2018

What is a Tree Worth? An Appraisal of the University of Pennsylvania's Tree Population

Eric Moore
University of Pennsylvania

An independent study project report by the The Martha S. and Rusty Miller Endowed Urban Forestry Intern (2017-2018)

What is a Tree Worth? An Appraisal of the University of Pennsylvania's Tree Population

Abstract
In 2018, the University of Pennsylvania received a level 2 arboretum accreditation. This new status provides incentive for establishing rigorous tree protection protocols and policies. To preserve and protect a healthy urban forest, it is necessary to develop a plant health care and maintenance program, which can be a costly process. By appraising Penn's campus tree population, and by determining the monetary benefits trees provide through their environmental and ecosystem services, we can advocate for a tree care budget that is consistent with the value of the asset.

We used methods outlined in the Council for Tree and Landscape Appraisal's (CTLA) Guide to Plant Appraisal to appraise a sample of Penn's campus trees. This process involved collecting data on the size, species, condition, and location of trees around campus. Additionally, an estimate of the environmental and ecosystem services rendered by these trees was generated using the i-Tree Eco program.

The appraised value for Penn's campus trees was $12.6 million dollars and the environmental benefits totaled approximately $161,000 dollars. The figure for environmental benefits is likely an underestimate, because we only included the minimum data required to run the i-Tree model. In the future, including interpretative signage on or around trees that mentions their appraised value and environmental benefits, may assist in educating the Penn and greater Philadelphia communities about the importance of trees in urban environments.

Disciplines
Forest Management

Comments
An independent study project report by the The Martha S. and Rusty Miller Endowed Urban Forestry Intern (2017-2018)

TITLE: **What is a Tree Worth? An Appraisal of the University of Pennsylvania's Tree Population**

AUTHOR: **Eric Moore,**
The Martha S. and Rusty Miller Endowed Urban Forestry Intern

DATE SUBMITTED: **APRIL 2018**

ABSTRACT:

In 2018, the University of Pennsylvania received a level 2 arboretum accreditation. This new status provides incentive for establishing rigorous tree protection protocols and policies. To preserve and protect a healthy urban forest, it is necessary to develop a plant health care and maintenance program, which can be a costly process. By appraising Penn's campus tree population, and by determining the monetary benefits trees provide through their environmental and ecosystem services, we can advocate for a tree care budget that is consistent with the value of the asset.

We used methods outlined in the Council for Tree and Landscape Appraisal's (CTLA) Guide to Plant Appraisal to appraise a sample of Penn's campus trees. This process involved collecting data on the size, species, condition, and location of trees around campus. Additionally, an estimate of the environmental and ecosystem services rendered by these trees was generated using the i-Tree Eco program.

The appraised value for Penn's campus trees was $12.6 million dollars and the environmental benefits totaled approximately $161,000 dollars. The figure for environmental benefits is likely an underestimate, because we only included the minimum data required to run the i-Tree model. In the future, including interpretative signage on or around trees that mentions their appraised value and environmental benefits, may assist in educating the Penn and greater Philadelphia communities about the importance of trees in urban environments.

What is a Tree Worth? An Appraisal of the University of Pennsylvania's Tree Population

TABLE OF CONTENTS

INTRODUCTION

Established in 1740, the University of Pennsylvania encompasses 302 acres of West Philadelphia. It is a highly urbanized campus, yet contains significant greenspace, retaining nearly 6,700 trees. In 2018, Penn's campus received a level 2 arboretum accreditation following Morton Arboretum's ArbNet criteria. These criteria include: an arboretum plan, a designated governance or organizational group, over 100 woody plant species that are labeled, paid management, public access and events, public education programs, a collections policy, and participation in the ArbNet network (Morton Arboretum, 2018). This newly attained status establishes Penn as the only university in the United States with multiple certified arboreta and further incentivizes setting rigorous policies and expectations regarding the protection and management of tree resources at Penn.

Penn continually strives to pioneer green infrastructure in the urban environment. Demonstrating a commitment to a greener campus, Penn has drafted an Ecological Landscape Stewardship Plan that is intended to guide landscaping decisions on campus towards sustainable and environmentally friendly solutions (ELSP, 2016). In a similar vein, the Morris Arboretum Urban Forestry Consultants have been working with Penn's Landscape Architect and Landscape Designer through the Office of the University Architect of the Facilities and Real Estate Services (FRES) Division, to draft a Tree Policy that addresses all tree-related concerns on campus. Morris Arboretum also maintains Penn's campus tree inventory and performs risk assessments for campus trees. A tree inventory and risk assessment can be a useful tool to advocate for budgeting effective tree maintenance (Allen et al., 2000). By proactively planning for various tree protection, pruning, and preservation work, urban foresters and landscape planners can work together to minimize the potential costs associated with trees and work to maximize their benefits.

To better inform tree and greenspace management on campus, it is important to develop robust tree and plant health care programs. However, these programs require adequate financial support to continue the upkeep and preservation of trees and other campus plantings. Therefore, it is critical to understand the value of the campus tree asset to determine an appropriate amount of funds to allocate to tree work. For insurance purposes; arboreta, botanical gardens, and other institutions that rely on trees for revenue will often have their trees appraised to determine damages in the case of losses. Tree appraisal can be a useful tool in dealing with insurance claims, but it can also be used to track maintenance records, argue for tax deductions, and quantify the contributions plants make to the quality of life in communities (Allen et al., 2000). These data can then be used by municipal arborists and urban foresters to plan and justify future budget requests.

Trees retain inherent monetary value for the materials they provide, including timber and food. However, trees also contribute significant aesthetic, ecological, environmental, and socio-cultural value to landscapes. Under many circumstances, it makes sense to quantify these other values. The United States Forest Service (USFS) developed a program, i-Tree Eco, to quantify the carbon sequestration, pollutant removal, oxygen production, and the storm water management capacity of urban trees. The i-Tree program can measure many other environmental benefits of trees and can also reliably attach a dollar value to these services (i-Tree). Trees can also increase property value. Mature, well-maintained trees are capable of increasing property value between two and nine percent in residential areas around Philadelphia (Wachter, 2004).

It is also worth noting that the value of trees, in terms of environmental benefits and contribution to property values, can appreciate over time as a tree grows (Bassett, 2015). Trees are one of few landscape assets that appreciate in value over time if managed correctly (Allen et al., 2000). However, if trees are neglected and their health declines, their value can depreciate rapidly. In other words, if not consistently monitored, trees can become a costly liability. Construction and storm damage can cause limb and full tree failure, which can damage other property or injure passersby. This problem becomes exacerbated in a dense, urban campus environment.

In this study, we sought to estimate the appraised value of the University of Pennsylvania's trees that includes the main campus, the Penn Alexander School, and Penn Presbyterian Hospital. To do this, we used the 'cost approach' outlined in the Council for Tree and Landscape Appraisers Guide for Plant Appraisal. This approach yields an estimate for how much it would cost to replace or replicate Penn's trees. Additionally, we estimated the carbon sequestration and storm water management potential of these trees using the i-Tree Eco program. The appraisal and i-Tree values can be used by Penn to generate a tree management plan consistent with the value of the asset. Overall, we hope that this appraisal project will be used as a tool to help Penn realize the full value of a healthy urban forest.

METHODS

Trees used in this project were selected from a full tree inventory Excel file provided by Penn's Landscape Architect and Landscape Designer through the Office of the University Architect of the Facilities and Real Estate Services (FRES) division.

Penn's tree inventory contains roughly 6,700 living trees. To get an accurate estimate (within 10% confidence) of the appraisal value of the entire campus tree population, we calculated that we would need to appraise 282 trees. However, because there are disproportionately fewer larger trees on campus than smaller trees, we needed to stratify our sample by size class to ensure that our results were not skewed. To do this, we generated a distribution curve of all campus trees by circumference at breast height (CBH) in inches. Trees were placed into one of five different size class bins: X > 70" CBH, 70" > X > 20", 20" > X > 10", and X < 10". This process ensured that the sampled trees CBH values accurately corresponded to the general campus tree population.

Each tree on Penn's campus has a unique accession number, which includes the year of accession followed by a four digit number. Trees were first accessioned in 2012 and assigned a random number generated from a set of numbers between 0001-9999. Following 2012, the four digit number following the year for each tree indicates the order in which the tree was accessioned that year. For example, the accession number 2015-0189*A indicates a tree that was accessioned in the year 2015, it was the 189th tree accessioned in 2015. Trees in each size class bin were randomly selected by accession number using a random number generator program.

The selected trees were mapped using the university's BG-Base and BG-Map software. These maps were uploaded to ESRI's Arc GIS online program for use in field data collection.

Field data collection was performed using ESRI's Arc Collector application. Data were collected on each tree using the guidelines explained in the Council for Tree and Landscape Appraisal's (CTLA) Guide to Plant Appraisal 9th Edition. Tree accession number, tree species common name and scientific name, tree condition, and tree site, contribution, and placement were recorded and evaluated in the field at the time of appraisal. I was accompanied by ISA Board Certified Master Arborist, Jason Lubar, during the first field collection day to ensure my evaluations were accurate.

Tree condition is scored on a 32 point scale, which includes 8 sub-categories scored on a 0-4 point scale. Sub-categories include: root structure, root health, trunk structure, trunk health, scaffold branch structure, scaffold branch health, branch/twig health, and foliage/bud health. Each of these categories was scored following a thorough visual inspection of each part of the tree.

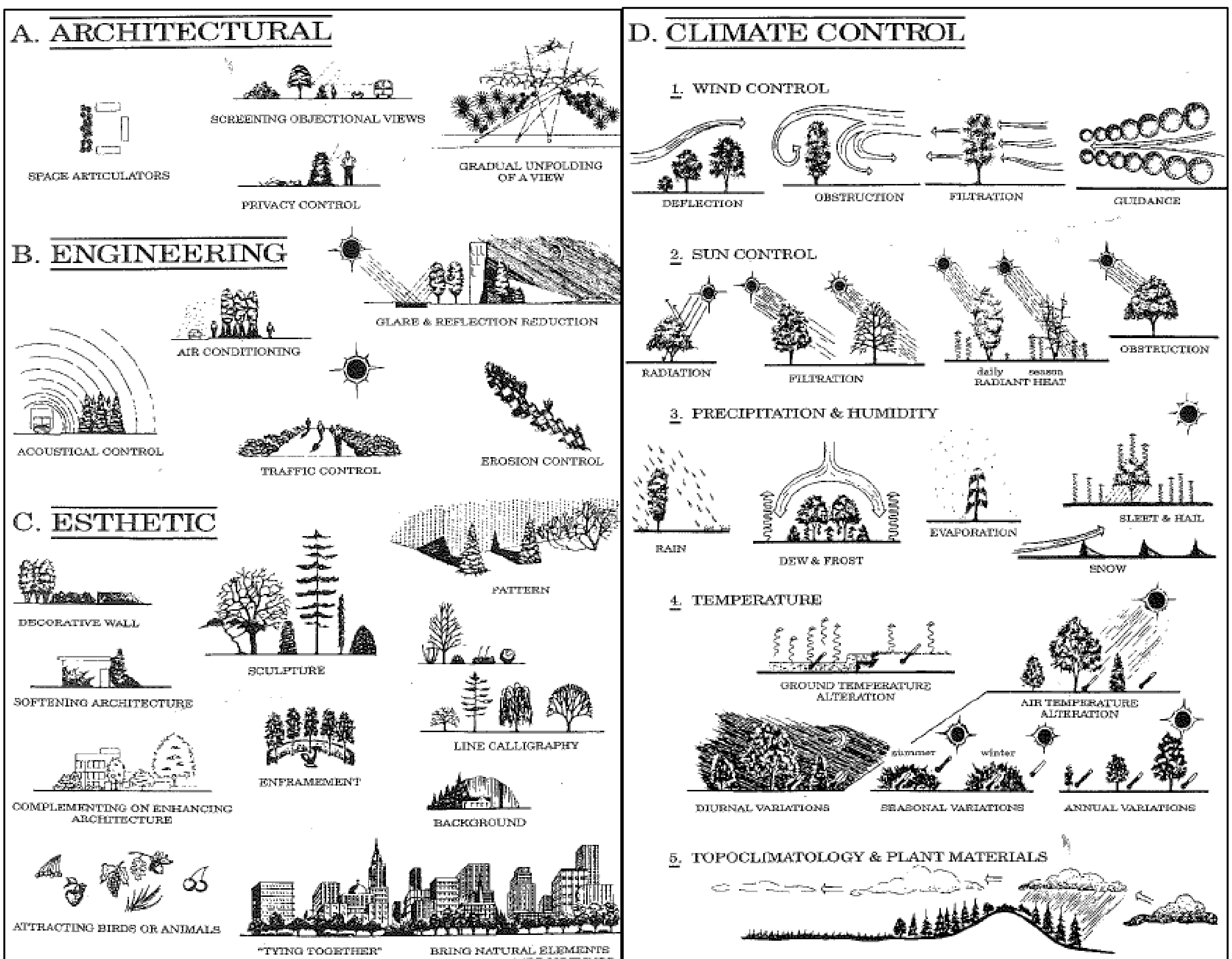

Figure 1: Illustration of some functional uses of plants in landscapes. Source: *Guide for Plant Appraisal 9th Edition*

The appraisal value is adjusted by location factors. Tree site, contribution, and placement were evaluated on a 0-100 point scale. The value for Site is reflected in the relative market value for the area in which the site is located. For example, a well-manicured residence would typically receive a higher site rating than the median of a four-lane highway. Contribution rating is determined by the plant's functional or aesthetic characteristics (Figure 1). For instance, historic or rare species trees may receive higher contribution ratings, as might evergreen trees planted as a privacy screening. Placement rating is a determined by how effective a plant is at providing its functional or aesthetic benefits. A tree that bears messy fruits placed directly adjacent to a sidewalk may yield a lower placement rating.

Tree species rating and size are also taken into account when determining the final appraised value. Species ratings typically reflect a particular species' suitability to the environment it is living in such as hardiness zone and preferred soil conditions (Figure 2) (Baley et al., 1993). Because species rating is adjusted on a given range, we decided to average the low and high ends of the range to come to an average species rating for each species. Gathering the necessary information to give a precise species rating for each individual tree appraised would be too arduous and time consuming considering the goals of this study. Tree size has a substantial influence on the tree's value and is typically reflected by the trunk area (TA) of the tree.

For trees greater than 30" in trunk diameter, the trunk formula method, an extension of the cost method, is used. Instead of the measured CBH, the adjusted trunk area (ATA) is used (Figure 3). The ATA concept is based on the premise that mature trees would not increase in value as rapidly as their trunk areas would increase (Allen et al., 2000). Past a certain point, trees reach economic and aesthetic maturity and increases in size do not necessarily correlate to an increase in value. For multi-stemmed trees, we used a method outlined in the CTLA guide (Figure 4), which uses an equation to combine the circumference of multiple circles (in this instance, trunks) into an equivalent diameter.

While there are a few different ways tree appraisal can be performed, we decided to use the cost approach, which is predicated on the assumption that the total value of a property can be derived by subtracting the cost to repair or replace the landscape plants. This method is useful when assessing the cost to replace or repair individual trees. We proceeded with the replacement cost method to find the appraised value of Penn's landscape trees. The appraised value is based on the cost associated with replacing a tree of the same or similar size in the same place.

Figure 2: Factors to considering when assigning species or cultivar rating. Source: *Guide for Plant Appraisal 9th Edition*

Climate adaptability	***Soil adaptability***	***Growth characteristics***	***Resistance or tolerance***
Cold hardiness	Structure and texture	Tolerance of difficult sites	Diseases
Frost tolerance	Drainage	Vigor	Insects
Drought tolerance	Moisture deficiencies or excesses	Structural strength	Air pollution
Storms, resistance to ice, snow wind	Acidity and alkalinity	Life expectancy	
	Nutritional deficiencies or excesses	Pruning requirements	

The installed plant cost is found first and includes the price of the most commonly available wholesale tree of reasonable size. For this project, we standardized a replacement caliper size of 3" for all trees (Figure 5). We accumulated wholesale prices for five different nurseries from various years between 2014-2017 and found the average price for each tree species at 3" caliper. The average price for replacement trees at 3" caliper was used for each appraisal. The planted cost multiplier was set at 2.5 to account for planting labor and potential site preparation/stump removal.

The replacement cost is determined by multiplying the price of the wholesale tree by the planted cost multiplier. The basic price of the replacement tree is the dollar value per square inch of trunk volume. The difference in trunk area between the replacement tree and the tree being appraised is multiplied by the basic price of the replacement tree to determine the value reflected in size difference between the appraised tree and replacement tree. This number is then depreciated by the species rating. After the species rating is considered, the replacement cost is

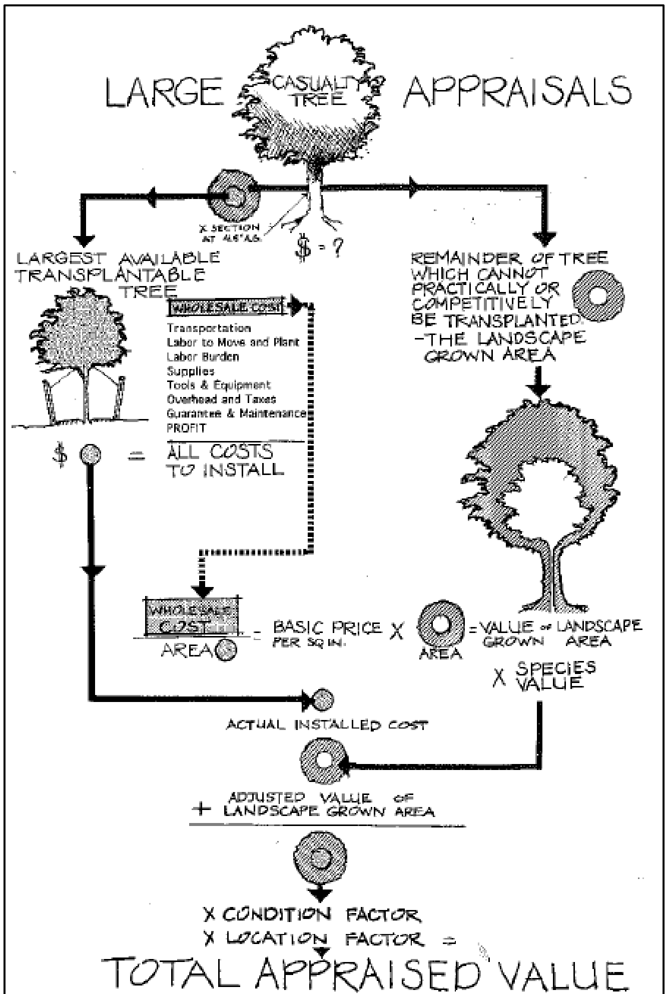

Figure 3: Illustration of how the Trunk Formula Method is used to appraise large trees. Source: *Pennsylvania and Delaware Tree Species Rating and Valuation Guide*

added in to yield the basic value of the appraised tree. Finally, the basic value is depreciated by condition and location factors and then rounded to the nearest hundred dollar to arrive at a final appraised value for the tree in question (Figure 5). All data were entered and calculated using a Microsoft Excel spreadsheet.

RESULTS AND DISCUSSION

The final appraised value of the sample was approximately $530,400 dollars. Extrapolating this figure to 6,700 trees indicates that the total tree population on Penn's campus has an appraised value of approximately $12.6 million dollars[1]. However, the actual appraised value likely falls between the range of $11.3 and $13.9 million dollars.

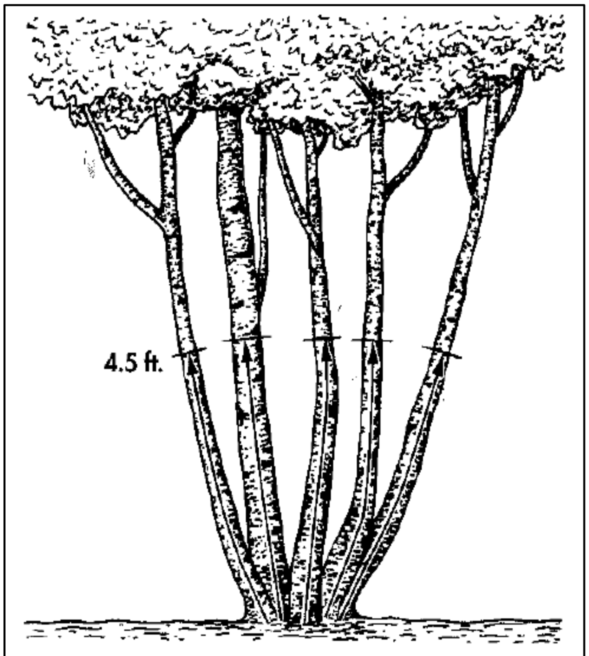

Figure 4: Illustration of method used to assign a DBH value to a multi-stemmed tree. Source: *Guide for Plant Appraisal 9th Edition*

The environmental benefits model run by i-Tree Eco indicated that our sample provides an estimated $6,779 dollars in environmental and ecosystem services annually, or about $161,000 for the entire campus population. Looking more closely at this figure reveals that carbon storage accounts for approximately $151,000 dollars, carbon sequestration accounts for $4,600, storm water management accounts for $5,500. However, because we only collected data on species and DBH, the minimum data required to run a model in i-Tree Eco, our results are not as accurate as possible. For this reason, we should treat these values as rough figures. Because we did not collect data on more specific metrics such as canopy spread and height, we were not able to assess the value of other environmental services like pollution mitigation potential. Also, because we did not include a specific spatial component in the i-Tree model, we were not able to calculate building energy savings. Therefore, the values described here are an underestimate of the actual savings and benefits of trees on Penn's campus.

Both the appraised values and values generated by i-Tree Eco should serve as a baseline comparison to be continuously updated in the future. In this way, the spreadsheet generated by this project serves as a living document that can be easily used for various analyses that will inform future tree care objectives. By tracking how the appraised and environmental service values change over time, we can monitor how well plant health care and protection programs are being implemented on Penn's campus. Additionally, when considering that the environmental benefits figure has the potential to increase exponentially as trees mature and increase in size, proper tree care and maintenance becomes a higher priority.

It is our intention that this research be used to advocate for more effective natural resource management at Penn. We hope these findings will ultimately be used to establish and

---

[1] The 10th edition of the Council for Tree and Landscape Appraisal's (CTLA) Guide to Plant Appraisal was published following the conclusion of this project. Some of the methods involved in the cost approach have been changed or removed in the most recent edition, so this figure may need to be updated.

enforce tree protection and preservation protocols on campus. Realizing the monetary value of a healthy urban forest with supporting data provides a strong financial incentive to invest in green infrastructure for the long-term benefit of the Penn campus community. In the future, including visual aids such as interpretative signage on or around trees that mentions their appraised value and environmental benefits, may assist in educating the Penn and greater Philadelphia communities about the importance of trees in urban environments.

Figures are inputted into the boxes

Assessor:	**Joe D. Arborist**		
Tree name:	**Katsura**		
Tree Location/Owner:	**Wherever, USA**		
Date:	**whenever**		
			Units
	Replacement caliper Size	3	inches
	Replacement Wholesale Price	$264.00	Dollars
	Planted cost multiplier	2.5	a number
	Equivalent Circumference of the Appraisal Tree at 4.5 feet	25.0	inches
	species rating	95	per cent
	condition rating	95	per cent
	site rating	80	per cent
	contribution rating	90	per cent
	placement rating	85	per cent
	1. **Replacement Cost**: Largest transplantable tree	$660.00	dollars
	2. **Basic Price** of replacement tree	$37.35	$/in^2
	3. Difference in trunk areas of appraised & replacement trees		
	A. Appraised tree trunk area (TA or ATA)	50.1	in^2
	C. Replacement tree trunk area ($^{TA}{}_{R}$)	7.1	in^2
	D. Difference in trunk areas	43	in^2
	4. Multiply **Basic Price** difference in trunk areas	$1,608	dollars
	5. Adjust Line 4 by **Species** rating	$1,528	dollars
	6. Basic Value	$2,188	dollars
	7. Adjust Line 6 by **Condition**	$2,078	dollars
	8. Adjust Line 7 for **Location**:	**$1,767**	dollars
	Location = (**Site**+**Contribution**+**Placement**)		
	9. **Appraised Value** = round line 8 to nearest $100	**$1,800**	dollars

Figure 5: Detailed breakdown of process to calculate appraisal value.

The data used in the appraisal process is saved under the file name "Eric_Moore_UPenn_Tree_Appraisal_2018" in the folder S:\Morris\PublicPrograms\ArboriculturalConsulting\UF Intern Files\Eric Moore.

REFERENCES

Allen, E.N.; Bloch. L.B.; Gooding R.F.; Harris R.W.; Ingram J.B.; Steigerwaldt W.M.; Urban, J.R. (2000). *Guide for Plant Appraisal 9th Edition*. Council for Tree and Landscape Appraisers. International Society of Arboriculture.

Baley, L.; Carlson, R.E.; Graham, A.W.; Ward, J.B. (1993). *Pennsylvania and Delaware Tree Species Rating and Valuation Guide.* Tree Valuation Committee of the Pennsylvania-Delaware Chapter of the International Society of Arboriculture.

Bassett, C.G. 2015. *The environmental benefits of trees on an urban university campus.* University of Pennsylvania, Master of Environmental Studies

i-Tree Eco. i-Tree Software Suite v6.x. (n.d.). Retrieved April 20 2018, from http://www.itreetools.org/resources/man ... ual_v5.pdf

Jonathan Alderson Landscape Architect Inc. 2017. Ecological Landscape Stewardship Plan. *University of Pennsylvania*

Morton Arboretum Arbnet. 2018. Levels of Accreditation. http://www.arbnet.org/accreditation/levels-accreditation

Wachter, S. 2004. The Determinants of Neighborhood Transformation in Philadelphia: Identification and Analysis: The New Kensington Pilot Study. *University of Pennsylvania, Wharton School*.