integrate science, art, and the humanities*. The Arboretum conducts four major activities: education, research, outreach, and horticultural display. The Arboretum provides research and outreach services to state agencies, community institutions, and to citizens of Pennsylvania and beyond. The UF Consultants and School of Arboriculture support the outreach and educational missions of the Arboretum.

The vision for the UF Consultants is to be the premier arboricultural consultants in the Philadelphia metro region and for the School of Arboriculture to become a leading regional resource for professional development in the fields of urban forestry and arboriculture. The mission of the UF Consultants is to provide expert arboricultural consulting services and advise clients to use best management practices for the care, maintenance, and budgeting of natural resources. The mission of the School of Arboriculture is to provide the highest quality educational experience and resource possible for arborists, landscape architects, contractors, and horticultural professionals in the greater Philadelphia area. In support of those missions, the goals are two-fold, 1) *To develop a sustainable operation that explores ways to produce more net revenue than today* and 2) *To raise awareness of the Arboretum as a regional resource for urban forestry and arboricultural training and education*. The following strategic plan develops objectives to achieve these goals.

METHODOLOGY

The primary goal of this project was to guide future efforts by identifying how time has been spent in relation to revenue generated. Employee time in terms of billable hours by project was the focus. Expenses that were billed to clients were not included in calculations of revenue generated by billable hours. However, billed expenses were included in aggregated revenue amounts for forecasting coming fiscal years.

To determine financial and project trends for the Urban Forestry Consultants, I began by matching invoices from the last three fiscal years 2011-13 to entries in the universal timesheet, which is an Excel spreadsheet used for recording time, expense, and billing rate by employee and project. The universal timesheet has been used to varying degrees over the past several years to record hourly project time. Fiscal Year 2013 was the most accurate in recording time, so where no entries were available on the universal timesheet I estimated the project hours based on the line items from project invoices recorded in Quickbooks accounting software.

Completed projects billed in separate fiscal years were included in the year the work was completed, and not necessarily when payment was received. This skews my results from previously reported FY accounting amounts. The primary example of this is the Princeton Borough tree inventory which was completed in FY13, but not billed and payment was not received until FY14; therefore, it was included in FY13 for the purposes of this project. This directly impacts the projected revenue for FY14 from a profit to a loss.

To obtain an accurate hourly billing rate for Jason Lubar and Bob Wells, Board Certified Master Arborists (BCMA), I calculated revenue based on each employee's hours worked excluding expenses from invoice payments. Therefore, I included billed expense as its own line item in spreadsheet calculations. My goal for calculating revenue in this manner was to determine actual hourly rates by revenue source and directly correlate this to employees' effort hours. Time for BCMAs was calculated from 37.5 hours/week for 52 weeks/year for a total of 1950 possible hours per year. Time for education department employees was based on 40 hours/week for 52 weeks/year for a total of 2080 possible hours per year. Possible revenue hours were calculated by deducting time for vacation, holidays, sick leave, educational development, and conferences. Pro bono time was based on time recorded by BCMAs. Administrative time was determined by subtracting possible revenue hours from pro bono hours. For planning purposes, staff time in the education department was calculated from 50% of available annual time, for a total of 1040 hours.

Hours for interns are not always invoiced to clients since interns' time is sometimes considered to be educational and does not necessarily contribute to project completion. When they are included on invoices, it was for work that could not have been completed by regular staff. For instance, if a tree inventory was conducted, the interns' time was generally billed, but if a tree health assessment was performed only regular staff time was billed to the client. Therefore, this skews the interns' time when compared to regular staff time.

Data for the School of Arboriculture was gathered by querying Raisers' Edge software. The dataset includes the following categories: class name, fiscal year offered, class date, class capacity, number of students registered, number of students that attended, the gross income generated, the direct expenses, and the net revenue received. In addition to reported direct expenses, expense data for Bob Wells' salary and employee benefits (EBs) and supporting educational staff time as well as indirect expense calculated at 15% of operating costs were deducted from the gross revenue to determine a more precise amount of annual net revenue. This data was then analyzed to determine trends in class sizes, attendance, expense, and revenue to inform strategic decisions and set objectives for the School's continued growth and development.

FINDINGS & ANALYSIS

From FY11 to FY13, the Urban Forestry Consultants have been running a sustainable business where revenue has been meeting expense. In the coming fiscal years, the greatest impact will be the loss of William Penn Foundation grant funding after FY14. Replacing it will be integral to maintaining future revenue levels. Of the last three years, larger contracts generated more revenue for the amount of time spent on projects. Two large contracts in 2013, the Princeton tree inventory and the Navy Yard project, greatly increased revenue above the prior two years. The average contract amount of the top five projects from FY11 and FY12 was \$7500, in FY13 it quadrupled to \$32,600.

The School of Arboriculture is currently operating at a sustaining level, breaking even each year in the last three years, unless indirect costs are factored in, which reduces operations to a minimal deficit. The greatest impact to the School was the loss of TRACE¹ training when

¹ Tree Risk Assessment Certification

TRAQ² was released and training was restricted to the International Society for Arboriculture (ISA). Replacing the revenue generated by TRACE training and balancing expenses with revenue is critical to making the School profitable moving forward.

From FY 11 to FY13, the School of Arboriculture had 1,323 registrations. Of the classes delivered, attendance averaged 95%. Over the last 3.5 years, 91 classes were scheduled and 12 were cancelled, half in the Fall 2013 (FY14) semester. Average registration is 16 students per class and attendance was 14 students per class. Attendance numbers may not be as reliable as registration numbers since attendance is recorded by gift shop employees at Widener and the receptionist at the Horticulture Center whose attention is often diverted in multiple directions (e.g. attending to customers, answering the phone, etc.). It is possible that students may have attended a class without being recorded. Average annual attendance for the School is 417. The number of unique individual students is 390 for the last three full fiscal years. In the fall semester of FY14, six classes out of 16 offered were cancelled. In the past three years only 11-12 classes had been offered in the fall. Sixteen classes may have been too many for the current student base of 390.

Average total expense of running the School was \$82k annually which included \$20k direct expense for TRACE training. When correcting for loss of TRACE, total expense can be estimated to be around \$65k annually. The average gross revenue for the last three years has been around \$69k with around \$9k coming from TRACE. Therefore, the target revenue goal for the School of Arboriculture is about \$65k annually to cover total expenses. Generally, the last two full school years have been on target to cover the total expense of operating the School. This number provides a starting point to set targets to move from sustainable operations to profitable ones.

FORECASTS

The two main functions that I considered in analyzing the data were time and revenue to indicate employee performance in terms of generating revenue for time expended for the last three fiscal years. I used this analysis to then forecast revenue for the next three fiscal years and to guide this strategic plan's development. Expense that was invoiced to clients was included as its own line item in the analysis of the data for this project, so as to correlate to officially reported annual revenue. Revenue was projected for the next three fiscal years based on the trends from the past three fiscal years assuming a conservative growth rate of 5% for the School of Arboriculture and for billing rates for the Urban Forestry Consultants. The rate of salary increase is 3%; employee benefit expense is 34.1% for FY14 with a rate increase of 0.2% annually; the rate of general expense increase is 2%.

² ISA Tree Risk Assessment Qualification

RECOMMENDATIONS

1. Increase Billing Rates

The Urban Forestry Consultants' billing rates have only increased by \$20/hour in the last twelve years. Cost of Living Adjustment (COLA) increases averaged 2.6%/year for the same period. To keep pace with rising costs and inflation, billing rates should be increased at least 9% for the coming fiscal year, and 5% every year thereafter to compensate for the 3% increase in expense. The Arboretum calculates compensation expense increases at a rate of 3% and general expense increase at a rate of 2%. Therefore, a 5% annual increase in billing rates will keep pace with the Arboretum's projections. Targeted contract amounts of \$7k should be pursued since these projects tend to return the most revenue for the amount of time billed. Expert witness cases generate a higher billing rate than standard arboricultural consulting projects. This type of work should be pursued to a greater extent to help achieve revenue goals. Further discussion of targeted marketing to grow client bases can be found under the discussion section below.

2. Seek Grant Funding

Both the Urban Forestry Consultants and the School of Arboriculture should pursue grants to bolster revenue to replace the loss of the William Penn Foundation funding and remain competitive with the Penn State Extension class offerings which are subsidized, respectively. EPA has recently announced \$4 million in grants awarded in the Philadelphia region for studying existing stormwater infrastructure. Seeking new partnerships and developing programming around stormwater management may increase the number of opportunities for future grant funding.

3. (a) Increase Marketing and Advertising

To increase the School of Arboriculture's class attendance, it is necessary to reach out to more potential students. Increasing the mail and email marketing lists by adding municipal contacts for Pennsylvania's Montgomery, Bucks, Delaware, and Chester counties, and New Jersey's Mercer, Ocean, Somerset, Hunterdon, and Morris counties may help increase attendance to reach class capacity. Mailing fliers with targeted content to municipal contacts may also benefit the Urban Forestry Consultants in generating new leads for projects. Marketing fliers can also be developed for other potential client categories, including developers, engineering firms, construction companies, HOA's, retirement communities, and regional institutions. Fliers should include testimonials from past clients. Client specific marketing plans should be developed with regular follow up with clients.

Another aspect of cultivating municipal relationships will be creating opportunities for face-to-face interactions with municipal staff. One way to achieve this is by offering training modules through the School of Arboriculture on topical issue areas that may include emerald ash borer management, tree canopy surveys and inventories, or simple pruning techniques from ground level. By offering these modules, municipal officials will become acquainted with the Morris Arboretum brand and the services offered by the Urban Forestry Consultants. These relationships may provide in-roads to new project work.

(b) Determine Market Penetration Among Arborists

As marketing activities increase, it is important to understand the reach of the School among local arborists. Determining the number of certified arborists who attend classes out of the total number of certified arborists in the region including New Jersey and Delaware will help guide marketing efforts as well as course content. Conducting surveys of those who attend classes may help develop content that will entice more certified arborists to take classes at the arboretum. Arborists should be considered the strategic core of the School's attendees.

4. Possible Staffing Increases

Another route to increasing revenue may be to add staff including a marketing/sales position or an additional arborist for the UF Consultants. A marketing/advertising position could shift some (6%) administrative/unassigned time (18% currently) from full-time staff and accomplish additional tasks that are not currently being performed but are integral to expanding the reach of both the UF Consultants and the School. By conducting marketing and advertising activities including managing municipal contact lists, website content, direct mailings, and client follow-up, more projects could be obtained that would in turn generate additional revenue. The additional revenue could potentially offset the expense of the marketing/sales position and generate enough work to justify the hiring of a part-time project-based employee as in the case of the Princeton Borough tree inventory.

5. Increase Class Attendance

There are two ways to increase attendance to School of Arboriculture classes: 1) Fill classes to capacity and/or 2) Offer more classes. While attendance for School of Arboriculture classes is at 95% of registered students, attendance is only at 42% of classroom capacity. The closer the rate of attendance approaches classroom capacity the greater the net revenue without increasing the number of classes offered. This requires a larger pool of students, which is supported by the marketing and advertising objective. Some of the professionals who should be developed in the student base include landscape architects, engineers, construction contractors, and property managers.

Offering more classes requires more course content to attract repeat students. One way to develop new content is by locating and bringing in emerging talent to present in classes. Emerging professionals have lower fees than established speakers and are seeking new audiences for their material. Some potential topics for future classes includes an introduction to GIS/mapping techniques for arborists, how to write more effective technical specifications, and the importance of calling the arborist first for project managers.

6. Improve Field Data Collection Technology

To improve field data collection methods, the UF Consultants have recently purchased two Apple iPads and ESRI's ArcCollector mobile application, a cloud-based GIS program for recording tree locations and user defined data. By using this new mobile platform, data traditionally loaded into MS Excel will be loaded directly into geospatially located maps. This will eliminate the old procedure of recording tree inventory locations manually on printed CAD maps and then loading the field-collected data into AutoCAD in the office. This should save several hours in project time per tree inventory conducted; an analysis of past universal timesheet data and invoices would provide a baseline of the amount of time spent on CAD map creation.

Recommendation Implementation Timeframe

- Field data collection improvements have already been implemented.
- Billing rate increases can go into effect at the beginning of FY 15.
- Grant opportunities should be pursued immediately as deadlines tend to fall into cycles based on fiscal year.
- A marketing contact database has already been created; data has been collected for Bucks, Montgomery, and Delaware counties. Further data collection for more counties will be an on-going process.
- Exploring the addition of a marketing/advertising position should begin now and requires a further analysis of costs and benefits to determine feasibility.

DISCUSSION

Client Base

Clients from FY11-13 have been categorized as follows:

- Municipal/governmental
- Landscape architecture/architecture firms
- Institutional/non-profit organizations
- Property managers
- Residential
- Attorneys
- Home owner associations
- Retirement communities
- Golf courses
- Engineering firms
- Developers
- Arborists
- Insurance companies
- Public presentations

Work performed in the past for municipalities has generated the most revenue of all client types because of the Princeton tree inventory; otherwise the largest revenue generating client type is design firms including landscape architects and architects. The opportunities municipal work offers should be further developed given growing concerns over the spread of emerald ash borer as well as other pests and pathogens and increased understanding of the benefits of urban canopy cover in sequestering carbon dioxide emissions. Marketing to municipal officials including directors of public works and parks and recreation departments will not only benefit the Urban Forestry Consultants, but the School of Arboriculture. Work has already begun on developing a marketing database of municipal contacts collected from municipal websites. These lists will be used to increase the number of mailings distributed to advertise classes with the School.

Work with insurance companies generated the highest return for the amount of hours spent, followed by municipal/governmental, attorneys and arborists. When developing the client base going forward, effort should be focused on these groups.

Morris Arboretum Brand

The Morris Arboretum is the official arboretum of the Commonwealth of Pennsylvania and its brand represents an esteemed tradition of education, research, outreach, and horticultural display, which is reflected in the leadership of the UF Consultants and School of Arboriculture. Both Jason Lubar and Bob Wells are Board Certified Master Arborists of which there are fewer than 500 in the world. This high level of achievement is reserved for arborists who have three to five years' experience as an International Society of Arboriculture Certified Arborist and pass a rigorous examination that demonstrates their superior abilities in the field of arboriculture. Jason and Bob have over 50 years of experience in urban forestry and tree care. Their combined

knowledge and expertise is an invaluable asset that can be rivaled by few competitors and should be highlighted when marketing the services of the Urban Forestry Consultants and course offerings of the School of Arboriculture.

Further enriching the Morris brand is the Arboretum's affiliation with the University of Pennsylvania, which is one of the oldest universities in America and one of the most prestigious higher learning institutions in the world. Penn represents a rich history of excellence in research and education that continues today. The Arboretum is already exploring ways to enhance this relationship and reinforce the bond with the University. The UF Consultants and School of Arboriculture should be used to achieve this goal. Through the existing services contract with Penn, the Urban Forestry Consultants have an established presence at the University that should be expanded upon. The possibility of co-teaching an urban forestry course is one avenue available that is currently being explored. This synergy between the UF Consultants, School of Arboriculture, Morris Arboretum, and Penn should be nurtured and developed. As the UF Consultants and School strive to be regional experts in the field of arboriculture and urban forestry, developing new theories and practices and becoming a source of original information will help achieve notoriety. The development of new ideas can be supported by the strong research traditions of the Morris Arboretum and the University of Pennsylvania.

FIGURES

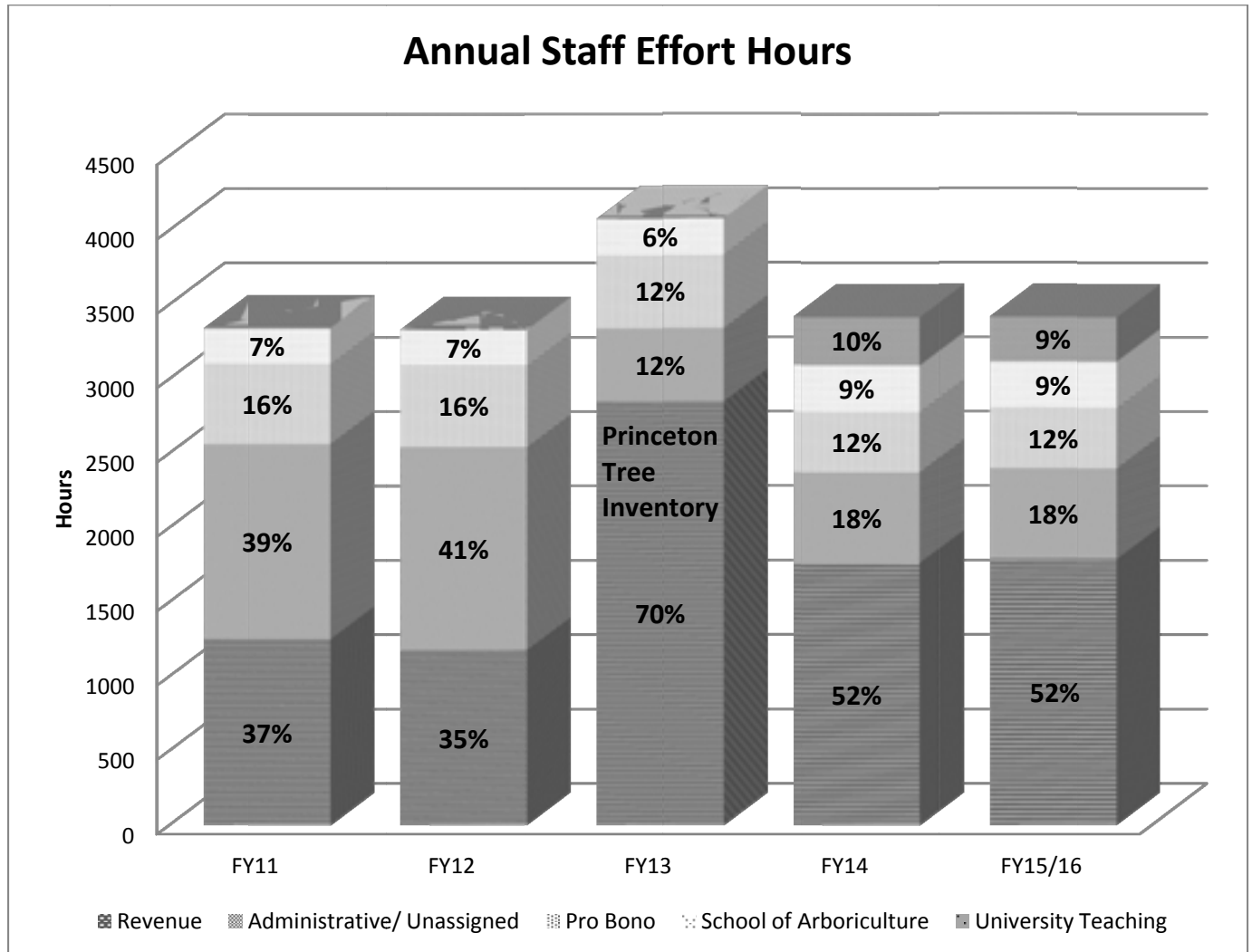


Figure 1: Annual Staff Effort Hours. This includes 2.25 FTE positions (2 BCMAs and 1 intern with .25 billable time), except for FY13 which had one additional part time project-based FTE.

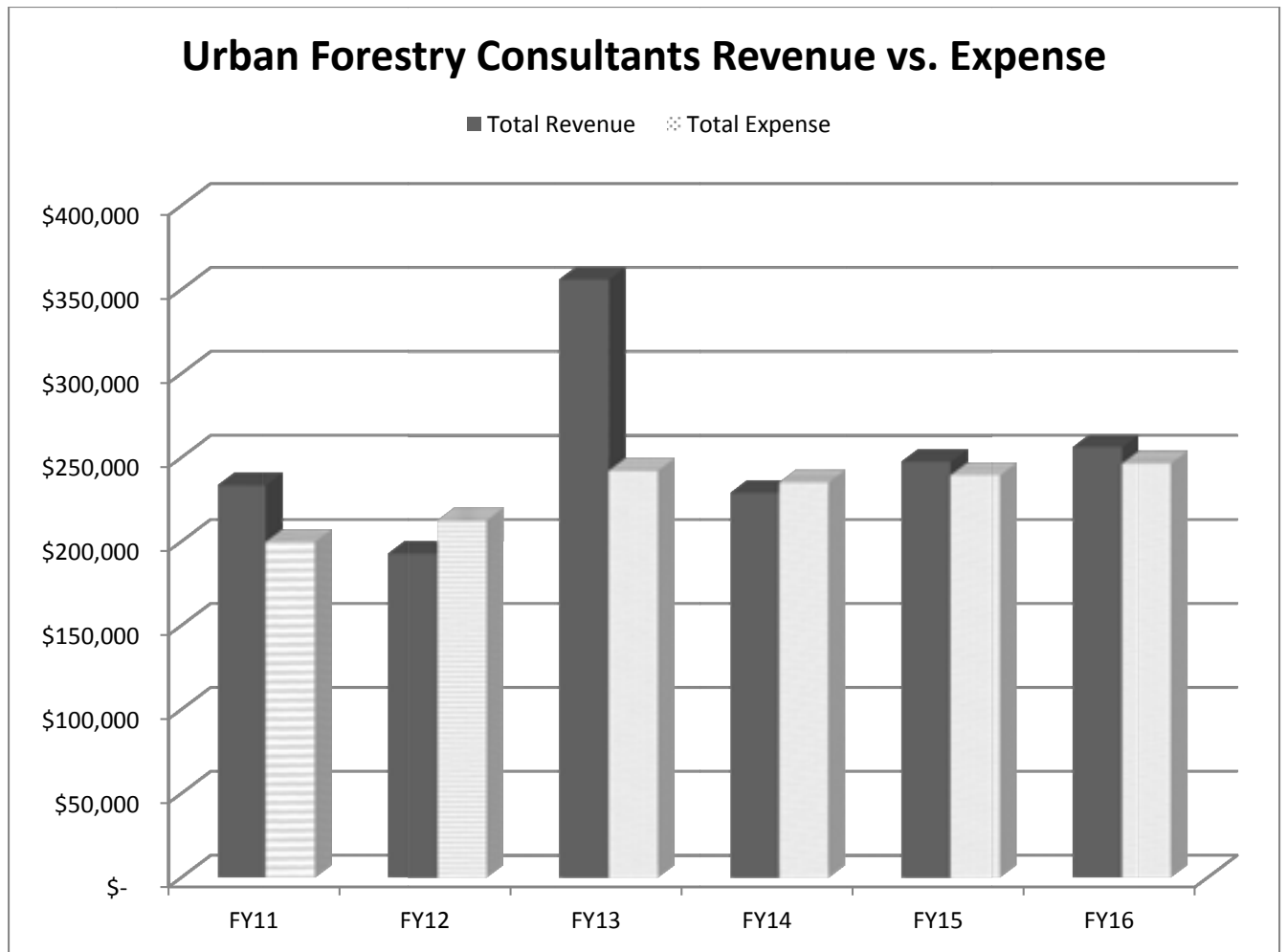


Figure 2: Urban Forestry Consultants Revenue vs. Expense. The revenue increase in FY13 came from the Princeton tree inventory when the work was completed. The bulk of the revenue was not invoiced and received until FY14 as was officially reported, but has been reported here based on the fiscal year the hours were expended.

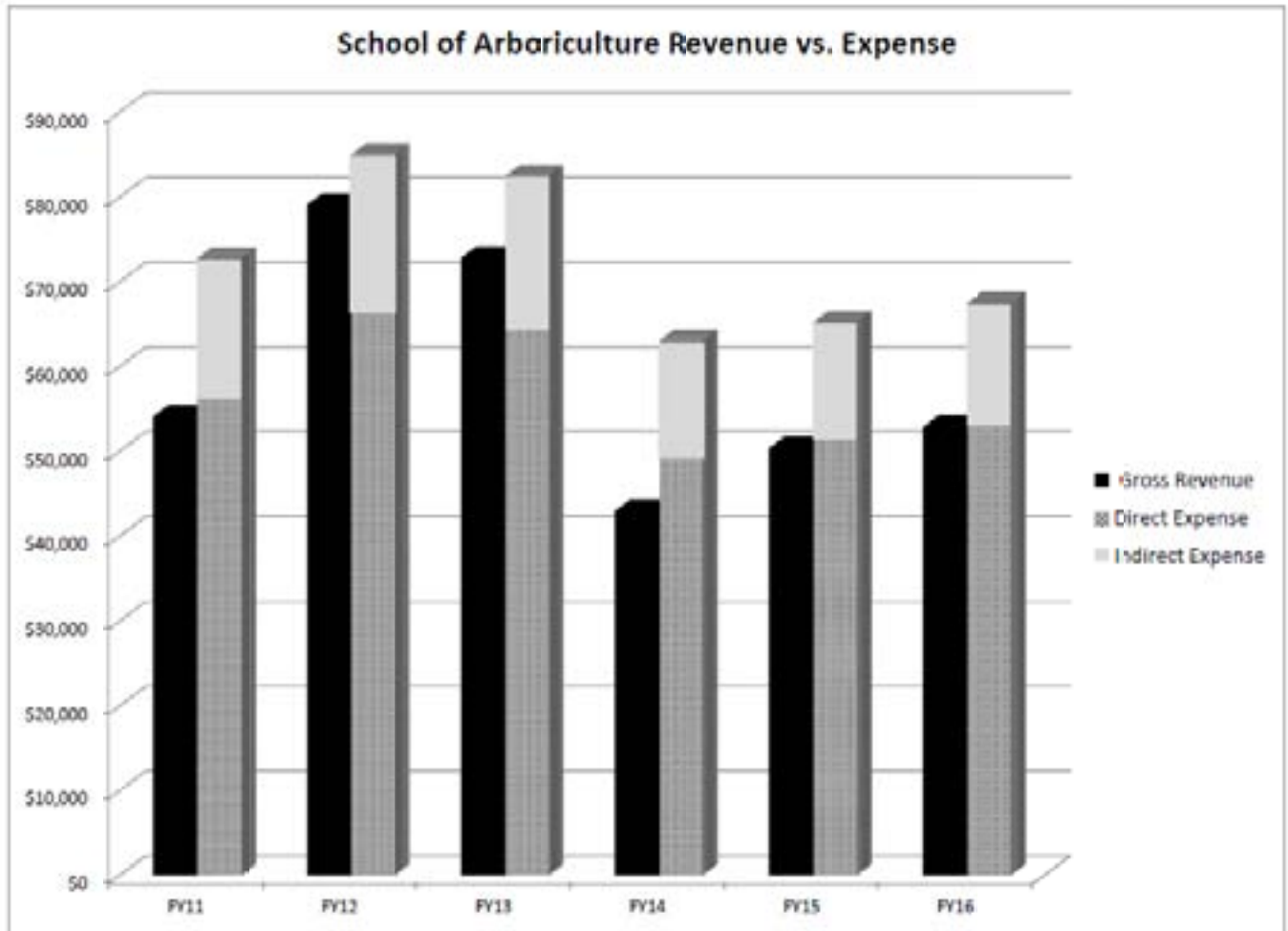


Figure 3: School of Arboriculture Revenue vs. Expense. Indirect expense is calculated as 20% of direct expense and staff time.

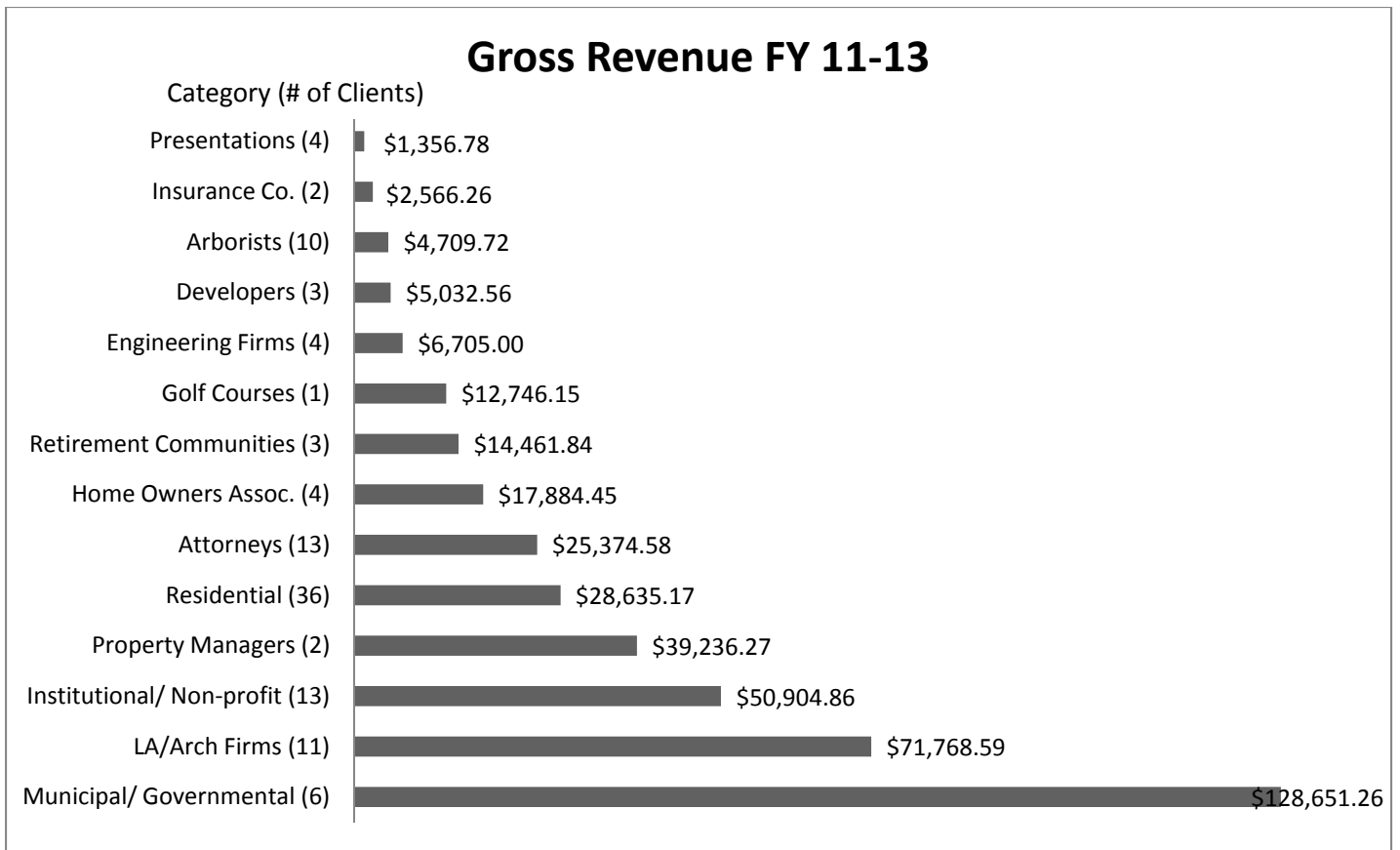


Figure 4: Client Analysis of Gross Revenue FY11-13

TITLE: MEMBER RETENTION THROUGH CONTINUING EDUCATION

**AUTHOR: Stephanie Kuniholm
The McLean Contributionship Endowed Education Intern**

DATE: April 2014

ABSTRACT:

Since the start of Fiscal Year 2013 Morris Arboretum received 1,297 registrants for continuing education courses (excluding the School of Arboriculture and symposia but including *Growing Minds* programming for families). Out of those 1,297 registrants, 61% were designated as member registrants. At the same time, 10.5% of Arboretum memberships were associated with course registrations. Assuming that membership retention often occurs through increased involvement, then it follows that an increase in continuing education participation from members should result in continued or added financial support. With this knowledge, we need not offer a larger quantity of classes but should instead tailor our offerings to provide the most engaging opportunities for new class-takers as well as continuing to engage our current class-taking members. This approach to facilitating retention and positive growth within the continuing education program as well as within membership involves converting non-class taking members into class-taking members while, at the same time, retaining our current class-takers.

The primary action of this project was to use research to inform program offerings resulting in a deeper understanding of our continuing education audience. This study involved research through membership records, demographic analysis, interviews, and an online survey. This research resulted in four recommendations for future programming: continue to offer a variety of classes at a variety of times, increase marketing efforts, look for new ways to engage the most populated membership categories, and continue to focus programming on collections, landscape, and gardens.

Member Retention through Continuing Education

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BACKGROUND & GOALS

Morris Arboretum Mission Statement:

“The Morris Arboretum of the University of Pennsylvania is a historic public garden and educational institution. It promotes an understanding of the relationship between plants, people and place through programs that integrate science, art and the humanities.

The Arboretum conducts four major activities: education, research, outreach, and horticultural display. As the official Arboretum of the Commonwealth of Pennsylvania, the Morris Arboretum of the University of Pennsylvania provides research and outreach services to state agencies, community institutions and to citizens of Pennsylvania and beyond.”

In the heart of the Morris Arboretum mission statement we see a clear inclusion of and emphasis on education. The Continuing Education Department, located within the Public Programs branch of the Arboretum, has evolved to embody this mission, offering an impressive spread of classes and workshops pulled together by a small yet efficient team. With two course brochures filled with almost 150 programs each year, the Continuing Education Department offers a range of opportunities for both members and non-members to engage with the collections, staff, research, and landscape at the Arboretum. Continuing Education offers a structured introduction for newcomers as well as a deeper connection to the Arboretum for long-time friends, visitors, and members.

Between 7/1/2012 and 2/1/2014 Morris Arboretum received 3,772 registrations for continuing education courses (excluding the School of Arboriculture and symposia but including Growing Minds). During the same timeframe, those 3,772 registrations were made by 1,297 registrants for continuing education courses. Out of those 1,297 registrants, 61% were designated as member registrants. At the same time, just 10.5% of Morris Arboretum memberships were associated with course registrations. If it's true that membership retention often occurs through increased involvement, then it follows that an increase in continuing education participation from members should result in continued or added financial support. With this knowledge, we need not offer a larger quantity of classes but should instead tailor our offerings to provide the most engaging opportunities for new class-takers as well as continuing to attract our current class-taking members. This approach to facilitate retention and positive growth within the continuing education program as well as within membership involves converting non-class taking members into class-taking members while, at the same time, retaining our current class-takers.

The primary action of this project was to use audience research to inform program offerings and registration trends, resulting in a deeper understanding of our current and potential audience. The emphasis of this project was on continuing education programs.

Over the past few months, my project has gone through several phases:

1. Baseline study of the audience
2. Audience survey and analysis of survey results
3. Interpretation of results with recommendations for continuing education programs.

Scope of Study & Defining Terms

For this study, I chose to focus on specific constituencies within a specific timeframe. The two main constituencies I researched included:

1. **Members who have taken classes** ('class-taking members')
2. **Members who have not taken classes** ('non-class taking members')

For this study, a '**member**' is someone associated with any level of active membership within 7/1/2012- 2/1/2014. A '**class-taker**' is someone who has paid for a course registration within the same time frame, 7/1/2012- 2/1/2014.

Registrations from the School of Arboriculture or other special conferences or symposia have been excluded from this study. The School of Arboriculture at the Morris Arboretum does not primarily seek to engage members, but instead serves as a resource for regional professionals. By excluding this constituency, I avoided diluting the results of the baseline study and survey with responses from a distinctly separate demographic.

Later in the study, I began to look at non-member class-takers and have included a brief overview of this constituency's demographics and habits. I included this constituency mainly as an introduction to an area of further study, not as a main component of my comparison and recommendations.

BASELINE STUDY: MEMBER INFORMATION & AUDIENCE ANALYTICS

To get a better understanding of our current class-taking audience, I analyzed information that had been previously collected from our membership using records stored in Raiser's Edge in combination with the Audience Analytics resource provided by the Greater Philadelphia Cultural Alliance. Throughout this preliminary study, I focused on the demographics and preferences of the previously described constituencies: members who have taken classes, and members who have not taken classes.

I. Raiser's Edge

When someone purchases a membership at the Arboretum, a unique entry is created in Raiser's Edge to hold information regarding giving, attendance at events, and other interactions

with the organization. Using this database, I was able to pull queries based on common activities such as payment for membership, class registrations, status as a volunteer, or membership level. The main lists I used throughout this phase of the study included cross-penetration lists of class-taking and active membership within the designated timeframe. I pulled lists of members who had taken classes within the timeframe, members who had never registered for a class, and also class takers who were not active members. The three lists I used were as follows:

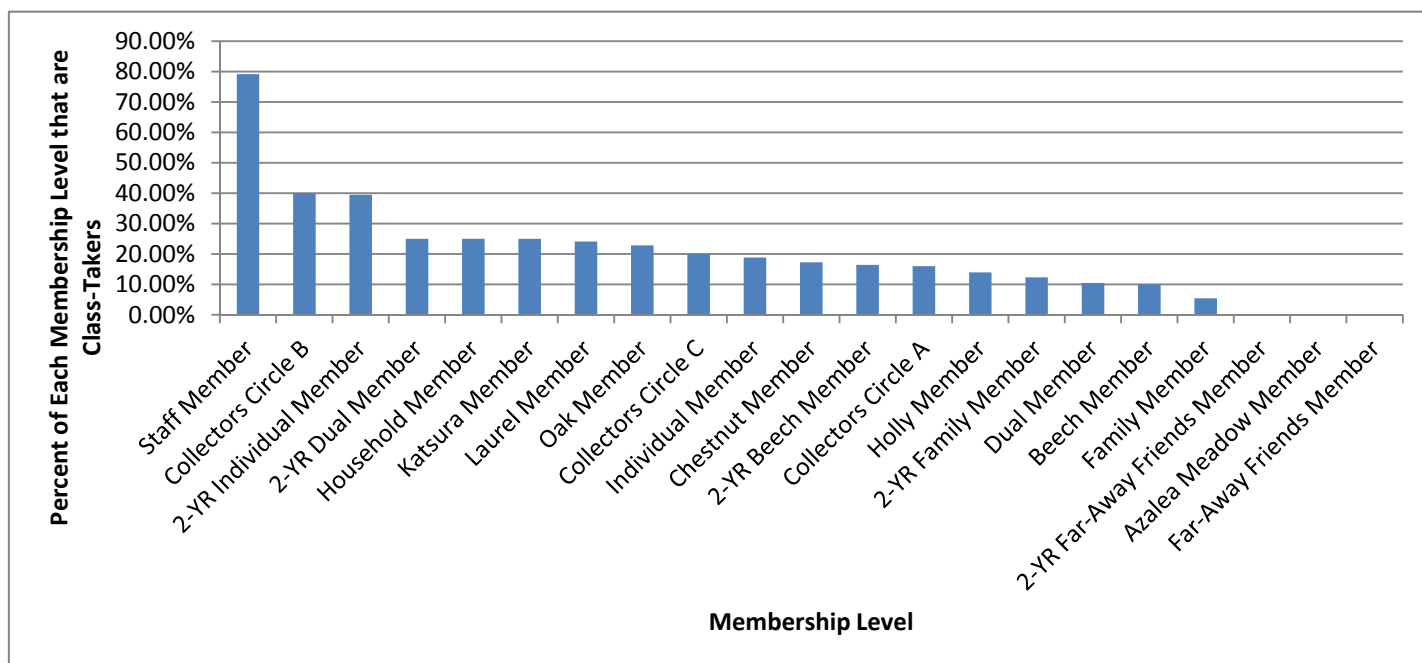
Class Taking Members- 785 records (10% of total membership, 61% of total class takers)

Non Class Taking Members- 6,711 records (90% of total membership)

Class Taking Non Members- 512 records (39% of total class takers)

By exporting data associated with these lists, I was able to learn more about our constituencies. I found the two following categories to be the most significant:

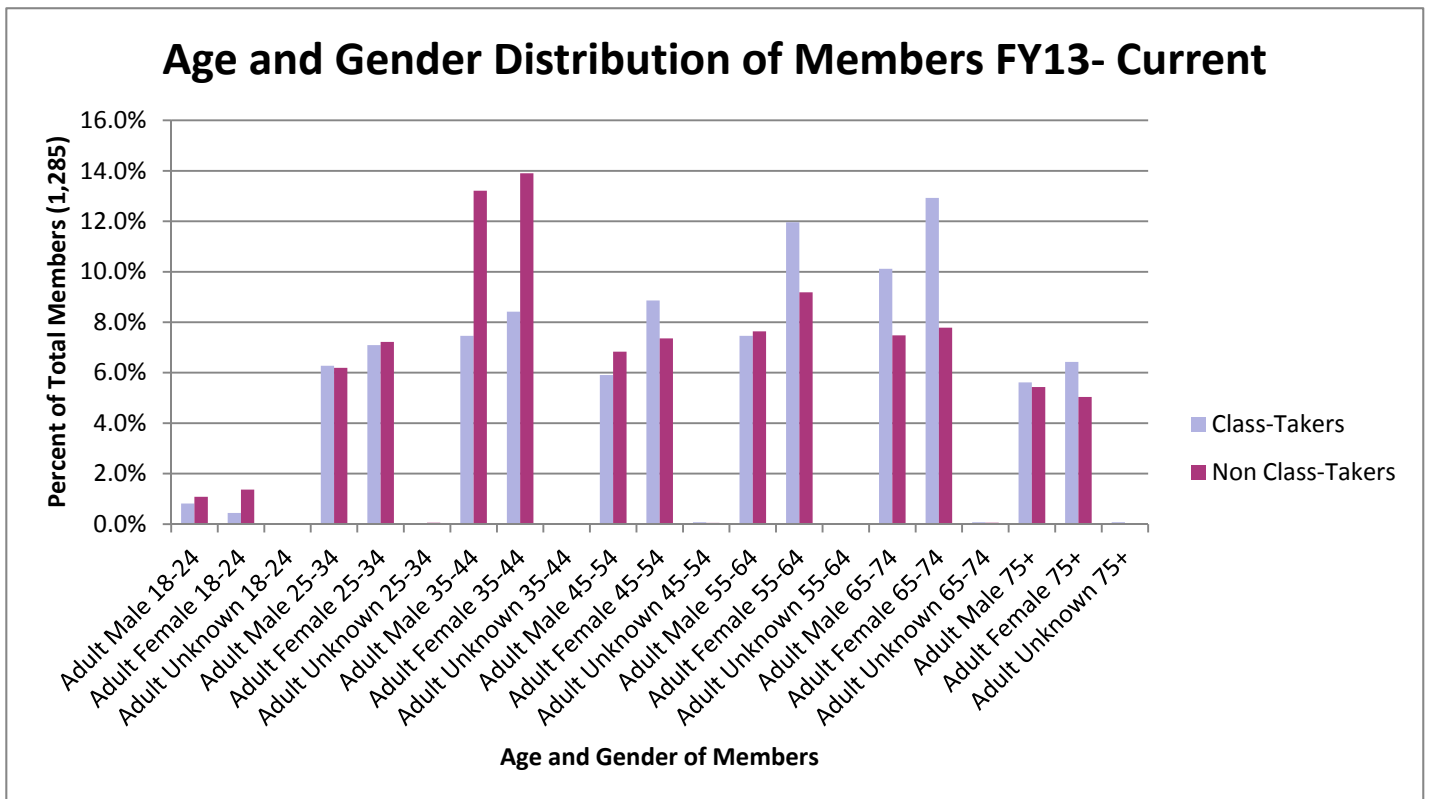
1. **Constituent Codes:** Each constituent entry in Raiser's Edge is associated with a code. These codes describe a person's relationship to the Arboretum and can describe a constituent as a staff member, volunteer, student, board member, etc. For this study, I wanted to evaluate if there was a correlation between class-taking and additional involvement at the Arboretum. 9% of class-taking members are also Arboretum volunteers while only 1% of members who have not taken classes are Arboretum volunteers.
2. **Membership Categories:** Similarly, membership levels are recorded in Raiser's Edge. I wanted to see if one category of membership was most likely to take classes so I pulled information of membership levels. The following chart displays the percent of each membership level that has taken classes within the specified timeframe:



II. TRG Arts Audience Analytics

After pulling this constituency information, I uploaded the lists onto TRG Arts Audience Analytics System, a resource made available to local cultural institutions by the Greater Philadelphia Cultural Alliance. By uploading these lists into the Audience Analytics System, I was able to run demographic reports, obtaining information on our constituency in general, not on specific individuals.

Looking at the demographic reports from TRG, I searched for significant differences between the two constituencies. The biggest difference in audience demographics appeared in most populated age groups. The most populated age category for non-class taking members is younger compared to the class-taking members:



AUDIENCE SURVEY

Following the baseline study, I developed an audience survey for both class-taking and non-class taking members. I looked for gaps in my baseline study and then built the survey around additional information I wanted to evaluate. To get a sense of attitudes toward continuing education from our membership as a whole, I created one survey that was sent out to our membership list. This survey included skip logic to direct the survey through the questions based on membership status and class-taking habits. The survey (Figure 2) was distributed to all members with active, usable email addresses through SurveyMonkey on February 28, 2014. The survey was sent to 5,445 member email addresses.

The survey consisted of 16 questions, although each respondent answered fewer questions based on the skip logic built in to the survey. For example, if a person responded that they had taken a class at the Arboretum, they would be taken to a separate set of questions than a person who responded that they had not taken classes.

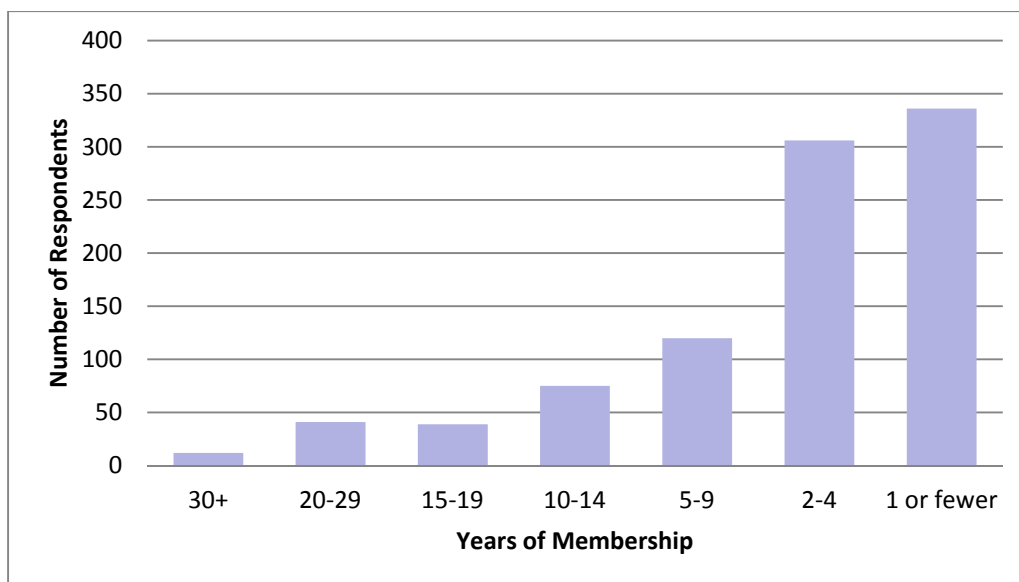
To inspire participation, people who completed the survey would be entered in a raffle to win a \$30 gift voucher to be used toward a Continuing Education class at the Arboretum or in the gift shop. After two reminder emails were sent, I had received a total of 943 completed surveys for a total response rate of 17%. A typical response rate for an online survey is 10-15% (REF.).

With close to 1,000 responses, there was a large amount of information to sift through. A full summary of the survey is included in this report. Below are the 16 questions included in the survey, along with a summary of the results and brief commentary:

1. “Are you a member of the Morris Arboretum?”

97% responded yes, 3% responded no. Out of the people responding “no”, many of them indicated they had lapsed memberships and/or planned to renew in the “other (please specify)” option.

2. “How many years have you been a member of the Morris Arboretum?”



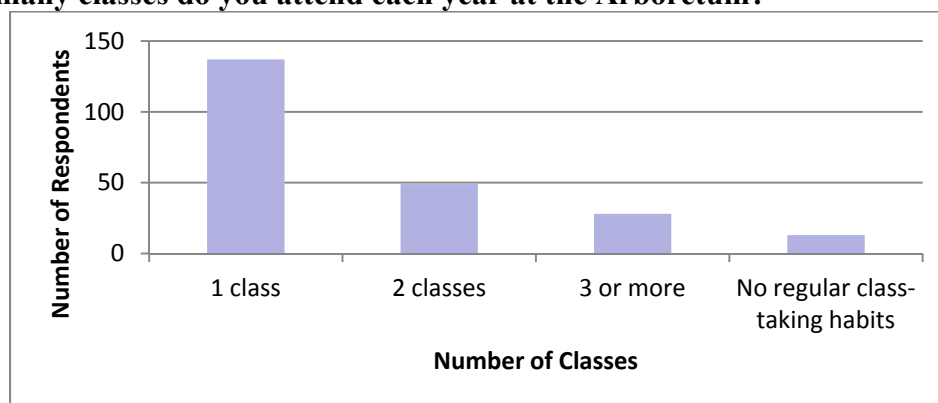
3. “Have you ever attended a class at the Morris Arboretum?”

70% of respondents indicated they had not attended a class at the Arboretum; 30% indicated that yes, they had taken a class.

4. “Did you take any classes at the Arboretum before you became a member?”

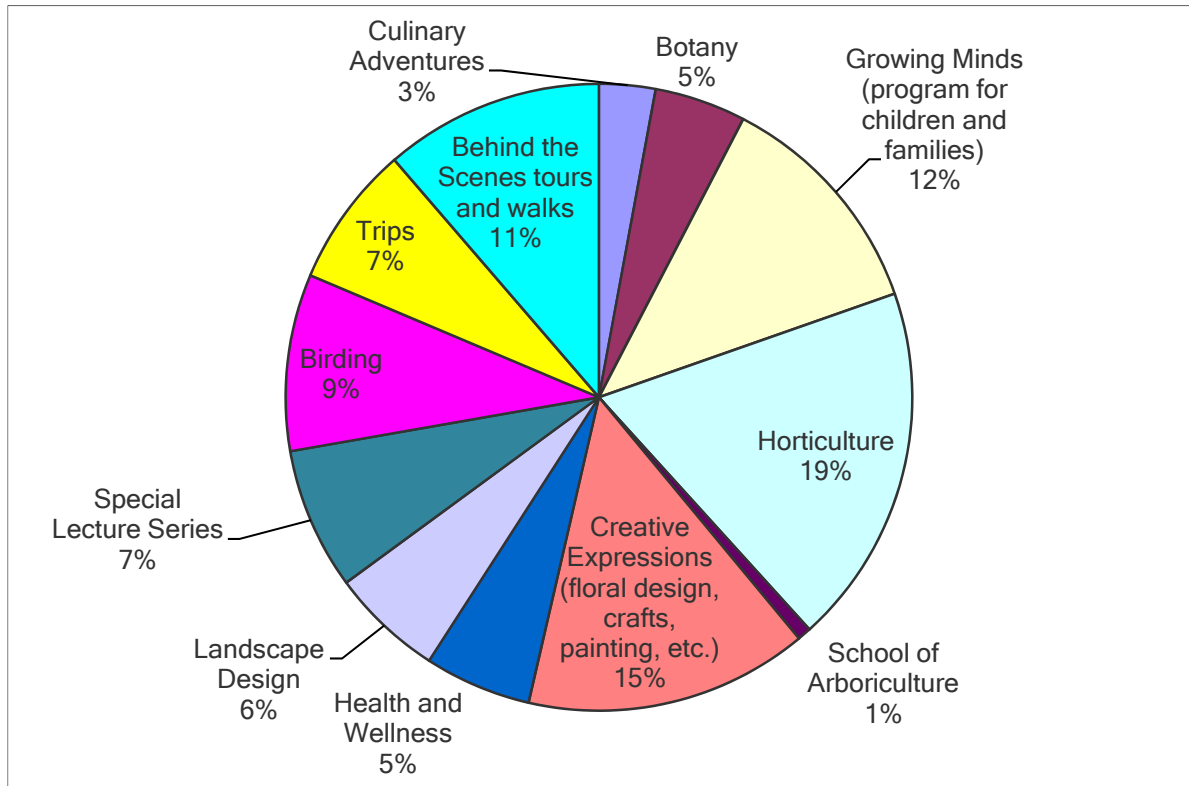
79% of respondents did not take a class before becoming a member; 21% indicated that they had taken a class before purchasing a membership.

5. “How many classes do you attend each year at the Arboretum?”



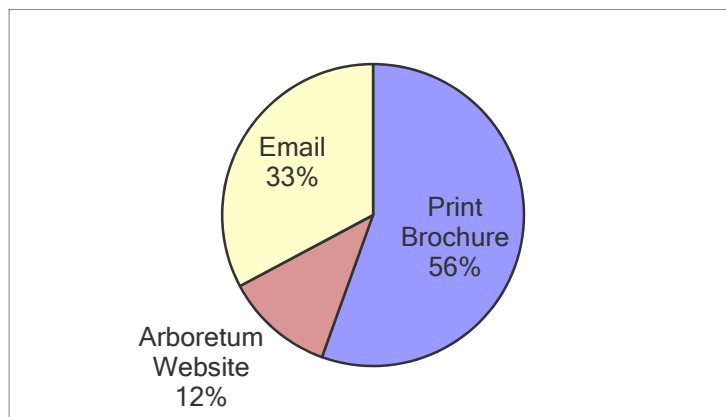
6. “Which category of class interests you most? Please pick your favorite option!”

Because I wanted to focus in on class-taking preferences of members, I required respondents to choose only one class category. The answer options for this question were based on the class categories regularly offered at the Arboretum and are an exact replication of a question we frequently send out for course evaluations.



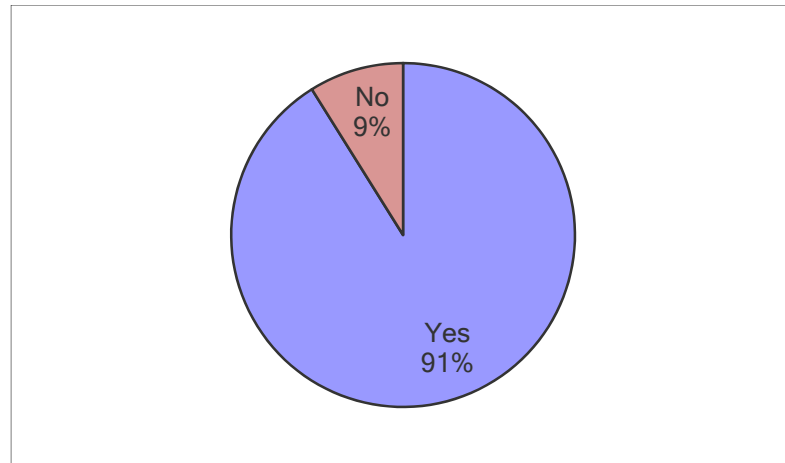
7. “How do you prefer to find out about classes?”

Based on previous course evaluations, I included only the 3 most popular communication options: Email, Print Brochure, and Arboretum Website.

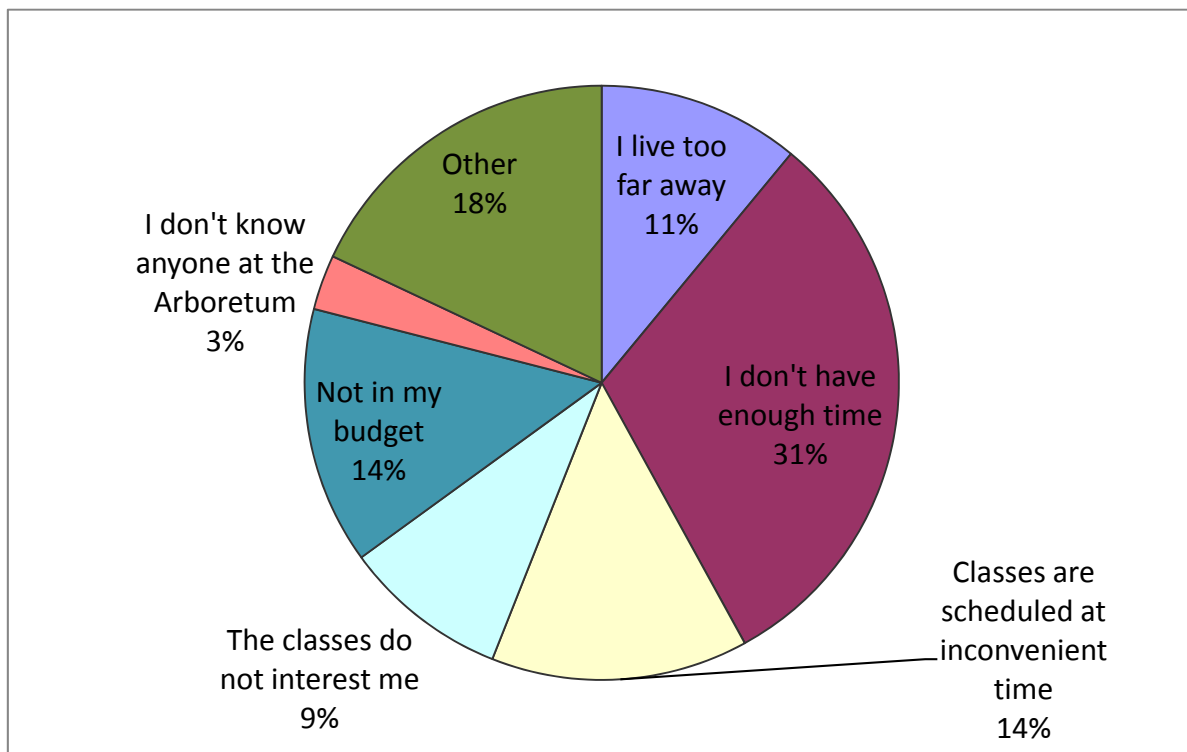


8. “Based on the classes you have taken in the past, do you feel that the cost of the class was reasonable?”

Again, several people wrote-in comments using the “Other (Please Specify)” options. These responses can be seen in Fig. 4



9. “What is the main reason you have not yet taken a class at the Arboretum?”



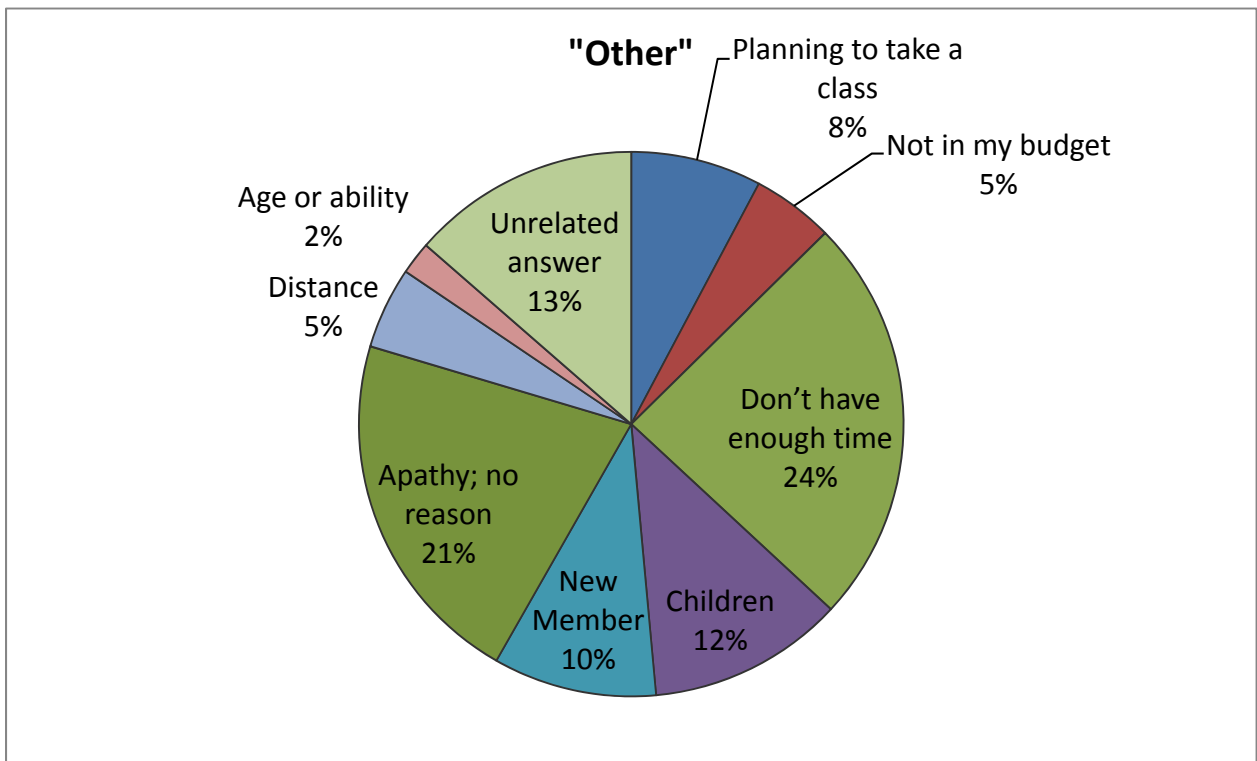
For simplicity’s sake, I chose to make this a multiple choice question. Otherwise, I would have spent a significant amount of time interpreting each open-ended answer. To avoid putting words in people’s mouths, I added an “other, please specify” option, which I interpreted in the following table. I looked for common themes and keywords, which resulted in 9 additional categories. Most of these categories are self-explanatory, but I will elaborate on the less obvious ones:

“Planning to take a class”- Several respondents mentioned that they had not taken a class but were interested. Some said they hadn’t thought about taking classes until reading this survey.

“New Member”- many people mentioned becoming a member over the winter and wanting to wait till spring to take a class.

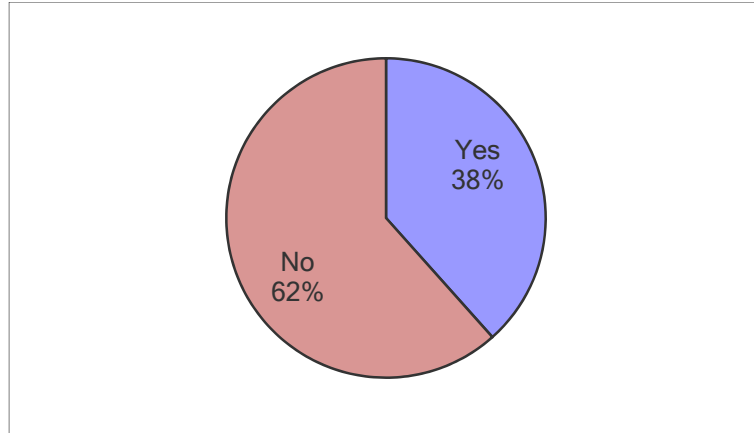
“Apathy; no reason”- Many people had no real reason for not taking a class. One person simply gave “Lazy” as a response.

“Unrelated answer”- I was unable to interpret any useful response from these submissions.



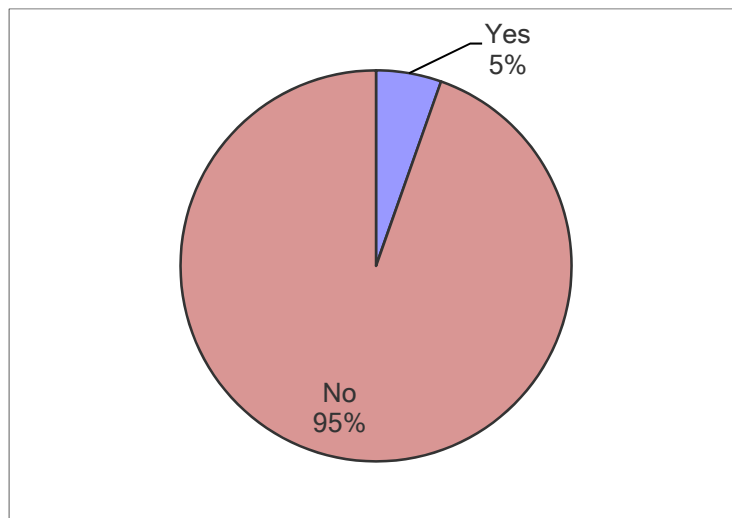
10. “Do you attend classes or workshops at other cultural institutions or museums?”

I was interested in comparing the results from this question with the results from Question 3: “Have you ever attended a class at the Morris Arboretum?” of which 70% of respondents indicated they had not attended a class at the Arboretum; 30% indicated that yes, they had taken a class.



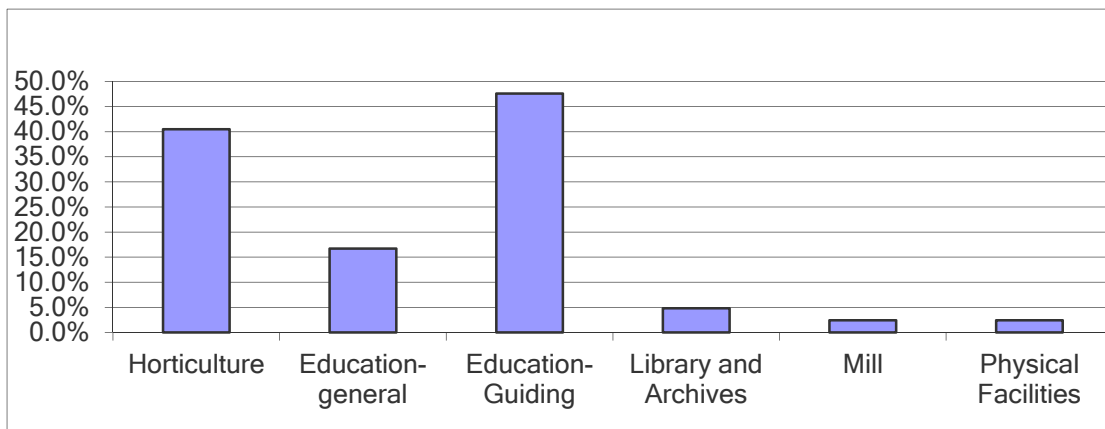
11. “Are you an active volunteer at the Arboretum?”

The results from this question were fairly similar to the statistics I had previously pulled from Raiser’s Edge which indicated that 9% of class-taking members are also Arboretum volunteers while only 1% of members who have not taken classes are Arboretum volunteers.

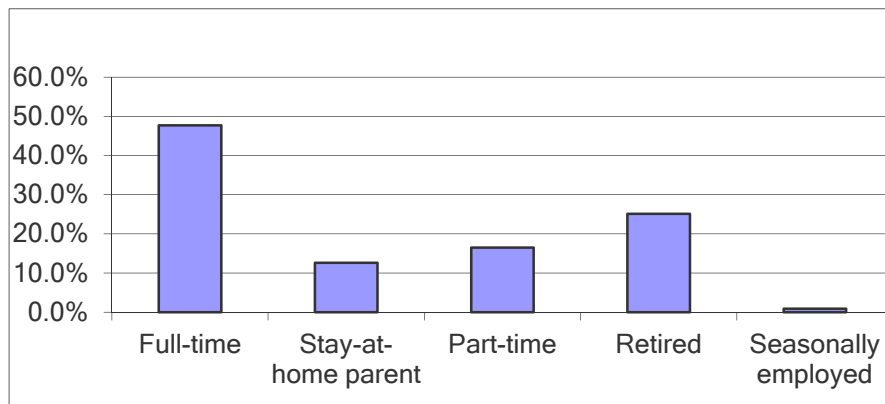


12. “In which department do you volunteer?”

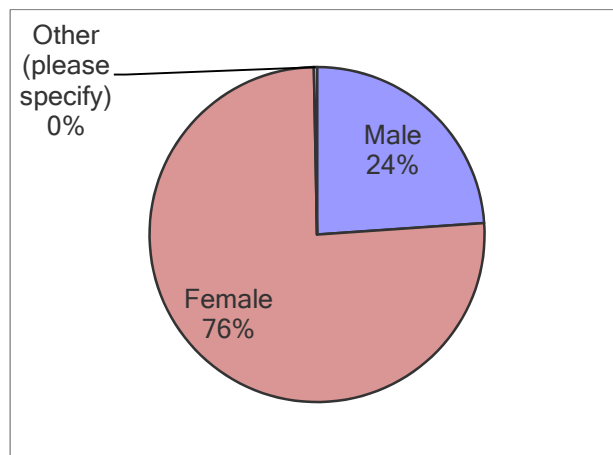
It was no surprise to see that, out of the active volunteers, most of them were either horticulture or education volunteers. Horticulture and education are our two largest volunteer groups at the Arboretum.



13. “Which of the following best describes your employment?”



14. “I am” Male/Female/Other (Please Specify)



15. “Why did you become a member of the Arboretum?”

This open-ended question resulted in hundreds of different responses. I did my best to interpret these results, looking for trends and patterns. The following table displays the results from a basic keyword with the number of times the word appeared throughout survey responses:

| | |
|--------------------------|-----|
| value | 8 |
| relax | 8 |
| cost | 13 |
| peace | 14 |
| admission | 14 |
| safe | 17 |
| discount | 17 |
| horticulture | 17 |
| plant sale | 18 |
| Groupon or Living Social | 40 |
| space | 21 |
| trains | 31 |
| beauty | 36 |
| education or classes | 56 |
| close | 51 |
| kids | 193 |
| beautiful | 103 |
| support | 103 |
| walk | 162 |
| enjoy | 193 |

16. “We would love to hear your stories from classes at the Arboretum. Please share a good experience you had while taking a class at the Arboretum”

I left this question open-ended to allow class-takers to express themselves. While this is certainly my own interpretation of the results, in looking at responses I noticed several themes:

Gaining a new skill:

“I attended a wreath making class a number of years back and since then I make seasonal wreaths for my home and even friends. It gave me a fun skill.”

“Amazed myself when I completed a Thanksgiving center piece, a Christmas wreath and boxwood tree with lights.”

“I always enjoy the classes I take there and find them inspiring, most recently the canning class by Marisa McClellan. It really and took the fear out of jarring/canning.”

“The most valued classes I attended were those which gave me some basic training in using a dichotomous key.”

“I greatly enjoyed taking a class on creating a Thanksgiving centerpiece. I learned a lot about floral design theory and then took home a beautiful centerpiece that I created myself.”

“I learned a lot about roses and was given the will to prune more.”

“I learned how to use an architectural ruler and draw to scale in a landscape design class. I created an in scale map of my front garden. It was fun!”

“I learned the correct method for pruning trees.”

“I really enjoyed the rose pruning class. I use the information that I learned there every time I work with my roses. Very helpful and informative.”

“I took a canning class with Marisa McClellan that finally got me started with canning. Seeing her go through the canning process and hearing her give details and answer questions made a big difference for me. I also went home with a delicious jar of strawberry vanilla jam, which I will make more of this summer.”

“I took an introduction to digital photography course, which sparked an interest into macro photography. Now when my family visits we are always searching for mosses, seeds and the intricate patterns of tree bark. My daughter recently photographed Canada geese footprints in the snow.”

“It was many years ago but I took a bonsai class and it's been a passion of mine ever since.”

“Last year I took the rose pruning class and I really enjoyed helping prune with the guidance of rose society. I went right home and did mine!”

“I particularly liked the pruning class when Iana Turner made us go out into the gardens in freezing March weather and prune the hydrangeas. I was concerned that I would make a mistake but she taught us to get aggressive and exactly where and what to cut. I gained so much confidence!”

Building Relationships

“I have taken my step daughter to a few Saturday art classes and it has helped us to bridge a otherwise precarious relationship. Thank you.”

“I'm taking a canning class in a few weeks with one of my friends. Now that we both have children, it's hard to make time to get together. This class will be a great way for us to learn more while spending some valuable time together.”

“My husband and I love to walk together through the arboretum while our daughter takes Pam's nature sleuth's class and enjoy quiet moments together!”

“The more memorable classes were one on winter tree identification taught by Paul Meyer and one on pruning, with hands-on instruction. I've also enjoyed classes on fitness while gardening, and lectures on horticulture. I also find interesting people attending the classes.”

Rest and Reflection

“I took a drawing course when I was home on maternity leave - so 17 years ago. I sat under pine trees and looked down over the wet meadow. It was so peaceful and the air smelled delicious. For a couple hours once a week, it was an escape to heaven.”

“Jennifer Schelter's yoga outside in the arboretum's meadow- the smells- the sun setting- truly tuning in to all the sounds and smells- makes me feel summertime through every pore!

“Seeing the underbelly of a flying duck at sunset during yoga with Jennifer.”

“Summer evening yoga classes on the hill looking out into the trees and sky were sublime and better than an expensive vacation.”

“Took Tai Chi. Loved the meditative, peaceful feelings. Still practice.”

“Yoga in the trees is inspiring and amazing. I lived for those early Saturday mornings!”

“Yoga on a limb was a magical experience. You felt like you were floating in the trees. Fabulous teacher, amazing venue.”

“Your outdoor evening yoga class is wonderful. It's such a gorgeous place to do yoga and connect with nature.”

Children's Enrichment

“It was my 2 year olds first class experience; they took the class led by Pam Newitt. It was incredible to see how engaged, excited and curious they were during the class. Beautiful grounds to explore and learn.”

“Ms. Pam (Newitt) taught a class on turkeys around thanksgiving, and she had a turkey that was in the woods and it was gobbling, and the kids had to find it. Then when we found the turkey, she had made "baby turkeys" out of pine cones for the kids. It was great.”

“My 3 year old was very engaged in the growing minds class and spoke up when Ms. Pam asked the class questions. It was the first time I had ever heard her proudly answer a question in a classroom setting by herself.”

“My 9 year old daughter took some AMAZING photos in her Nature Photography class.”

“My daughter loves Miss Pam (Newitt) she is wonderful with the kids. We all get plenty of exercise and make fun crafts in her class!”

“My daughter took the photography class and had a good time "discovering" places in the arboretum.”

“My niece and I took a painting class and we so appreciated that it was accessible for my niece. We had fun painting!”

“My son and I attended one of the nature classes for children this past autumn. It was amazing to watch him learn and explore, and to see things through his eyes!”

“My son took the photography class & loved it.”

“My little girl experienced her first gazebo, first scarecrow contest, first Fernarium, first giant insect exhibit, and first winter sledding experience, and bought her first umbrella, played in her first giant birds next, and bonged her first gong at the Morris Arboretum.”

“Seed to Sprouts is simply the greatest class. My daughter learned so much. The teacher was so knowledgeable but kept it to a child's level of understanding. Such a rewarding class.”

Member Testimonials

Additionally, I asked 12 active members to share stories about their experience in classes at the Arboretum. While this information is not quantitative, I wanted to get at the heart of our purpose in offering classes in the first place- to connect people, place and plants. Many of these interviews repeated similar themes to the ones found in the open-ended questions in the survey.

The following are some highlights from my interviews:

“[I met] interesting, vastly different people - some with amazing knowledge.”

“[I met] someone on this trip who is a landscape designer - she was extremely interesting to talk to and I learned some things that I could use in my own garden.”

“I have taken many great classes over the course of the many years I have belonged but what really stays with me are the relationships I have developed with my teachers and classmates. I have met them outside the classroom and we have become friends, colleagues and partners.”

“The one class I have taken consistently is the Yoga in the Garden class offered over the summer. The class hasn't necessarily enlarged my knowledge of horticulture but it has given me a greater sense of the beauty of the place. Sunset over the Magnolia Slope is truly stunning. I always leave with a sense of peace and well-being.”

“The last class I took was with Tim Block. It was a botany class on fruits. I love systematics. It fun to put things in groups because you can think more quickly, for instance a watermelon is a berry. The seeds are inside, unlike a strawberry with the seeds on the outside. Tim had a beautiful display of fruits. Many of them we had never seen. When the lecture was over we ate the display. How much fun is that?”

Non-Member Class Takers

While looking at class-taking members and non-class taking members, a third constituency became interesting: class-taking non-members. I created a list of these individuals and ran a very basic demographic report. Most importantly, I pulled membership information on these constituents to see if they were lapsed members. Of these non-members, 207 out of 512 (or 40%) records were associated with a lapsed membership. So this number, combined with the lists of class-taking members, show us that 992 out of 1,297, or 76% of class-takers were at some point associated with a membership. This method falls slightly outside the scope of this study, but would be helpful as a starting point for further research into member retention.

Analysis and Recommendations

After obtaining information and insight through a baseline study, an online survey, and personal interviews, I was able to analyze my findings and develop recommendations for future programming. It is my hope that by better meeting the needs and expectations of our members and by drawing in new class-taking members, we will continue to see strong trends in membership retention.

Based on the data I pulled for the baseline study, paired with survey results I have four general recommendations for future programming:

1. Continue to offer classes at a variety of times on a variety of different topics. With so many conflicting schedules, needs, and interests (Survey question 9), diversity seems to be the key to filling classes. As we continue to send out our regular course evaluations combined with class cancellations due to low enrollment, we will begin to build a larger understanding of class time preferences. We won't be able to predict people's preferences, but hopefully, with good record keeping, we can begin to see what works and what doesn't. Survey results suggest that diversity might be our secret weapon (Survey question 6) to filling classes and engaging new class-takers.
2. Increase marketing efforts for continuing education programs. In reviewing the open ended responses of question 9 we see a number of members who were unaware of Continuing Education programming at the Arboretum. Coordinated and consistent efforts between marketing, membership, and continuing education will ensure that new and renewing members will become aware of classes.
3. Continue to look for new ways to engage our largest membership categories. Some of our most populated member levels (including family memberships) are actually the least likely to register for classes. Combined with the responses to questions about barriers to class-taking, I recommend offering inexpensive one-time classes for families in addition to some of the current Growing Minds classes.

While we should continue to reach out to these membership categories, we need to keep in mind that families will always be a difficult group to formally engage. Based on the answers from the survey, we see that young families are short on time and money, and often have their priorities elsewhere. With this group, I think it's important to offer classes and programming for people who are interested, but perhaps we should direct more of our energy to engaging this constituency in less formal ways such as the Discovery Table. I would recommend an emphasis on these drop-in activities because parents are looking for ways to spend time outdoors in a safe environment with their children.

Another way to engage new members in continuing education classes might be to offer a one-time use coupon for a reduced registration fee (perhaps an extra 10% off of the member price).

4. Continue to focus class-takers and members on the gardens themselves. All classes should be tied tightly to the mission of the Arboretum and should celebrate and explore the collections, landscapes, and setting we love so much. As shown in questions 15 and 16, people become members because of their love for the Arboretum and their desire to spend time here. When we focus our classes on the Arboretum, we continue to draw people back to the reason they became members in the first place.

What an opportunity for growth with only 10.5% of our memberships registering for classes! These people are already associated with the Arboretum and are invested enough to purchase memberships. With continued research and a keen ear for listening to our membership, we have the potential to continue to evolve our already impressive educational offerings, giving members more of what they love, finding better ways to engage new people, and offering ways for members to reinvest in the Arboretum.

TITLE: TRIALING OF POTENTIAL GREEN ROOF PLANTS

AUTHOR: Ryan Plante
The Hay Honey Farm Endowed Natural Lands Intern

DATE: April 2014

ABSTRACT:

The purpose of this project was to increase the biodiversity of the Morris Arboretum's intensive green roof by doing a series of trials with a variety of plants. To do this I first had to evaluate what was already growing on the roof and what had been tried in the past. Using this information I compiled a list of candidate plants based on the criteria of tolerance to extreme cold, full sun, drought, alkalinity, and wind exposure, as well as considering floral appeal. The trial was separated into two parts, a fall planting that occurred in the fall of 2013, and a spring planting which is scheduled for April 15th, 2014. The fall planting was monitored throughout the winter and was evaluated in the early spring. I will monitor the spring planting until I leave in June, at which point the responsibility will fall upon my section leader Louise Clarke.

Trialing of Potential Green Roof Plants

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INTRODUCTION

In the last decade there has been a large increase in the interest of green roofs. People have not only begun to appreciate the beauty that they can bring to a building but they have started to recognize the potential benefits green roofs have to offer. They have become popularly used in cities, on college campuses, and even on rural and suburban homes. However, green roofs have been around for far longer than most people might think. The first recorded case of this is the Hanging Gardens of Babylon, which were constructed in about 500 B.C. The methods and plant selections used for this were far different than what we are used to seeing today but the principle was very much the same. The modern style of green roof that has become so popular was invented during the 1960's in Germany.

Today's green roofs are generally a frame with foundation layers comprised of (from bottom to top) waterproofing membrane, protection course, root barrier, insulation moisture retention/ drainage panel, filter fabric, and growing media. The plants chosen for a green roof depend on multiple factors such as climate, light levels, amount of growing media, and use of irrigation. A typical green roof will tend to have plants that are tolerant of full sun, dry soil conditions, and cold temperatures. This is because the general goal of a green roof is for it to be relatively self-sustaining, thus you want plants that can handle unfavorable conditions.

Those who are unfamiliar with green roofs might say "green roofs are visually appealing but are an expensive investment. What benefits would I get from installing one on my building?" If constructed properly green roofs can keep a building warmer in the winter, cooler in the summer, and can often double the life of a roof. There is no doubt that with the money you could save on heating, cooling, and roof maintenance that your investment would gradually pay for itself over a long period of time.

The purpose of my project is to trial new plants on the Morris Arboretum's intensive green roof in an effort to increase the diversity of plant life, bring in new colors and textures, and to incorporate new native plants. I first had to familiarize myself with the plants that we currently have on the intensive roof. To do this I spent time on the roof observing the existing plants and I reviewed the planting list to see the full collection and to see what had been trialed in the past. The roof contains a large mix of both native and non-native plants including cold hardy succulents, herbaceous perennials, warm season grasses, and low growing shrubs.

One way that I tried to gather inspiration for this project was visiting places that have similar environmental characteristics to the green roof. When doing so I was looking for places with high sun exposure, nutrient poor soils with excessive drainage, and high pH. The theory of this being that any plant suited to this environment would be suitable for green roof culture. One example of a place we visited was Mt. Cuba's scree garden. Louise and I met with Vic Piatt to discuss his strategies for creating life in an area with rather unfavorable conditions.

MATERIALS AND METHODS

Cold hardy succulents make great candidates for intensive roof culture due to their capacity to withstand drought. In addition they provide excellent aesthetic appeal with both attractive foliage and flowers. Some examples of succulent plants that have been successful are *Delosperma*, *Sempervivum*, and *Sedums*. While many succulents are hardy, it does not necessarily mean that they will survive the winter. A key problem that they face is becoming over saturated with water and rotting. One such plant that has been found to have this problem is *Agave*. We have tried several varieties on the roof in the past but all have failed due to the same reason.

As part of my project I introduced two new varieties of *Sempervivum* to the roof. The first variety is called *tectorum* 'Reinhard'. This is a typical variety with a tight rosette that has sharp, pointed tips. It features bright green foliage that is purple at the ends. The second variety is *Arachnoides* 'Cabense'. This is a variety that produces an abundant amount of pubescence that forms a web-like covering over the entire plant. This exists as a defense mechanism to prevent predators from feeding on it. In addition the foliage holds colors of green, yellow, pink, and red. The predominate reason I chose to use *Sempervivum* is because I have had experience working with them in the past and I know how well adapted they are. In a prior project I used them in a planting for a stone staircase that I turned into a rock garden. The reason I decided to use two different varieties such as these is that I wanted to see if the pubescence would cause problems with moisture control and cause the plant to rot.

The original plan had included two other hardy succulents including *Opuntia* and *Cylindropuntia*. Unfortunately there were complications when we tried to order these, so I decided to use another type of hardy succulent called *Orostachys boehmeri* 'keiko'. This plant creates a mat of cabbage-like rosettes connected by thin succulent stems. In the late summer it produces spikes covered with tiny white flowers that reach up 3 to 4 inches in height. It is common for the rosettes that produce flowers to die while the younger ones will shrivel and overwinter to the next year. This variety of succulent is relatively uncommon and there is little information discussing its capacity for green roof culture, though I am confident that it will be successful. It is hardy from zones 5-9, has a high capacity for drought tolerance, and can handle full sun. It has been noted that young plants may not return after winter if conditions are not favorable. Fortunately these will have a full growing season to establish before they have to withstand the harshness of winter.

There are many herbaceous perennials that are well adapted to green roof culture. Those that can withstand full sun, periods of drought, and alkalinity are generally well suited candidates. Usually these plants are native to areas like alpine regions, barrens, prairies, and deserts. Some of the herbaceous perennials that we currently have on the roof are, *Achillea*, *Solidago*, *Iris*, *Allium*, *Phlox*, *Aquilegia Canadensis*, *Perovskia*, and *Armeria maritime*. Despite being hardy and adapted to similar climates, not all perennials will thrive in green roof culture. Some fail to make it through the winter due to excessive moisture from melting snow. Some fail due to lack of nutrients or their inability to adapt to the alkaline soils. An example of this is

Papaver alpinum (alpine poppy), which was planted in 2010 but failed to return after the following winter.

My primary focus when considering the herbaceous plants that I chose was drought tolerance. The first and foremost priority was to pick something that would survive the growing season. When I had a list of plants that were drought tolerant I then filtered them out further to plants that could also handle full sun and that would be hardy to our zone. With what I had left I then picked plants based on aesthetic appeal.

I purchased two varieties of herbaceous perennials for the trial. The first was *Geum triflorum* (prairie smoke), a plant native to the prairies of North America. It forms a rosette of fernlike leaves and produces a 6-8" stalk with 3 reddish pink flowers. Later the flowers become seed heads that look like feathery poofs, which is where the plant gets its common name. It spreads by rhizomes and seed dispersal forming an interesting groundcover. Additionally it is noted that Native Americans used the roots to make a tea that would treat upset stomachs and sore throats. The second perennial I purchased was *Campanula rotundifolia* (round leafed bluebell). This North America native perennial features attractive blue bell-shaped flowers that bloom from June to September. It starts as a small rosette that produces a long stalk (up to 20" in height), which holds the flowers singularly or in small clusters. I chose this plant for its adaptability to full sun, well drained soils, and for its floral interest.

In addition to the plants I sourced I also came upon a few other trial plants through different means. The summer before I moved here for the internship I spent some of my free time growing plants at the nursery at which I worked. One of my little side projects was starting a tray of *Kniphofia* by seed. Upon returning to Rhode Island I found my seedlings to be in good health and thus I decided to use them for my project. *Kniphofia* are accustomed to periods of drought, well drained soils, and full sun. The only worry for this plant is that they can be susceptible to winter rot. In addition the tall orange flower spikes would make a fantastic accent on the roof.

I received two of my trial specimens as a donation from Jelitto growers. One year ago Louise was given two packs of seeds to test their potential for green roof culture. The species we were given were *Eritrichium canum* and *Silene regia*. I started the seeds in the Greenhouse on November 25th to be ready for the spring planting. The *Eritrichium* had no need for a cold period so they germinated right away and even flowered while in the Greenhouse. This plant is classified as biennial, perennial, and annual depending on where it is grown. It has a clumping form and produces a flower stem that is densely covered in small powder blue flowers. The *Silene* were put through three months of cold stratification, and then brought into the Greenhouse. Unfortunately after weeks of waiting there were no results from the *Silene* and I was forced to cull them.

Another way I was able to obtain trial material was collecting seed in the field. When considering plants to collect you must first think of the environment in which they grow and how it compares to the green roof. The ideal characteristic you are looking for is rocky well drained soils that are low in organic matter, high in alkalinity, subject to period of drought and have high sun exposure. Another important factor is accessibility. It would be impractical to go somewhere that would take multiple days of travel or require trekking over harsh terrain. Fortunately there

was a place that fits all of these requirements. Pennsylvania is home to many serpentine barrens. These are predominately grasslands with poor, rocky soils. In the past these sites were mined for the substance serpentinite, a greyish-green mineral used in the construction of many old buildings. It is expected that any plant adapted to the harsh condition of the serpentine barren would be applicable to green roof culture.

As it happens our senior botanist, Dr. Ann Rhoads, has been doing research in the serpentine barrens and agreed to accompany Louise and me on a collecting expedition. Ann's expertise proved to be an invaluable resource. Not only was she able to help us identify the plant we were looking for but she enlightened us with many of the other native species as well as some history of the site. The particular barren that we visited was in Unionville, PA. According to historic records the barren used to encompass about 88 acres. Over time the surrounding trees deposited leaves on the ground forming a layer of organic matter that gradually changed the composition of the soil. This allowed new species to take up residence thus changing the biodiversity of the barrens. Currently the Unionville barren only has about 8 acres remaining. Efforts have been made to help restore it to its previous form through clear cutting and controlled burns, though it is a long process.

The plant that we chose to collect was *Symphyotrichum depauperatum* (serpentine aster), a native plant that is considered to be mildly endangered. This is a small shrubby aster with small white flowers in the summer that form fuzzy seed heads in the fall. One of the characteristics that helped us differentiate it from its counterparts was its short, narrow leaves. The other varieties of aster that were present all had larger more rounded leaves. Due to the miniscule size of the seeds, we collected stems that contained clusters of seed heads. Once we had an adequate amount of material it was time to separate the seeds from the plant matter. I did this by removing the seed heads and crushing them. I then ran the seed chaff mixture through several strainers to achieve a relatively clean product.

I sowed these seeds into two half flat trays. One I put into cold stratification in the medicinal house, while the other I put straight into the Greenhouse. After two weeks the one that was put into the Greenhouse began to germinate. The rate of germination for this tray was approximately 30% based on the surface area of the tray. The second tray was taken out of the Medicinal House on March 3rd and put into the Fog House to compare the rate of germination based on the effect of a cold stratification period.

In addition to collecting seed of *Symphyotrichum depauperatum*, we also collected seed of *Aristida purpurascens* (Arrowfeather threeawn), a perennial clumping grass native to the serpentine barrens that is considered to be endangered. These seeds were not collected to be trialed on the roof, but as a thank you to the Department of Conservation and Natural Resources for allowing us to collect the serpentine aster. My goal is to present them with young plants that I have been raising in the greenhouse towards the end of May.

| Fall of 2013 planting results | |
|---|--|
| First planting | Second planting |
| <i>Sempervivum tectorum</i> ‘Reinhard’ » 6/6 Alive | <i>Geum triflorum</i> » 5/6 alive » 1/6 Questionably alive |
| <i>Sempervivum arachnoides</i> ‘Cabense’ » 3/6 Alive » 2/6 questionably alive » 1/6 dead | <i>Campanula rotundifolia</i> » 2/3 alive » 1/3 questionably alive |
| <i>Knifophia</i> » 8/8 dead | |

In addition to the plants I am trialing, I have compiled a list of plants that would make good candidates to be trialed in the future. Most of these are plants I considered as an afterthought once I had already put together my list for the trial. Some were not trialed due to the lack of space on the roof. Additionally some plants were chosen with the consideration of the ever changing environment on the green roof.

One group of plants that I did not cover in my trial was woody shrubs. A select few shrubs make excellent candidates for green roof culture particularly species that are adapted to poor soil conditions and excessive drought. Currently there are a few species of low growing woody shrubs on the green roof. Of these are *Rhus aromatica* ‘Grow Low’, *Prunus pumila* var. *depressa*, *Juniperus conferta* ‘Silver Mist’, and *Juniperus horizontalis* var. ‘Bar Harbor’ and ‘Wiltoni’. A woody shrub that I think would make an excellent candidate for our green roof is *Cotoneaster*. If this were to be trialed it would be wise to use a low growing species such as *microphyllus*, or *horizontalis*. Additionally *horizontalis* has a very attractive variegated cultivar called *variegatus*. This would do well on the roof because *Cotoneaster* is tolerant of drought, full sun, and alkaline soils. Another shrub that I think would be worth trialing is *Symphoricarpus X chenaultii* ‘Hancock’. This low growing variety of coral berry is adapted to full sun and a wide range of soils making it a suitable candidate for green roof culture.

Another group of plants I didn't touch upon are perennial bulbs. Many bulbs do well in green roof culture due to the fact that the well-drained soils prevent the bulbs from rotting during the winter. Some examples of bulbs that we currently have on the roof are *Camassia*, *Crocus*, *Dichelostemma*, *Muscari*, and *Tulipa*. One particular bulb that I would like to see used on the roof is *Fritillaria*. While *F. imperialis* would most likely not work due to the fact that its bulb is roughly the size of a grapefruit, there are many other varieties with much smaller bulbs that would make good candidates such as *F. eastwoodiae*, and *F. biflora*. I believe another good candidate is *Crocsmia* (Montbretia). This bulb forms clump of broad grass-like foliage with very attractive long slender stems bearing small star-shaped trumpet flowers that range from yellow to red. Another bulb that might work well on the roof is *Anemone blanda*. This is a hardy species of anemone with a white flower.

If we desired to push the boundaries of our hardiness zone I found a variety of bulb that would make an excellent accent on the roof. It is hardy to zone 7 but that is the low end of its range. Assuming we don't have a winter such as the one we are currently having they would most likely survive. *Acidanthera bicolor* (Peacock Orchid) is a South African native bulb with slender grass-like foliage and a white star-shaped flower with a reddish purple throat. These flowers are also noted for being extremely fragrant.

Considering the limited space available on the roof I could only use so many plants leaving a good number of perennials left untried. One that I think has very good potential is *Liatris* (prairie blazing star), which is native to the prairies of Northern America. It is very tolerant of drought and full sun, as well as providing spectacular visual interest with its long pink flower spike. If I had the opportunity to redo my plant list I would have perhaps switched this out for the *Campanulas*, but it is still possible for it to be tried in the future.

Another perennial that I would have liked to fit into the trial is *Centaurea montana* (Mountain Bluet). This stoloniferous clumping perennial is native to central and Eastern Europe. It is tolerant of full sun, drought, and dry soil making it a good candidate. Additionally I find the flower to be quite attractive with a purple bristly center and blue fringed petals. It is my desire to see more blue on the roof, which this would achieve.

Another good candidate is *Helianthemum* (Rock rose), a low growing perennial subshrub native to eastern North America. This is very suited to harsh conditions preferring excessive drainage and alkalinity. It has evergreen foliage and produces small rose-like flowers. Additionally it has an abundant amount of color options, though personally I find the red varieties to be the most attractive.

Another possibility is *Gaillardia* (Blanket flower). The very common shrubby perennial with multicolored aster flowers would make a nice addition to the visual appeal of the roof. Being tolerant of dry soils and drought it would make a fair candidate for green roof culture. It is noted for being short lived so perhaps that is something to consider. Another aster that I feel would work well is *Erigeron* (flea-bane). This aster is native to rocky bluffs and sub-alpine regions of North America. The particular variety *Erigeron peregrinus* known as subalpine daisy is taller than its coastal counterpart and has large aster flowers ranging from white to purple.

A plant that I think would work that I was previously unfamiliar with is *Dictamnus albus*. This shrubby perennial native from southern Europe to central and eastern Asia does have minor drought tolerance. It produces stems covered in attractive flowers that are very typical of a rutaceous plant that range from white to pink. While I don't see this as having extremely high potential I believe it would be worth a try.

While I did use cold hardy succulents in the trial, I avoided using cacti for reasons of availability or potential hazards. The following is a list of cacti and succulents that were not trialed but are plants that I believe would make good aesthetic additions. The first of which is *Echinocereus x lloydii*, a low growing round cactus with clusters of thin curved spines. I chose this particular one for its flower, which has large bright orange petals with a yellowish green center.

Another interesting cactus is *Echinofossulocactus zacatecasensis* (Zacateca brain cactus). It earned its name for the wavy margins that cover its surface. It has small clusters of short, thick spines and produces white flowers with purple accents. I chose this plant for its unusual texture, which really stands out among any cacti that I have ever seen. Another cactus with interesting stem texture is *Pediocactus simpsonii*. This plant has rounded ridges that swirl and bend around the surface of the stem giving it the appearance of being covered with snakes. Additionally, it is covered with miniscule clusters of spines. Another cold hardy cactus with an interesting appeal is *Toumeyia papyracantha* (Paper spined cactus). This small cactus holds flat, flexible, grey papery spines, which is where it gets its name. Though the name should not fool you, it does in fact have spines closer to the stem but they are rather insignificant. It also produces a large white flower with feathery petals.

One variety of cold hardy succulent that I believe would make a great addition to the roof is *Hesperaloe parviflora* (red flowered yucca). With vegetation very similar to its cousin the yucca, it produces a stem covered with small bright red flowers. It is extremely well adapted to dry soils and drought. Though it is recommended that it has occasional watering in order to achieve profuse flowering, it is not necessary for survival. This species is noted to be the most reliable of its genus in cold climates.

CONCLUSION

It is no wonder that green roofs have become so popular. They infuse our modern architecture with the beauty of nature. Additionally they can give us the benefits of thermal regulation and increase the longevity of a roof. While we have come a long way in the creation of these horticultural masterpieces, the potential for what is to come still seems limitless. It is challenges like this that inspire horticulturists to think "What else can I plant up there?" I have no doubt that with time we will see an evolution of design and techniques that will allow new and different things to become applicable to green roof culture.

I would like to thank those who helped make this project possible; Vic Piatt for meeting with me and inspiring my planting list, Dr. Ann Rhoads for sharing her knowledge and wisdom on the collection of serpentine aster, Shelley Dillard for allowing me the space in her greenhouse to prepare the plants for my project, and to Louise D. Clarke for her support and guidance throughout this project.

TITLE: **RESOURCE RECOVERY PLAN FOR PARKER’S
PIPEWORT (*ERIOCAULON PARKERI* B.L. ROB)
IN PENNSYLVANIA**

AUTHOR: **Alexandra E. Seglias
The John J. Willaman & Martha Haas Valentine Endowed Plant
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DATE: **April 2014**

ABSTRACT:

Eriocaulon parkeri (Parker’s pipewort) is a small, aquatic species in the family Eriocaulaceae (pipewort family). The species is native to tidal rivers and estuaries of eastern North America from Canada down through North Carolina. Parker’s pipewort is listed as vulnerable at the national (N3), and global (G3) levels. In Pennsylvania the species is listed as extirpated (SX). *Eriocaulon parkeri* was once quite abundant along the tidal marshes of the Delaware River and its tributaries, but due to extensive habitat destruction as a result of development, dredging, pollution, and climate change, the species is now confined to only a few of the River’s tributaries in New Jersey.

The purpose behind this project was to determine germination methods of *Eriocaulon parkeri* and the potential for reintroduction of the species in Pennsylvania. Plants were collected along the Maurice River in Millville, NJ and brought back to the Morris Arboretum in Philadelphia. When the flower heads were mature, seeds were extracted under a microscope and placed in a growth chamber at 5°C for four months. Following the four months, a portion of the seeds were moved to the greenhouse at ~19°C in petri dishes filled with water. The seeds exhibited strong germination rates in water, with 92.1% of the seeds germinating. A germination study using sediment collected from the tidal freshwater marsh at Bristol Marsh along the Delaware River, and Neshaminy Creek was also conducted.

*Resource Recovery Plan for Parker’s Pipewort (Eriocaulon parkeri B.L. Rob.) in
Pennsylvania*

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***Eriocaulon parkeri* B. L. Rob.**

CLASSIFICATION

Eriocaulon parkeri (Parker's pipewort), in the family Eriocaulaceae (pipewort family), was recognized as a distinct species and described by Benjamin Lincoln Robinson in the fifth volume of *Rhodora* in 1903 based on specimens collected along the Delaware River near Camden, NJ (Robinson, 1903). It was previously collected and included as *E. septangulare* by T.P. James in September 1858, and C.F. Parker in October 1877. Robinson dedicated the species to the late Charles F. Parker, curator of the Philadelphia Academy of Natural Sciences.

Synonyms

Eriocaulon pellucidum f. *rollandii* (J.Rousseau) Moldenke (1979)

Eriocaulon rollandii J.Rousseau (1957)

Eriocaulon septangulare var. *parkeri* (B.L.Rob) B. Boivin & J. Cay (1967)

Eriocaulon septangulare f. *rollandii* (J.Rousseau) Lepage (1974)

(The Plant List, 2013)

DESCRIPTION

Morphology

Eriocaulon parkeri is a small, erect, annual aquatic herb composed of 1-4 straight, unbranched, leafless flower stalks, referred to as scapes, 1-20 cm long with 4-5 longitudinal ridges, surrounded by a dense rosette of thin, pliant, basal, grass-like leaves, 1-6 cm long (Figure 1). The leaves have 3-9 nerves with numerous cross-veinlets, creating a net-like appearance. At the top of the scape sits a small (3-4 mm wide), button-like, grayish-white flower head (or capitulum) comprised of unisexual flowers, ~2 mm long. A small, receptacle bract supports each flower of the capitulum. Each flower contains two sepals and two petals, with a nectary gland located on the petal just below the apex. Short, white hairs can often be seen on the receptacle bracts, sepal, and petals with magnification. The staminate flowers contain four pollen-bearing stamens protruding from a short stalk, referred to as an androphore. The carpellate flowers have a single, two-chambered ovary on a short stalk, called the gynophore (Figure 2). The diminutive, capsulated fruit encloses two minute (0.5-0.7 mm long and 0.3-0.5 mm in diameter), ovate to elliptic, reddish-brown seeds with a delicate network of horizontally orientated rectangles (Figure 3). *Eriocaulon parkeri* has been reported to have a chromosome number of $2n=48$ (Schuyler, 1990).

REPRODUCTION

Eriocaulon parkeri is monoecious, meaning it has separate staminate and carpellate flowers within the same inflorescence. Male flowers tend to congregate towards the center of the capitulum, surrounded by the female flowers on the outside (Sawyer et al., 2005). The inflorescences of Parker's pipewort are protandrous, meaning the male flowers mature before the female flowers. In 1875 Eichler referred to the Eriocaulaceae family as the 'compositae amongst the monocotyledons' due to the similarity to Asteraceae (Stützel and Trovó, 2013). In his 1981 and 1984 papers, Stützel stated that the arrangement of male and female flowers within a capitulum has an effect on the reproduction of the species, and might result in autogamy (geitonogamy), despite the flowers being unisexual (Stützel and Trovó, 2013). There is a large range in the number of seeds produced in a single capitulum. I collected as little as three seeds, and as many as 56 seeds from one capitulum from specimens collected at Riverview Park in Millville, NJ on 16. October 2013.

Pollination and Seed Dispersal

There is dispute among authors as to the method of pollination in the Eriocaulaceae. *Eriocaulon parkeri* flowers from July to October (Fernald, 1950). Pollination most likely occurs between flowers on the same capitulum, rather than between flowers on separate heads (Uphof, 1927). Uphof described the presence of mites, which did not move from one flower head to another, but instead transferred pollen from male to female flowers on the same capitulum. He discovered that mites were more prevalent than flying insects. Haines (2001) stated that other methods of pollination have been described as autogamous (self-pollinated) or entomophilous (insect-pollinated) by Cook (1996), and as anemophilous (wind-pollinated) or entomophilous by Gleason and Cronquist (1991). Due to the type of habitat in which *E. parkeri* is found, Schuyler (1990) determined that most reproduction is from seeds, which may be dispersed by wind, water, and/or waterfowl.

A Connecticut field and greenhouse study completed by Sawyer et al. (2005) suggests that *E. parkeri* depends heavily on self-pollination for seed production. Bagged plants in the greenhouse produced the highest amount of seeds, and field observations showed limited insect visitation.

Seed Germination and Seed Banking

Very little research has been done on the germination requirements of *Eriocaulon parkeri*. For this reason, W.C. Muenscher's methods for storage and germination of *E. septangulare* seeds were followed (Muenscher, 1936). Alexandra Seglias, Ann Rhoads, and Cynthia Skema collected Parker's pipewort in mid-October 2013 at low tide from Riverview Park along the Maurice River in Millville, NJ (GPS: 39.39961N, 75.05370W). The plants were taken back to the Morris Arboretum greenhouse and placed in the 20°C room. When the flower heads reached maturity the seeds were extracted under a microscope, stored in vials of water (seeds from one capitulum/vial), and placed in a cold chamber at 5°C. After four months in the cold chamber, a portion of the seeds were moved to the greenhouse at ~19°C in petri dishes filled with water. The seeds exhibited strong germination rates in water, with 92.1% of the seeds germinating.

A second germination study was conducted in sediment from sites where *Eriocaulon parkeri* historically occurred. Sediment was collected from the tidal marshes at Bristol Marsh, and Neshaminy Creek. Both sites are located in Bucks County, PA. The sediment was collected in containers (~22 cm x 15 cm x 4 cm), and brought back to the Morris Arboretum. Seeds extracted from specimens of Parker's pipewort from Riverview Park were sown in the sediment, and the containers were placed in the growth chamber at 14-21°C with day and night conditions. The seeds have germinated in the sediment from both sites, but it is too early to determine if there is a statistical significance between the two sites.

ECOLOGY

Range

Eriocaulon parkeri is native to tidal rivers and estuaries of eastern North America. The species occurs in the Ottawa River and Saint Lawrence River estuaries of Quebec and the Miramichi River estuary of New Brunswick in Canada, south to North Carolina, excluding New Hampshire, Vermont, and Rhode Island (Figure 4). Parker's pipewort is presumed extirpated in New York, Pennsylvania, and the District of Columbia (NatureServe, 2013).

Habitat

Parker's pipewort is usually found in fresh to slightly brackish (< 5.0 parts per thousand) intertidal zones of rivers and estuaries; on mudflats (Figure 5), or in tidal marshes; and occasionally in coastal ponds (NatureServe, 2013). Species previously associated with *Eriocaulon parkeri* in New Jersey include *Elatine americana*, *Elatine minima*, *Isoetes riparia*, *Limosella subulata*, *Micranthemum micranthemoides*, *Sagittaria subulata*, *Zizania aquatic*, and occasionally *Spartina alterniflora* where conditions are somewhat brackish (Schuyler, 1990). Ann Rhoads (14. September 2013) identified *Eleocharis flavescens* var. *olivacea*, *Cyperus bipartitus*, *Orontium aquaticum*, *Nuphar advena*, and *Peltandra virginica* growing alongside *Eriocaulon parkeri* on the Maurice River mudflats in Millville, NJ.

CONSERVATION STATUS

Eriocaulon parkeri is ranked as vulnerable at the global (G3), and the national (N3) levels (NatureServe 2013). It is ranked as vulnerable (S3) in Quebec and Maine, imperiled (S2) in New Brunswick, New Jersey, Delaware, Maryland, and Virginia, critically imperiled (S1) in Massachusetts, Connecticut, and North Carolina, possibly extirpated (SH) in District of Columbia, and presumed extirpated (SX) in New York and Pennsylvania (Figure 6).

ERIOCAULON PARKERI IN PENNSYLVANIA

Early Herbarium Records

The earliest Pennsylvania records of *Eriocaulon parkeri* come from Tinicum in Delaware County (1864, 1874). The last recorded collection in Pennsylvania comes from Bucks County in 1932 (Table 1). These herbarium specimens are housed at the Academy of Natural Sciences in Philadelphia, PA.

Eriocaulon parkeri is known from three counties in eastern Pennsylvania from tidal mudflats along the Delaware River (Figure 7). All populations in Pennsylvania are presumed extirpated. The last collection of *E. parkeri* in Pennsylvania was above Philadelphia near the mouth of Neshaminy Creek in 1932 (Schuyler, 1986).

STATUS OF *ERIOCAULON PARKERI* IN OTHER STATES

Connecticut

Eriocaulon parkeri is ranked critically imperiled or imperiled (S1S2) in Connecticut. There are extant populations in Middlesex County and New London County. Historically the species also occurred in Fairfield County and New Haven County, but these populations are now possibly extirpated (NatureServe 2013). According to Haines, there were five current populations and 7 historic occurrences in Connecticut as of 2001.

Delaware

Eriocaulon parkeri is ranked imperiled (S2) in Delaware. There are extant populations of the species in New Castle County and Sussex County (NatureServe 2013).

Massachusetts

Parker's pipewort is ranked critically imperiled (S1) in Massachusetts. There are four current, and three historic occurrences in the state (Haines, 2001). The species exists in Essex County and Plymouth County (NatureServe 2013).

Maryland

Eriocaulon parkeri is ranked imperiled (S2) in Maryland. Populations can be found in Baltimore County, Caroline County, Cecil County, Dorchester County, Harford County, Wicomico County, and Worcester County. There is a historic occurrence of the species in Charles County, but the population is presumed extirpated (NatureServe 2013).

Maine

The species is ranked as vulnerable (S3) in Maine. There are 31 current populations in the state and three historic occurrences (Haines, 2001). Extant populations are located in Kennebec County, Lincoln County, Penobscot County, Sagadahoc County, and York County. Historic populations occurred in Cumberland County, Hancock County, and Waldo County (NatureServe 2013). Dates of documented observations are: 1924, 1937 (2), 1979, 1983 (2), 1985 (3), 1986, 1990 (4), 1992, 1994, 1995 (2), 1996 (2), 1998 (11), 1999 (2), 2000, 2001, and 2002 (5) (Maine Department of Conservation, 2004).

North Carolina

North Carolina is the southern extent of the range of *E. parkeri*. The species is listed as critically imperiled (S1), and can be found in two counties in the state: Hyde County and Tyrrell County (NatureServe 2013).

New Jersey

Eriocaulon parkeri is ranked imperiled (S2) in New Jersey. According to Haines (2001) there are eight occurrences of Parker's pipewort in the state. The species can be found in the following counties: Atlantic, Burlington, Cape May, and Cumberland. The species historically existed in Camden County, Gloucester County, Mercer County, Monmouth County, Ocean County, and Salem County, but is now presumed extirpated at all those locations (NatureServe 2013). The extant populations of *E. parkeri* in New Jersey occur along tidal portions of tributaries of the Delaware River and coastal rivers in the Pine Barrens, as well as in a few coastal ponds. Based on the number of extant populations, Schuyler (1990) determined that *E. parkeri* had a high element occurrence (EO) in the Mullica and Great Egg Harbor systems. *Eriocaulon parkeri* has been restricted to a few scattered sites along three tributaries of the Delaware River: Rancocas Creek, Deep Run near the junction with Alloway Creek, and the Maurice River. It is additionally found in a tributary of the Maurice River, Menantico Creek. The species historically occurred at many more sites in the Delaware system, but now populations are few and small, indicating a lower EO quality.

New York

Eriocaulon parkeri historically existed along the Hudson River in New York, but is now presumed extirpated (SX). Counties in which the species historically existed are: Albany, Columbia, Dutchess, Greene, Orange, Rockland, and Ulster (NatureServe 2013).

Virginia

Parker's pipewort is ranked imperiled (S2) in Virginia. Current populations can be found in the following counties: Charles City, James City, King William, King and Queen, New Kent, and Stafford. Populations that are now presumed extirpated were recorded from the following counties: Caroline, Essex, Fairfax, Gloucester, King George, Middlesex, Prince George, Southampton, and Suffolk (NatureServe 2013).

CRITICAL MANAGEMENT ISSUES

Population Decline

There are approximately 130 extant occurrences of *Eriocaulon parkeri*, 88 historical occurrences, and 22 occurrences that are now considered extirpated (NatureServe 2013). The species has faced population declines in most states and provinces from which it has been documented, especially in the southern part of its range. Parker's pipewort was once quite abundant in the Delaware River Estuary, but has disappeared from all known sites along the River's main channel, and is now limited to only a few sites along tributaries in New Jersey. The species also historically existed in the Hudson River Estuary, but is now listed as extirpated in New York State. The Chesapeake Estuary has additionally seen population decline, and the species is considered historical or extirpated in the District of Columbia.

There are an estimated 40,000-120,000 individuals of *Eriocaulon parkeri* remaining, according to the most recent occurrence counts. The species has experienced a long-term decline of 30-70% (NatureServe, 2013). Haines (2001) states that populations of Parker's pipewort can be exceedingly variable in both number and locations of plants from year to year, and dramatic differences can be seen in as little as three years. Some populations can contain extensive colonies, whereas others may have only a few plants. These dramatic fluctuations are typical of an annual species, and suggest that *E. parkeri* may have a strong relationship with environmental conditions. Most current occurrences are small, with less than 50 individuals. About 41-125 current occurrences are considered to have good viability (NatureServe, 2013).

Contributing Factors

Habitat loss/degradation – Increase in development along major rivers has been, and continues to be a major threat to *Eriocaulon parkeri*. In the Delaware Estuary, an estimated 50 percent of the natural marshes have been lost due to development, conversion, and degradation (State of the Delaware River Basin Report 2008). Wetland losses have been most severe in urban areas, where only about five percent of freshwater tidal marsh remains. This degradation of freshwater tidal marsh may have had detrimental effects on populations of Parker's pipewort along the Delaware River.

Habitat loss can occur as a result of other processes, such as inundation, dredging, and pollution. Pier and dock construction may be responsible for population decline (Haines, 2001). The construction itself can result in toxicity and disturbance, and following establishment, a dock may prevent direct sun from reaching populations. Changes in wake patterns as a result of increased boat traffic along the Delaware River may have also contributed to population declines of *Eriocaulon parkeri*. Once habitat destruction occurs, whether it is from dredging, construction, or pollution, the ability of the original intertidal flora to re-vegetate the area will be extremely limited due to reduced dispersal mechanisms (Ferren and Schuyler, 1980).

Climate change – *Eriocaulon parkeri* is exposed twice daily during low tide, suggesting that prolonged periods of inundation are likely detrimental (Haines, 2001). Higher water levels as a result of global climate change (Figure 8) may be having a harmful effect on populations of Parker's pipewort. The rate of sea level increase at Philadelphia from 1900 through 1999 was 0.108 inches/year, or about one inch

every nine years (State of the Delaware River Basin Report 2008). As sea levels rise, freshwater areas will face the intrusion of salt water. Freshwater flows from the rivers and streams in the Delaware estuary prevent salinity intrusion into freshwater areas. A combination of rising sea levels and decreasing fresh water flows could have a negative effect on the ability to take in fresh water and prevent intrusion of salt water. *Eriocaulon parkeri* is confined to fresh to slightly brackish habitats (less than 5.0 parts per thousand). The distribution of the species seems to be restricted by the limits of tidal influence upstream and by salinity flows downstream (NatureServe, 2013). According to Steve Eisenhauer of Natural Lands Trust at Peek Preserve, NJ, increase of salinity in the Maurice River area has led to population declines of Parker's pipewort (personal communication, 2014). Eisenhauer expects that salinity levels fluctuate with the tides and the seasons, but he has noticed that just downstream from the former *E. parkeri* habitat, salt tolerant emergent wetland plant species have started to appear. This may be a good indicator of the changing salinity levels in the area surrounding Peek Preserve in the Maurice River.

Water pollution – Increased toxicity of water was, and continues to be a major threat to populations of *Eriocaulon parkeri*. According to Schuyler (1990), poor water quality in the vicinity of Philadelphia during the mid-20th century most likely contributed to declines in occurrences of Parker's pipewort along the Delaware River. Water quality has improved in the latter half of the 20th century, but there still exist areas that have poor nutrient quality. Factors that contribute to the pollution of the River and subsequent extirpations and reductions of intertidal plant populations include the dumping of dredging spoil, landfills, and refuse (Ferren and Schuyler, 1980). Eisenhauer hypothesizes that the location of a sewage treatment plant upstream of the *E. parkeri* habitat at Peek Preserve has degraded the area and affected the ability of the species to subsist (personal communication, 2014). Discharge from the treatment plant – potentially containing chlorine, or other contaminants – has affected subaquatic vegetative growth, and has increased water levels downstream.

CONCLUSIONS

Stabilization of Existing Populations

The existing populations of *Eriocaulon parkeri* in New Jersey, and other states, should be monitored from year to year. Increasing salinity in freshwater areas may be a reason for decline in populations in some tributaries of the Delaware River in New Jersey.

Tidal wetlands are vulnerable to pollution, and rising sea levels, and as a result are facing increased degradation and destruction. It is imperative that these areas, and adjacent land, are protected from further damage in order to conserve species that rely on the resources and habitat for survival, and to allow for up-slope migration with increased sea level.

Establishment of New Populations

An attempt should be made to restore populations of *Eriocaulon parkeri* to historical sites where suitable habitat remains. Potential sites and environmental factors should be evaluated for the likelihood of establishment of new populations. Initial results show that Neshaminy Creek may be a possible site for reintroduction, but more research still needs to be conducted to determine the probability of the species to

subsist at this location. Seeds from the closest existing, and natural population should be propagated off site to generate plants for the purpose of establishing new populations.

Measures of Success

- Closest populations in NJ stable or increasing
- Clear and established propagation methods

Research Needs

- What are the effects of increased salinity on populations of *Eriocaulon parkeri*?
- What are the critical environmental factors that limit where *E. parkeri* grows?
- How can new populations be established following off-site propagation?
- How long does viable seed remain in the soil? What is the seed banking potential for the species?

FIGURES



Figure 1. Morphology of *Eriocaulon parkeri*. Source: USDA Plants Database



Figure 2. Microscopic image of female flower.
Photographed 21. October 2013



Figure 3. Microscopic image of two mature seeds, ~0.7 mm. Photographed 21. October 2013.

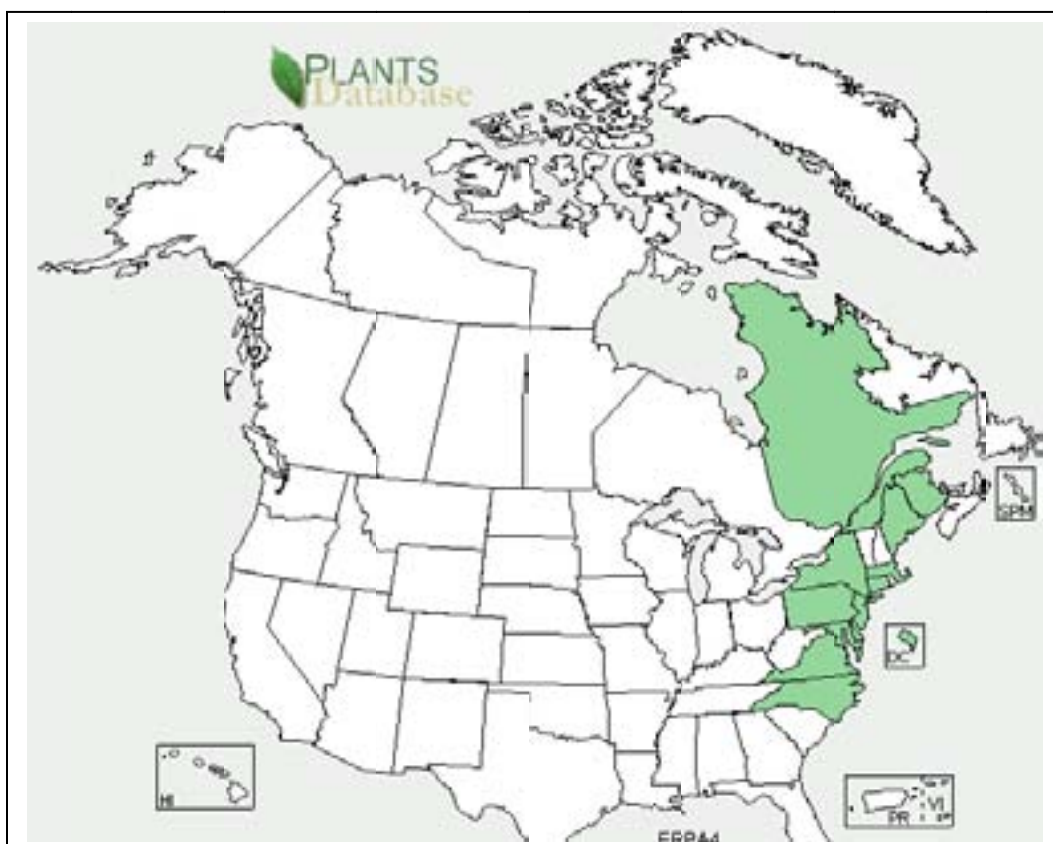


Figure 4. Range of *Eriocaulon parkeri* in North America. Source: Plants Database



Figure 5. Tidal freshwater mudflat with *Eriocaulon parkeri* at low tide on the Maurice River in Millville, NJ. Photographed by Ann Rhoads October 16, 2013.

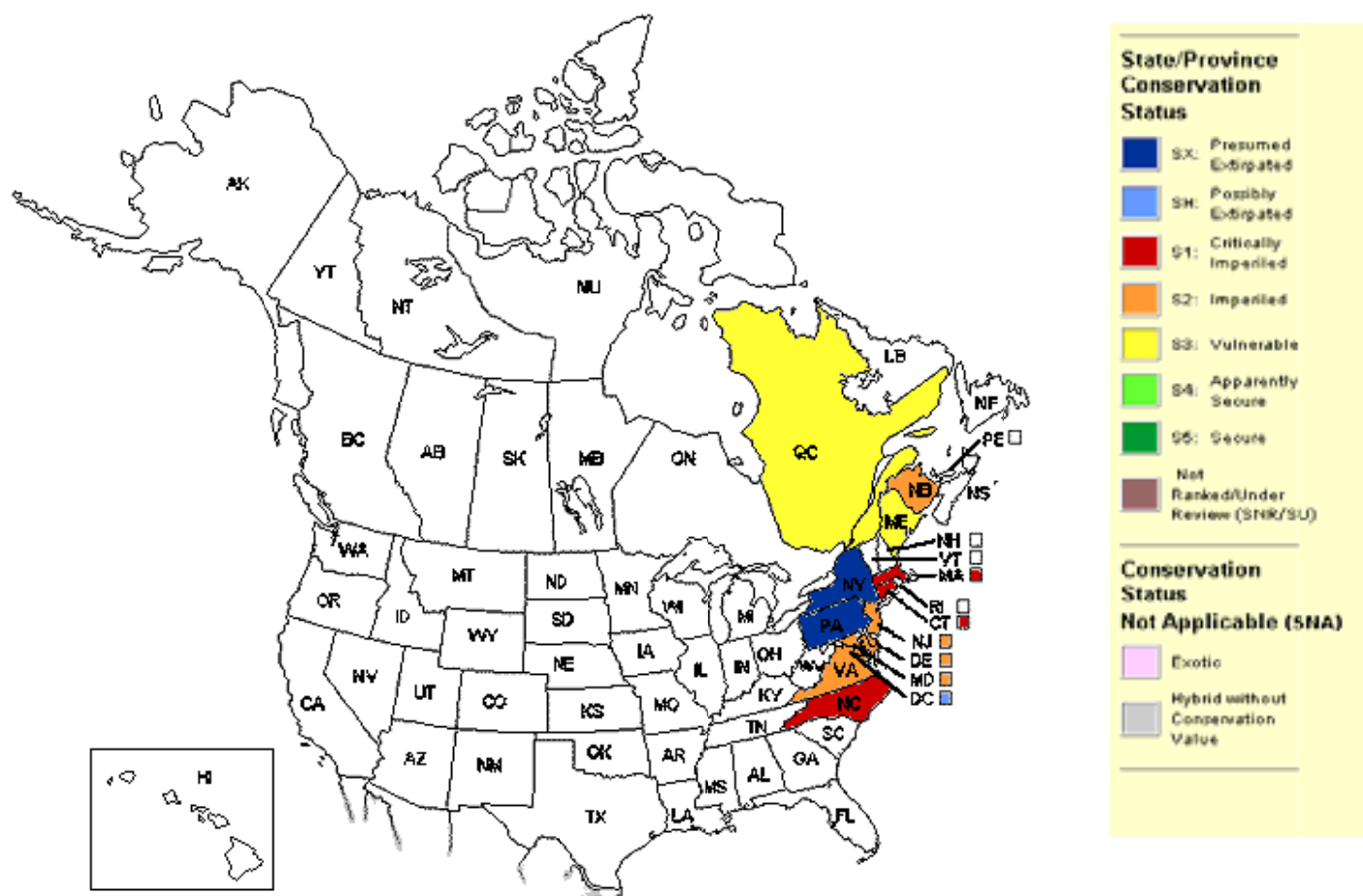


Figure 6. Conservation status of *Eriocaulon parkeri*. Source: NatureServe 2013.

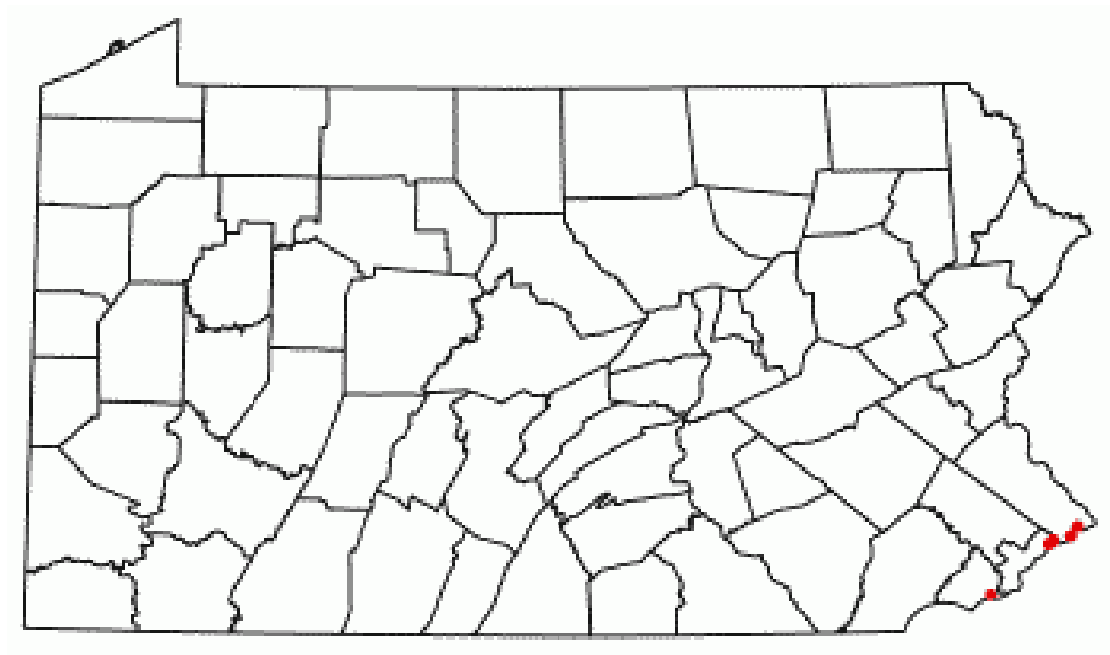


Figure 7. Map of historical occurrences of *Eriocaulon parkeri* in Pennsylvania. Source: The Pennsylvania Flora Project



Figure 8. 2001 aerial photograph of Maurice River Cove depicting a receding shoreline since 1890. Photo courtesy of J. Gebert, U.S. Army Corps of Engineers, Philadelphia District. Source: State of the Delaware River Basin Report 2008.

Table 1. *Eriocaulon parkeri* specimen records from Pennsylvania.

Source: Herbarium of the Academy of Natural Sciences of Philadelphia

| Year | County | Location | Location Detail | Collector |
|-----------|---------------|------------------|---|------------------|
| not given | | not given | | not given |
| not given | Delaware | Tinicum | | not given |
| 1864 | Delaware | Tinicum | Shores of Delaware River | Geo. Smith |
| 1864 | Delaware | Tinicum | | A.H. Smith |
| 1874 | Delaware | Tinicum | Along the Delaware River | J.W. Eckfeldt |
| 1874 | Delaware | Tinicum | Tide water | J.W. Eckfeldt |
| 1904 | Philadelphia? | Torresdale | | Stewardson Brown |
| 1923 | Bucks | Torresdale Manor | Andalusia | Bayard Long |
| 1926 | Bucks | Bristol | Tidal mudflats | Walter M. Benner |
| 1927 | Bucks | Tullytown | Wet, sandy tidal shores along Common Creek | Bayard Long |
| 1932 | Bucks | Edington | Tidal shore of Neshaminy Creek near its mouth on Bensalem Twp. side | Walter M. Benner |

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TITLE: **RESOURCE RECOVERY PLAN: BIDENS
BIDENTOIDES, A RARE PENNSYLVANIA PLANT**

AUTHOR: **Chelsea Smith
The Eli Kirk Price Endowed Flora of Pennsylvania Intern**

DATE: **April 2014**

ABSTRACT:

The purpose of this Resource Recovery Plan was to uncover information about a rare tidal marsh species in Pennsylvania, *Bidens bidentoides*. After compiling and determining its classification, description, ecology, conservation status, and historical populations, the plan shows what needs to be known and done about this species in terms of further research that should be conducted to prevent this species's extirpation.

In addition to compiling the plan that will be submitted to the Pennsylvania Department of Conservation and Natural Resources, three sites where *Bidens bidentoides* has been found in the past were visited to get a better understanding of its present populations. Also, the 120 specimens of *Bidens bidentoides* in the PH Herbarium at the Academy of Natural Sciences of Drexel University were imaged and databased. This historical population information will be made available to the public in the near future.

Resource Recovery Plan: Bidens Bidentoides, A Rare Pennsylvania Plant

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INTRODUCTION

Assigning rarity to plants is a difficult task. The decision cannot be based just on numbers because there are other factors that influence the suspected longevity of a species. Not only does rarity have to be determined, but ranking of rarity does as well. Which species are in the most danger? There are committees of botanists who decide this for their local flora using a variety of guidelines and personal observations.

David DuMond created a general guide for determining whether a species is rare or not. To do this he developed a list of nine habitual traits. If a species fits one of these requirements and lives in a habitat that will be affected by the activities of man in the near future, its rare quota is filled. *Bidens bidentoides*, a native freshwater intertidal species, fulfills at least two of DuMond's requirements (DuMond 1973). This small plant, commonly known as the swamp or Delmarva beggartick, is found in a very specific habitat, the upper zone in three freshwater estuaries on the east coast of the U.S. According to local botanists, the numbers of *Bidens bidentoides* in its limited range, at least in Pennsylvania, has already decreased over the years due to increased usage of the Delaware River estuary system for industry.

Dr. Tim Block, the John J. Willaman Director of Botany at the Morris Arboretum received a grant to fund the compilation of Resource Recovery Plans for rare plant species in the state, which will be submitted to the Wild Resources Conservation Fund of the Pennsylvania Department of Conservation and Natural Resources. These plans include background information about the species, their habitat, and their distribution. Ultimately, these plans determine what needs to be known about the plant and what needs to be done in order to increase its numbers and survivability in its ecosystem. I have worked on one of these plans for the aforementioned *Bidens bidentoides*. The following is the majority of the plan, excluding a few sections that do not pertain specifically to *Bidens bidentoides* as a species or to its status in Pennsylvania. There is also some added information about what I did outside of the plan to enhance the accessibility of information for this little studied species.

Resource Recovery Plan for *Bidens bidentoides* (Nutt.) Britton, the Delmarva beggartick, in Pennsylvania

CLASSIFICATION

The genus *Bidens*, in the Asteraceae family, includes 150-250 species, about 25 of which are native to North America (Fernald, 1950; Gleason and Cronquist 1991; Flora of North America Editorial Committee, e. 2006).

Bidens bidentoides (Nutt.) Britton is one of about 15 species of beggartick that have been documented in Pennsylvania (Rhoads and Klein 1993; Rhoads and Block 2007).

Nomenclatural History of *Bidens bidentoides*

In 1841, Thomas Nuttall described a new species based on a single specimen, *Diodonta bidentoides*, which was collected. He separated this genus from both *Coreopsis* and *Bidens*, two very similar genera, calling it an intermediate genus between the other two (Nuttall, 1841).

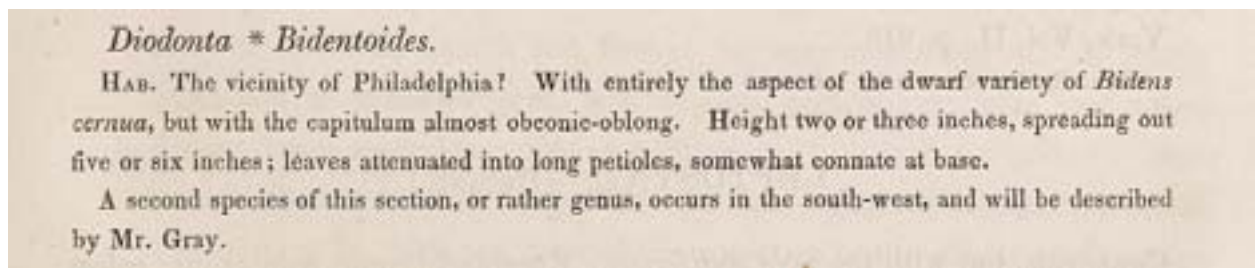


Figure 1: Original publication of *Diodonta bidentoides*

In 1842, John Torrey and Asa Gray described the same species as Nuttall, but called it *Coreopsis bidentoides*, mentioning that Nuttall's description was of one immature single plant of unknown origin (Torrey and Gray 1842).

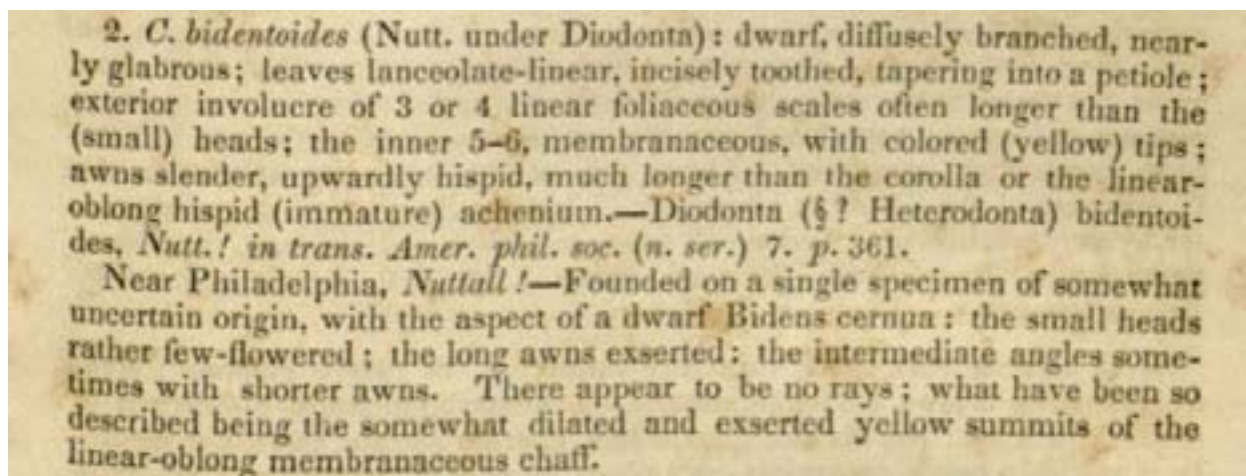


Figure 2: Original publication of *Coreopsis bidentoides*

This species was renamed again in 1893 by Nathaniel Lord Britton to *Bidens bidentoides*. Historically, the separation of the genera *Coreopsis* and *Bidens* centered on seed morphology; *Coreopsis* had winged achenes with antrorsely barbed awns and *Bidens* had unwinged achenes with retrorsely barbed awns (Tadesse et al 1995). However, in the 1900s, the use of these morphological characteristics as sole identifiers was called into question. At the time, there were several species of *Coreopsis* known to have unwinged achenes when immature and therefore the use of this characteristic for identification purposes could only be applied when the plant was mature. The definitive separation of the direction in which the achene awns were barbed had also become troublesome when botanists began discovering North American plants identical to *Coreopsis* species, but with retrorsely barbed awns, and the opposite for *Bidens* (Sherff 1915, 1936, 1937). Britton indicated the inefficacy of utilizing barb direction as the sole identification feature when he moved six species of *Coreopsis* to *Bidens* in 1893, *Coreopsis bidentoides* being one of these, by using other morphological indicators (Britton 1893).

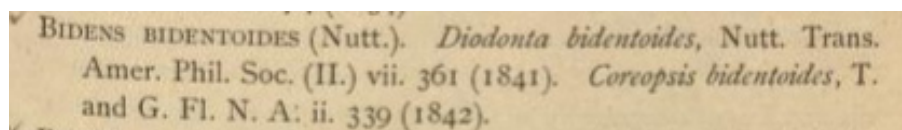


Figure 3: Original publication of *Bidens bidentoides*



In 1929, Sydney Fay Blake published a description of a new species

that was almost identical to *Bidens bidentoides* except that its range was further south, in Maryland, and it presented shorter awns and pubescent corollas. He called it *Bidens mariana* (Blake 1929). A year later, Earl Sherff determined this species to instead be a variety, *Bidens bidentoides* var. *mariana* (Sherff 1930). The *Bidens bidentoides* found farther north was then also called a variety, *Bidens bidentoides* var. *bidentoides*, though this was unpublished. More recently, however, the species is typically not broken up into varieties.

Figure 4: Illustration for original publication of *Bidens mariana*

DESCRIPTION

Bidens bidentoides is an herbaceous annual that grows to be from 6 inches to 3 feet tall. The leaves are simple, oppositely arranged, lanceolate in shape with entire or serrate to denticulate margins. Flowers are usually in singly borne heads. The flower heads have calyx-like structure of 3-5 bracts or bractlets that are usually spreading, narrowly lanceolate, sometimes foliaceous, with margins entire. The involucre is narrowly campanulate to cylindric, with oblong phyllaries. There are no ray florets, however, there are 7-30 disk florets, 3-6 mm long with yellow corollas. The fruit is an achene-like cypsela that is red-brown, flattened, narrowly cuneate to linear, faces smooth or striated. There are two pappi that are erect to spreading with 2 antrorsely barbed awns (Strother and Weedon 2006; Rhoads and Block 2007)

Important distinguishing characteristics, specifically in Pennsylvania, include the lack of ray florets, simple lanceolate leaves with serrate to denticulate margins, and antrorsely barbed achene awns. These characteristics distinguish it from the other species of *Bidens* that grow in the same environment in Pennsylvania.

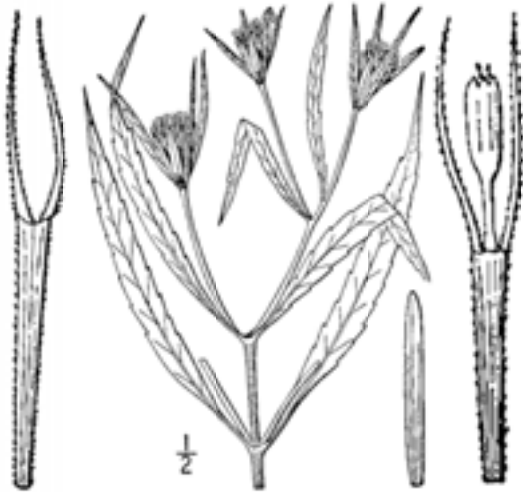


Figure 6: Simple, lanceolate leaves (Source: Rob Naczi)

Figure 5: Botanical illustration of *Bidens bidentoides* (Source: Flora of the Northern United States, Canada and the British Possessions. 3 vols. Charles Scribner's Sons, New York. Vol. 3: 496.)



Figure 7: Lack of ray florets (Source: Rob Naczi)



Figure 8: Achene barb direction

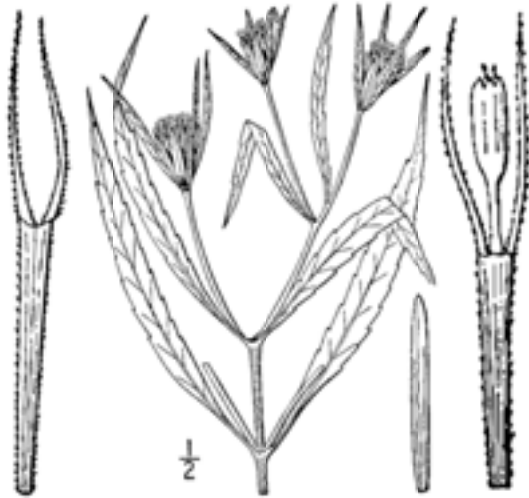
Phenology

Flowering occurs from late August to mid-October; fruits mature from late September to late October.

ECOLOGY

Range

Bidens bidentoides is found in counties in five states that have freshwater estuaries. Its northernmost reach is New York along the Hudson River, in Albany, Columbia, Dutchess, Greene, Rensselaer, and Ulster counties. The Delaware River estuary system is in three states. In Pennsylvania, *Bidens bidentoides* has been found in Philadelphia, Bucks, and Delaware Counties. In New Jersey, it has been found in Burlington, Camden, Cumberland, Mercer, Gloucester, Middlesex, and Salem counties. It is presumed to be extirpated in the last three counties. In Delaware it was found in New Castle County, though it is presumed to be extirpated there as well. At the most southern part of its region, it has been found along the Chesapeake in Maryland (Keller and Brown 1905; Benner 1932; Rhoads and Klein 1993; NatureServe 2013).



Retorse vs. Antrorse

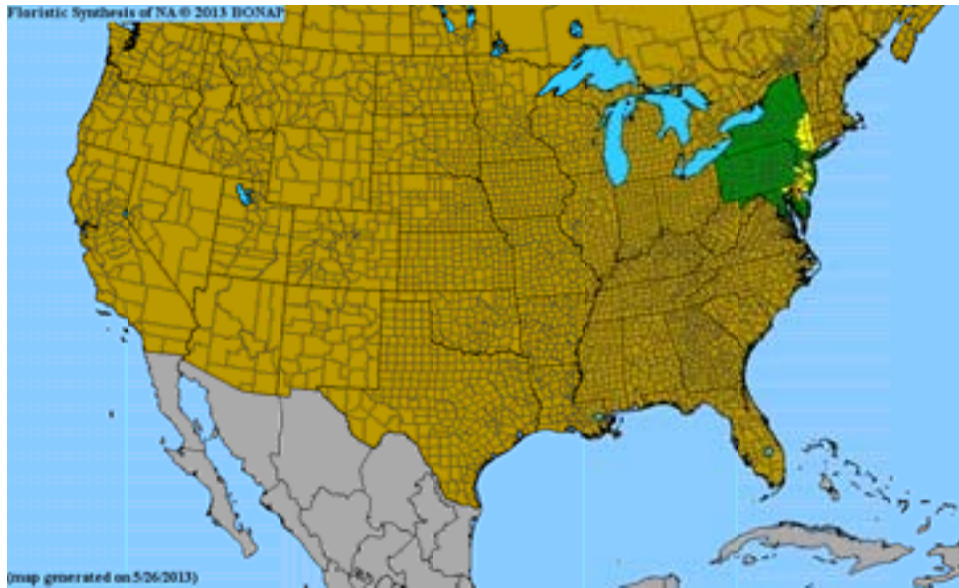


Figure 9: Range of *Bidens bidentoides*, in green

Habitat

The habitat for *Bidens bidentoides* is fairly restricted. It is a facultative wetland species that grows in freshwater intertidal marshes, mudflats, and shores. Often in the higher intertidal zone, it can be found growing among detritus or on decaying wood (Rhoads and Block 2007; PNHP Factsheet 2011).



Figure 10: Intertidal marsh in New York (Source: Robert Naczi)

CONSERVATION STATUS

Bidens bidentoides is classified as vulnerable at the global and national level (G3, S2). This global status was determined in 2005 and reviewed in 2009, but remained unchanged. It is ranked in every state in which it is found. It is ranked SH in Delaware (possible extirpated), S1 in Pennsylvania (critically imperiled), S2 in New Jersey (imperiled), and S3 (vulnerable) in both New York and Maryland (NatureServe 2013).

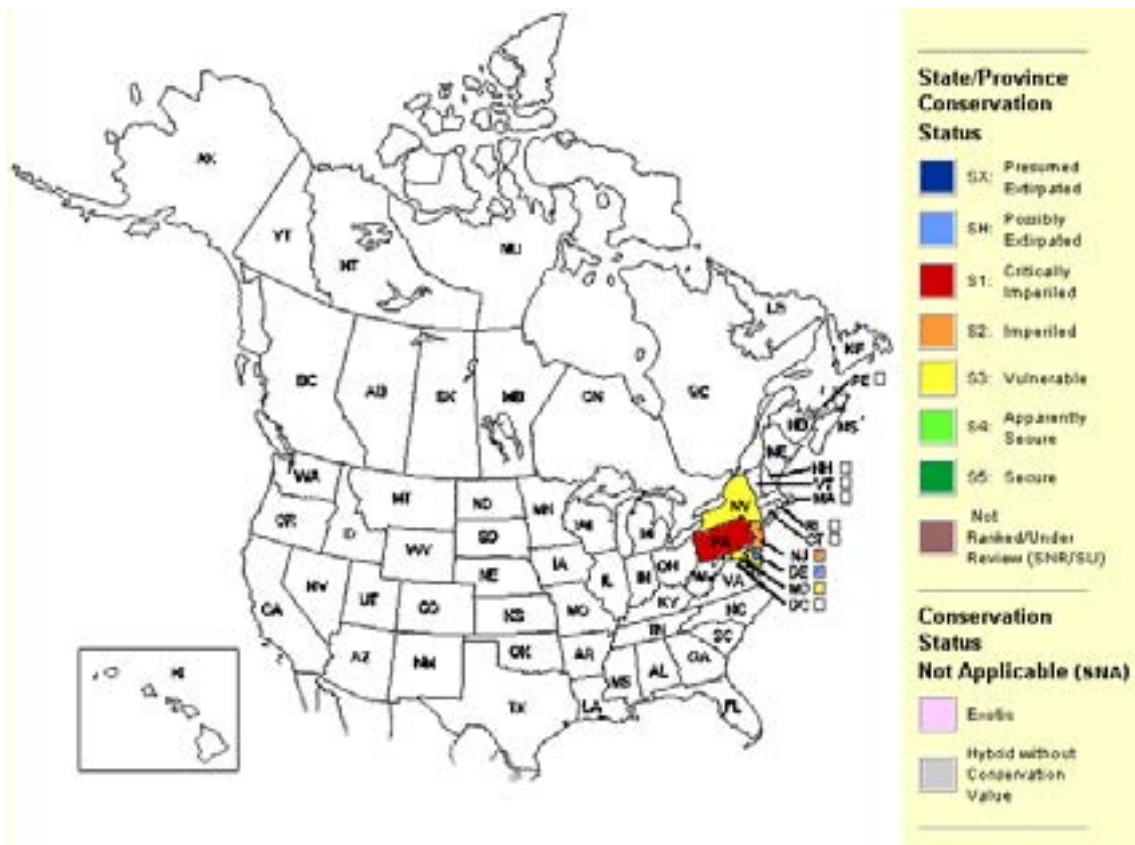


Figure 11: Conservation status of *Bidens bidentoides* (Source: NatureServe 2013)

HERBARIUM STUDIES

Herbaria are important for the study of plants in general. For this report, they are important for looking at historical and modern plant populations.

The two most likely herbaria to have specimens of *Bidens bidentoides* from Pennsylvania and the two that I had access to were the herbarium here at Morris Arboretum and the one at the Academy of Natural Sciences of Drexel University where I also work as part of my internship. There are 29 specimens of *Bidens bidentoides* here at the Arboretum herbarium, not including the specimens that were collected in the fall, and 50 at the Academy.

In addition to writing the plan, I curated, databased, and imaged the 120 specimens of *Bidens bidentoides* at the Academy herbarium. Curation entailed general upkeep, such as replacing linen strips and sewing woodier specimens to the sheet. This ensures that they remain in good condition for many years to come. All the label information for each specimen was databased and then the specimen was scanned to create a high resolution image. This information will be made public in the near future and can be found through the PH Herbarium online database and JSTOR Plants. This is important because only an incredibly small percentage of specimens in the PH Herbarium's general collection have been databased and imaged and

therefore the *Bidens bidentoides* information is special.



Figure 12: Locations and relative numbers of herbarium specimens collected pre-1950 (left) and post 1950 (right).

In order to connect recent population information to the collecting information from the herbarium specimens, I was able to visit three sites where *Bidens bidentoides* has been found previously. These are shown in blue in Figure 12. Based on personal observations over the years from eminent botanists like Dr. Ann Rhoads, Dr. Tim Block, and Dr. Ernie Schuyler, and comparisons to past collections, it is clear that *Bidens bidentoides* has declined in Pennsylvania.

CONCLUSIONS

There have been no studies on *Bidens bidentoides*, which needs to change in the future if we want to understand this species and prevent it from becoming extirpated. I think we need to understand its decline. It is threatened by dredging, filling, pollution, development, and competition from voracious invasives. Half of the plant species extirpated in Pennsylvania are gone because intense urbanization in the coastal plain region of the state has reduced this habitat to just a few isolated remnants. If the greatest threat to this species can be determined and decreased, then *Bidens bidentoides* would have a better chance at surviving.

The populations of *Bidens bidentoides* in Pennsylvania are almost nonexistent at the least and scattered at the most, therefore the gene pool in populations is small. Granted, plants handle

inbreeding much better than animals and sometimes species that are naturally sparsely distributed have genetic systems that are adapted to the genetic drift. However, loss of variation can reduce the ability of populations to adapt to changing environments and increase their susceptibility to pressures. It would definitely be interesting to look at the genetics of populations of *Bidens bidentoides* across its range to determine viability. If the species reproduces by incrossing, the small gene pool would not matter, but a lack of genetic variation could definitely reduce viability if the species turns out to be outcrossers.

Germination requirements are another aspect of reproduction that should be studied. This would help in potentially propagating *Bidens bidentoides* to be transplanted into the wild to boost population numbers and expand the gene pool. This could also aid in answering the question that I had about why this species is restricted to a tidal marsh environment while other *Bidens* that grow with it are also found along lakes. If the germination requirements are the same between these species, perhaps *Bidens bidentoides* could grow along lakes and just could not get there because its awns do not attach to moving animals like retrorsely barbed awns do.

It would also be beneficial to determine the presence of *Bidens bidentoides* in the seed bank and to do an inventory of the flora of the Delaware River estuary to truly see the decline and or fluctuations in all plant species in the tidal marsh.

ACKNOWLEDGEMENTS

I would like to thank Dr. Ann Rhoads, Dr. Tim Block, and Dr. Cindy Skema for introducing me to the world of botany, figuratively and quite literally, for they showed me the sites that were visited for this plan. I would also like to thank Dr. Ernie Schuyler for his input and in-depth knowledge of the Delaware Estuary.

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TITLE: REVIEW AND PROPAGATION OF THE HOLLY SLOPE

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The Martha J. Wallace Endowed Plant Propagation Intern

DATE: March 2014

ABSTRACT:

The purpose of this project was to complete several goals that contribute to a long-term ongoing renovation of the Holly Slope section at the Morris Arboretum. The first of these goals was to perform an assessment to determine if any of the hollies on the slope are rare or unique. This goal was completed by contacting nine other major holly collections to provide lists of their plants. Following the assessment, the next goal was to propagate those hollies with the eventual intention of offering specimens to other gardens and arboreta. The results of this work will contribute directly to future goals for the slope, including determining which holly plants can be removed to reduce crowding in order to revitalize the collection and open up some areas to interplant the hollies with live oaks (*Quercus virginiana*). In addition to the previously mentioned efforts, this paper will explore a brief history of hollies and provide some general information on the taxonomy and botanical description of the holly genus, *Ilex*. It will also look at the evolution of the holly collection at the Arboretum, particularly on the holly slope, and discuss propagating hollies from cuttings. Finally, there will be a look to the future and using the findings of this project to make changes on the Holly Slope.

Review and Propagation of the Holly Slope

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INTRODUCTION

Hollies are plants with a long horticulture tradition that are known and recognized by many gardeners. Like any other industry, horticulture has trends and in recent years, hollies have often been snubbed in favor of plants that are newer to the nursery trade. Despite often being overlooked these days, hollies are still plants with much horticulture value and deserve to remain an important part of our public and private gardens.

The holly collection at the Morris Arboretum, particularly in the area known as the “Holly Slope,” has been a site of ongoing renovation since 1999. This ongoing long term project has many objectives, and my contribution towards the work on the Holly Slope involved several interrelated goals. The first of these goals was to determine if any hollies on the slope are unusual, special, or rarely present in other major holly collections nearby. This assessment was completed by way of correspondence with the staff at the institutions that house these collections. The next goal was to propagate the special hollies with the eventual intention of offering specimens to other gardens and arboreta that may be interested in building up their own holly collections. Propagation of these plants by cuttings was undertaken in the winter of 2013-2014, and they are currently growing in the Greenhouse at the Arboretum.

This project also contributes directly to some future goals of the larger Holly Slope renovation; it sets the stage for determining which holly plants can be removed to reduce crowding on the slope to revitalize the collection. The information from the assessment will be helpful in making decisions about what plants should be removed. If it is decided that any of the special hollies have to be removed, they will have already been propagated and will be growing in the Greenhouse. Opening up space on the Holly Slope is an important aspect of another related goal in the larger renovation project: interplanting the hollies with live oaks (*Quercus virginiana*). These beautiful, majestic evergreen oak trees are iconic of the southeastern United States, but are not hardy in Pennsylvania. The Arboretum’s director of horticulture and curator, Tony Aiello, collected acorns from live oaks in the northernmost part of their natural range in the hope that the resulting plants would be more likely to survive here in Pennsylvania. They were sown and are now growing at the Greenhouse here at Morris Arboretum; some of them will eventually be planted on the Holly Slope.

HISTORY AND GENERAL INFORMATION ABOUT HOLLIES

Ethnobotany

Humans have a very old and intimate relationship with hollies. While we may now primarily think of them as garden plants, mankind’s use of hollies predates horticulture and written records indicate that people have used many species of holly for religious rituals, spiritual practices, medicinal treatments, and practical tools since before the time of the Romans. Hollies likely drew the attention of humans throughout the centuries with their evergreen leaves and bright red berries that persist through the winter when not many other plants have leaves or fruit (Bailes, 2006).

Symbolism

Hollies have been important symbols to many cultures and people throughout history. Using evergreen holly branches to decorate homes and places of religious importance for the

winter solstice is a traditional practice in much of Europe and Asia. Hollies are still used today in holiday celebrations, but the traditional symbolic significance has been lost and they are viewed by most as merely festive decorations for the season. For example, in pre-Christian times, the green leaves and red berries of the holly that persistent through the cold and dark winter months represented fertility; this same image was later appropriated by the Christians into a representation of Christ's crown of thorns and blood. On another note, for some Native American tribes the holly was a symbol courage and fierceness; warriors in these tribes pinned and painted holly on themselves before going into battle (Bailes, 2006)

Folklore

Many cultures around the world believed that hollies had magical properties and have superstitions and spells involving them. Native Americans intentionally planted hollies around their permanent settlements in an effort to repel malevolent spirits. In the British Isles, it was seen as bad luck to cut down a holly tree and furthermore, people considered them as a good plant choice for hedgerows as they would prevent witches from gallivanting about the countryside (Bailes, 2006).

Medicine

Many species of holly have purgative, narcotic, emetic, and stimulant properties that have been used in various rituals and folk medicines by cultures throughout the world. The bark, leaves, and berries have all been used for these purposes from a wide range of holly species, including familiar garden plants *Ilex aquifolium*, *Ilex cornuta*, and *Ilex vomitoria*. Perhaps the most famous and significant of these is the South American species *Ilex paraguayensis*; this tender species of subtropical distribution is the source of the popular drink *yerba mate*, a brewed beverage with gentle stimulating properties made with the fermented leaves.

Other hollies that are used to brew teas include *Ilex latifolia* and *Ilex vomitoria*. The latter of these is a native to the US and is known better by its common name, Yaupon holly. Native Americans in North America used this plant to create cassina or "black drink," an important element in a ritual. Consuming the beverage caused the drinker to sweat and vomit; these effects were considered healthful (Bailes, 2006). Other medicinal uses for holly include the Chinese using *Ilex cornuta* as a cure for kidney disease (all parts of the plant were used in Chinese medicine) and *Ilex verticillata* and *Ilex aquifolium* used for treating fevers (Bailes, 2006)

Tools

Holly wood is hard and has a close grain; these properties have made it a useful source of wood to create tools. Over the years, practical applications were often merged with magical ones to make the best use of the holly's physical and metaphysical qualities in tandem. The holly plant itself was considered to have a mystical power over horses and that, combined with the strong yet pliable quality of holly wood, made it an ideal substance for making horsewhips in Britain. Boughs of holly also made a good tool for sweeping chimneys since they served the dual purpose of driving away evil spirits (Bailes, 2006).

Taxonomy

Hollies are in the Aquifoliaceae family; the name of this family is derived from *Aquifolium*, a word that means pointed or spiny leaves. *Aquifolium* is the pre-Linnean and

classical name for holly (Galle, 1997). The family of Aquifoliaceae once had 4 genera, these were: *Ilex*, *Byronia*, *Nemopanthus*, and *Phelline*. Through the years, taxonomic authorities have revised the family and decided to incorporate *Byronia* into *Ilex* as a subgenus. *Phelline* has been given its own family - Phellinaceae. This left the monotypic genus *Nemopanthus* in the Aquifoliaceae along with *Ilex*. But in 2000, taxonomists deemed that the only species in this genus, *N. mucronatus*, be placed in *Ilex* as well, where it is known by its new name, *Ilex mucronata* (Bailes, 2006).

The taxonomic classification of hollies has changed much over the years; even deciduous hollies used to have their own genus (*Prinos*) until 1890 and, as stated above, hollies themselves were once in a different genus, *Aquifolium*. Linnaeus changed the genus to *Ilex* in reference to the classical name for the holly oak or holm oak, *Quercus ilex*, which somewhat superficially resembles the English holly, *Ilex aquifolium* (Galle, 1997). Interestingly enough, the holm oak was actually named after its resemblance to holly as 'holm' is an old word for holly (Holm Oak).

Most gardeners are only familiar with common garden holly trees and shrubs that come from America, England, China, and Japan, but there are many more from all around the world. *Ilex* is a large, complex, and varied genus, and taxonomic authorities don't agree on the number of species in it. Depending on who you ask, you might hear anywhere from 500 to a number closer to 800, with approximately 30 species being deciduous and the rest evergreen. This difference in opinion is primarily because the tropical range of the genus is not well documented and is generally unexplored. When exploration is undertaken, new species are discovered but often there are also indications that many species already described are the same (Bailes, 2006). Work on *Ilex* taxonomy is underway at both Conservatoire et Jardins Botaniques in Geneva and at the Royal Botanic Gardens at Kew (Galle, 1997).

Species in *Ilex* are present throughout the world in temperate, warm temperate, subtropical, and tropical climates in all continents except Antarctica in both hemispheres. It is also widely recognized in the fossil record, which shows evidence of 250 species that appear to be forerunners of present day *Ilex*. The diversity of the genus can be attributed to a few factors; it is indigenous to many microhabitats, and species can easily fertilize one another when flowering at the same time (Galle, 1997).

There are three major areas of diversity for *Ilex*, the first of which is the Sino-Japanese region which includes Taiwan, Japan, China, Korea, Myanmar, and the Indo-China peninsula. Next is Latin America with a significant representation in South America and Brazil. The third major area is the Malay Peninsula and archipelagos that consists of Malaya, Indonesia, Borneo, New Guinea, the Philippines, Papua, and the Pacific islands. This wide area of distribution is a good indicator that hollies are plants of ancient origin (Galle, 1997). Additionally, it is interesting to note that *Ilex* is primarily a species of the tropics and subtropics considering that many of our familiar garden hollies are not tropical plants (Bailes, 2006).

Botanical Description of Holly

Habit

How do we know a holly when we see one? There are certain traits that characterize the genus *Ilex*; however there is much variety among the many species classified within it. All hollies are woody plants with many being evergreen trees or multi-stemmed shrubs. Less than 30 holly species are deciduous. Holly trees include *Ilex aquifolium*, *Ilex opaca*, and *Ilex rotunda* and range in height from 50-65 to 100 feet. Hollies with low shrubby habits include *Ilex colombiana* and *Ilex cumulicola* and can range from 3-6 feet. Additionally, some hollies are low growing and others are climbers or epiphytes (Bailes, 2006). The habits of more obscure hollies can be hard to determine since many areas have been disturbed and cut back and the generally slow growing plants have not had an opportunity to reveal their true forms (Galle, 1997).

Flowers

Hollies are dioecious and have male and female flowers on different plants. Holly flowers are not what the plants are valued for in the horticultural world, but can be somewhat showy when there are many of them. They are borne in the leaf axils between the leaf and the stem (not on the ends of the branches); have a light fragrance; and can be white, cream, green, pink, or lavender. They usually possess 4 sepals, 4 petals, and 4 stamens though they can have up to 5 to 9 (Brooklyn Botanic Garden, 1993). Evergreen hollies tend to flower earlier than deciduous hollies. Temperate hollies, like the ones native to the Philadelphia region, often flower from early spring to summer. The flowers have a small inflorescence, with the male flowers usually being larger in number than the females (Bailes, 2006).

Fruit

The fruit of the holly, though commonly referred to as a berry, is not a berry nor is it a true drupe (Galle, 1997). There is actually no single term for this type of fruit, though it does share features with both a drupe and a berry (Bailes, 2006). Holly fruits are globe or egg shaped and made up of 4 segments; there is one seed within each segment. Most holly fruits are red, but can also be found in white, cream, yellow, orange, or black in the wild and in cultivation. It is important for gardeners to note that only females have berries and they do need a male plant nearby to pollinate their flowers to produce viable fruit. Some hollies bear fruit without a male plant, however the plant often sheds this type of fruit before it is ripe and the seed inside is not viable (Brooklyn Botanic Garden, 1993). Holly fruits are important horticulturally since they persist through the winter unless they are eaten by birds (Bailes, 2006).

Leaves

Along with the fruits, the foliage of hollies is valuable to gardeners because the evergreen species offer year-round greenery and deciduous hollies offer fall color (Bailes, 2006). Like other botanical elements of hollies, the leaves can be quite variable from species to species; however, holly leaves are always simple and never compound or lobed. They are usually alternate but a few species are opposite. The texture can be thick, waxy, and leathery, or quite paper like. The leaf outlines, margins, tips, bases and surfaces can vary widely from species to species; in fact, different leaf forms can be found on the same plant (Brooklyn Botanic Garden, 1993). Spininess is a feature of many hollies in cultivation, but is a minority in the genus as a

whole. Leaves become less spiny as the plant matures; spininess on younger plants may be a defense against browsing animals (Bailes, 2006).

Hollies in Horticulture

Hollies also have a long horticulture tradition but are not necessarily one of the most currently sought after plants. Some of their desirable qualities are seemingly working against them. Since they are robust and adaptable and can thrive in urban areas and difficult environments, they are often used for utilitarian plantings and have become overly familiar. Because they are shade tolerant, they can get lost in the understory of larger trees and shrubs and go unnoticed. Yet there are still many reasons to consider a holly for the garden; there are many species of holly and countless cultivars making for a lot of options to choose from. Hollies also make great structural plants and can be a dominant focal point or serve as supporting elements. They are, of course, noted for their winter interest of evergreen foliage and persistent fruit, and as they are traditionally used, great plants for hedges and topiaries. They also work well as screens (Bailes, 2006).

HISTORY OF HOLLIES AT MORRIS ARBORETUM

Holly Slope

In 1948 when the Arboretum purchased Gates Hall, the four acres of land now known as the “Holly Slope” were also acquired. Many hollies were planted on this location in the years from 1949 to 1953. It was selected as a good site for these plants because it provided southern exposure and well-drained soil. The original planting on the slope was organized according to the hardiness of the species; the curator during this era of the Arboretum chose to plant many plants and cultivars of our native *Ilex opaca* near the top, which was more exposed, and planted the more tender species like *Ilex aquifolium* and *Ilex* × *altaclerensis* in the lower part of the slope where they would receive more shade and protection from the elements (Aiello & Goff, 2005).

Collection through the Years

The Morris Arboretum has been an official holly arboretum since 1948. While some hollies do remain from the time when John and Lydia Morris lived here, the collection has grown, and more plants have been added through the years both on the Holly Slope and throughout the Arboretum. The Arboretum can now boast 174 taxa of holly; with many plants that are over half a century old, it is one of the largest collections in the Delaware Valley. Unfortunately, the collection has suffered some neglect at times over the years and there has been an ongoing effort by Arboretum staff to maintain and renovate it at various points in time. Parts of the collection were reviewed and verified in 1979 and again in 1987, at which time records and maps of the hollies were updated. Many new hollies were planted in 1980s and 1990s, including a significant planting of *Ilex glabra* ‘Densa’ for a hedge dividing the four quadrants in the Rose Garden (Aiello & Goff, 2005).

Recent and Current Work on the Holly Slope

Notably in recent years, the Arboretum’s current curator, Tony Aiello, has had an ongoing long-term project of renovating the holly collection by verifying, pruning, planting, and removing plants since he came into the position in 1999. The goals of this project are “to improve health and beauty by removing unidentified and unhealthy specimens, grow wild

collected species and propagate superior varieties from other collections, add diversity to the collection, share hollies with other gardens and individuals and to demonstrate a wider range of hollies to the public.” The plants in the collection were evaluated for recommendations of propagating, pruning, and removing in 2002. Since 2001, there have been ongoing efforts to expand the holly collection through visiting other collections for hollies to propagate and to eventually plant out (Aiello & Goff, 2005).

PROJECT

Assessing the Hollies and Correspondence with other Holly Collections

The first goal of my project was to assess the plants located in a particular section of the Holly Slope. Using the Arboretum’s plant locator computer program, you can see that the map of the Arboretum is divided into a grid with numbers on the horizontal axis and letters on the vertical axis. The area I worked with is located within grids K20, K21, L20, and L21. The two criteria that I was concerned with were whether any of the plants located in this area were special, rare, or unique and whether any of them held some significance to the Arboretum.

In order to determine the first of these two things, I had to contact a number of major holly collections. I contacted staff at nine gardens and arboreta, many of which are located fairly close to the Arboretum. In my initial correspondence, I emailed an appropriate staff member and explained my project and its objectives. I also asked two questions: if they could send me a list of the hollies in their collections, and if they would be interested in adding any of the hollies we propagate to their collections. Most places responded right away and provided me with a list of their hollies, and all but a few of these institutions said they would be interested in seeing our list of plants in order to expand their own holly collections. This is a particularly exciting aspect of the project for me, as it is quite thrilling to know that many other notable gardens will likely be adding plants that I personally propagated to their collections.

The next step was to take all of the lists I received and compile them into one master list that I organized alphabetically. I compared the plants on this master list to a list of the plants located in the specified grids on the holly slope. This comparison yielded yet another list of 18 different species and cultivars that none of the other gardens I contacted had in their collections. These were the plants I propagated. Later, we generated a second list of a select six plants that were present at only one other place and propagated those as well. Among the plants on the lists were several old *Ilex opaca* cultivars from the late 1940’s and early 1950’s that seem to have been lost from the nursery trade. Included amongst these were *Ilex opaca* ‘Formal,’ which originated at the Morris Arboretum and *Ilex opaca* ‘Morris Arboretum,’ a cultivar with vivid yellow orange fruits (Galle, 1997).

Holly Propagation

Research

Hollies can be propagated by seed, severing stolons, layering, grafting, tissue culture, and rooting stem cuttings, which is the most commonly used method and also the one that I used. In order to produce new individual plants from stem cuttings, they must be rooted. This process involves removing a terminal stem consisting of current season’s growth. It is best to get a

cutting length of 4-6 inches to ensure sufficient length for rooting; often a stem over this length is taken from the plant and cut down to size later. Some important things to keep in mind when taking cuttings is to choose the right time of year to take cuttings for a particular species, avoid taking cuttings on a day where the temperature is below freezing, and to carefully label everything. The rooting process is done by cutting the shoot down to the appropriate size and removing most of the leaves; this allows the cutting to put its energy towards root production while it is still able to perform photosynthesis. The next step is to wound the base of the stem to expose the cambium layer to the rooting hormone. Then the cutting is treated with a root promoting chemical. Finally, the cuttings are stuck in a damp medium and placed in a warm, humid, well-lit environment (Brooklyn Botanic Garden, 1993).

Methods

When I was ready to take cuttings from the plants on my propagation list, I did some preparation in advance. First I reviewed some books and the propagation files in the greenhouse to find out the appropriate time range for taking holly cuttings; this turned out to be roughly October to March. Also using the greenhouse propagation files, and in consultation with the Arboretum's propagator, Shelley Dillard, I decided to use media made up of 70% perlite to 30% peat to stick the cuttings into. I mixed the media and prepared the pots in advance so they would be ready to go once I arrived back with the cuttings.

I took cuttings of most of the plants in late December and a few more in late January. The second round of cuttings was done in late February. Each cutting was trimmed to 4-6 inches in length, given a double wound at the base of the stem, and treated with a rooting hormone. I used IBA powder and K-IBA liquid both in a concentration of 8,000 parts per million. IBA (indole-3-butyric acid) is a synthetic form of the plant hormone auxin. The liquid K-IBA contains potassium, which is thought to help transport the hormone through the cell membrane. The purpose of the two treatments was to see if the cuttings would root better with liquid or powder rooting hormone, but there was no significant difference. Then they were stuck in the media and placed in the warm greenhouse propagation room. I aimed for 20 cuttings from each plant.

Results, Discussion, and Conclusion

The results for my cutting propagation have been very good. Cuttings from all 18 plants on my initial propagation list have rooted and many have new growth, some of which is very vigorous. It is still too early to tell the results for the plants I propagated in February. We began potting up the cuttings into individual pots in early April 2014.

Some issues that I faced during the propagation process included finding little new growth on some plants when taking cuttings, cuttings that died, and pests. *Ilex opaca* 'Formal', one of the plants I was most hoping to successfully propagate because of its significance to the Arboretum had barely any current season's growth. I did manage to find about 10 cuttings that were at least a few inches tall, though not nearly close to 4-6 inches. Fortunately, despite being short, almost all the cuttings appear to be rooted. Inexplicably dead cuttings are another concern, particularly since many of them actually had good root growth. It is hard to tell why they died, but in some cases I suspect the dripping water from the fogger in the propagation greenhouse was the cause. Finally, many of the cuttings became infested with cottony camellia scale and some had white fly egg cases. It is likely that these pests existed on the plant outside and came in

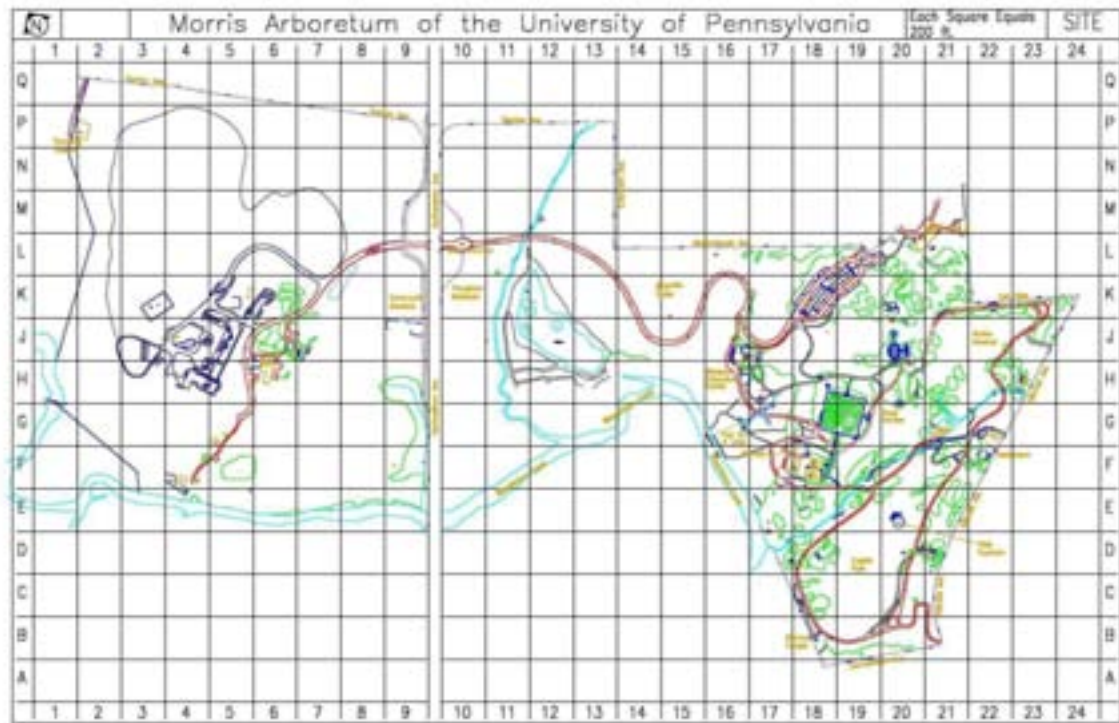
with the cuttings. This is especially likely with the white fly egg cases since there was no evidence of white fly in the greenhouse. Furthermore, when viewed under the microscope, they all appeared to have exit holes. To treat these issues, the cuttings were sprayed with oil.

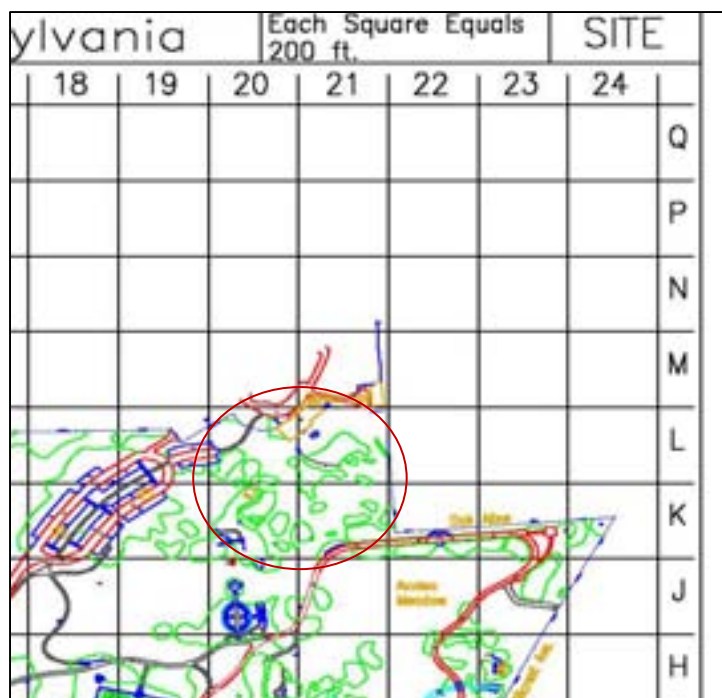
In conclusion, to finish up my contribution to the Holly Slope renovation, I plan to continue collecting data on all the plants I propagated and continue potting up the rooted cuttings. Also, I intend to contact the holly collections with which I corresponded with a final list of the hollies that we are offering to share as a result of this project. In the future, the plants on the holly slope will be assessed on a variety of criteria to determine if they should remain there or be removed to create more space. The live oaks growing in the greenhouse will be tested for hardiness over the next few years and those that survive overwintering will be candidates for planting out on the Holly Slope.

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APPENDIX A – Map and Holly Slope Grids





APPENDIX B – List of Gardens and Arboreta Contacted

New York Botanical Garden
 Tyler Arboretum
 Scott Arboretum
 U.S. National Arboretum
 Dawes Arboretum
 Longwood Gardens
 Bernheim Arboretum and Research Forest
 Rutgers Gardens
 Brooklyn Botanic Garden

APPENDIX C - Hollies Propagated

| Acession # | Grid # | Name | Common name | | | |
|------------|--------|---------------------------------|--------------------------------|--|--|--|
| 49-377*A | K21 | Ilex aquifolium 'Integrifolia' | Entire-leaved English holly | | | |
| 51-634*A | K20 | Ilex aquifolium 'Wheeler No. 4' | Wheeler No. 4 English holly | | | |
| 48-851*C | K20 | Ilex aquifolium 'Yonkers' | Yonkers English holly | | | |
| 2007-250*A | K21 | Ilex 'Conive' | FESTIVE holly | | | |
| 64-754*A | K21 | Ilex crenata 'Repandens' | Spreading Japanese holly | | | |
| 49-831*A | K20 | Ilex cumulicola 'Fort McCoy' | Fort McCoy Hummock holly | | | |
| 49-845*A | L20 | Ilex opaca 'Beulah' | Beulah American holly | | | |
| 49-844*A | L20 | Ilex opaca 'Fay' | Fay American holly | | | |
| 50-013*A | K21 | Ilex opaca 'Formal' | Formal American holly | | | |
| 50-008*A | L21 | Ilex opaca 'King Christmas' | King Christmas American holly | | | |
| 49-849*A | K20 | Ilex opaca 'La Bar No. 1' | La Bar No. 1 American holly | | | |
| 48-871*B | K20 | Ilex opaca 'Laura Thomas' | Laura Thomas American holly | | | |
| 51-462*A | K20 | Ilex opaca 'Lewis Swartz' | Lewis Swartz American holly | | | |
| 51-463*A | K21 | Ilex opaca 'Mallory' | Mallory American holly | | | |
| 49-799*A | L21 | Ilex opaca 'Perrine' | Perrine American holly | | | |
| 49-799*C | L21 | Ilex opaca 'Perrine' | Perrine American holly | | | |
| 49-443*B | K20 | Ilex opaca 'Sara Higgins' | Sara Higgins American holly | | | |
| 48-878*B | L21 | Ilex opaca 'Wheeler No. F-1' | Wheeler No. F-1 American holly | | | |
| 49-379*B | K20 | Ilex perado ssp. platyphylla | Canary Islands holly | | | |
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