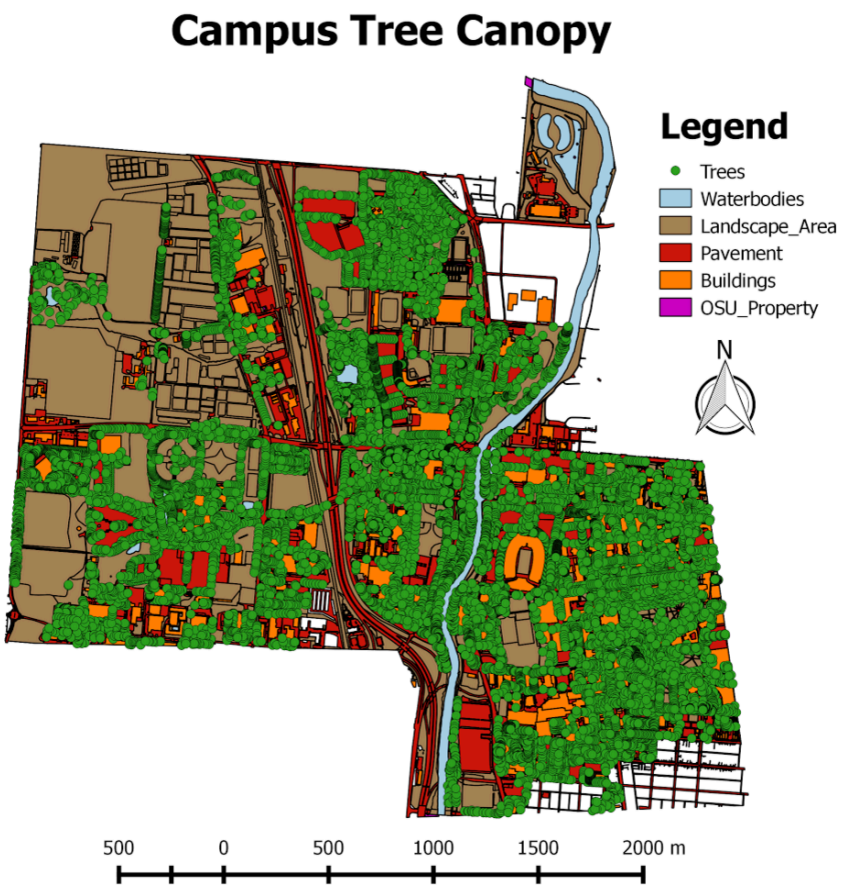

Buckeyes for Buckeyes: Increasing the Tree Canopy on The Ohio State University's Main Campus

Anna Koontz, Anna Madrishin, Kennedy Kowalski, Veronica Havran-Vena, Ryan Ludwig

AEDECON 4567 Capstone Course Final Report

April 26, 2016

Tree Canopy Inc.
127 E 13th Ave
Columbus, OH
43201

Table of Contents

I. Executive Summary

This semester, our team sought to help The Ohio State University reach its sustainability goals as developed by the President and Provost's Council on Sustainability in 2015. We have chosen to research and develop a plan to implement Resource Stewardship Goal 7d, which seeks to double the tree canopy, increase multifunctional and productive acreage by 10% and reduce maintained acreage by 2025. Our research objectives were fourfold and required analyzing the existing tree inventory, identifying Ohio State's future development plans, developing an implementation plan, and deciphering the costs and benefits of such a project. These objectives guided our project and provided us with a sequential progression of tasks that built off one another.

Through the use of The City of Columbus' Tree Canopy Planner tool, we found that Ohio State's current tree canopy cover is 13% of its total land area. We also found that the maximum tree canopy coverage that can occur without planting in impervious surfaces is 24%, which falls just short of the needed 26% for doubling. For this reason, we have revised Resource Stewardship Goal 7d from requiring a doubling of the tree canopy to simply maximizing its full potential. In order to maximize the tree canopy to 24% coverage, Ohio State needs to plant between 3,843 and 15,645 trees. This range is based on the average crown diameter of the tree mix that is ultimately chosen, as the raw number of trees planted and relative increases in tree canopy are not equivalent. In fact, the same tree canopy goal can be met by either planting many small trees or fewer large trees. The number and mix of trees ultimately chosen will be based on percent tree canopy increase, but can vary based on the crown diameter chosen. Overall, our team found that the benefits of increasing the tree canopy outweigh the costs in all scenarios. Because of the declining age class of Ohio State's tree canopy, we have found that a policy

change with regards to how Ohio State views trees on campus would be most valuable in both increasing and maintaining the tree canopy. This policy is important because both the age complexion and average tree size of the campus tree canopy are decreasing each year with extraction, as are the benefits derived.

II. Introduction: The Importance of Trees

Our overall research goal is to "double the tree canopy, increase multifunctional and productive acreage by 10% and reduce maintained acreage by 2025," in accordance with Ohio State's sustainability goals. For the purposes of this report, our team focused primarily on the first part of this objective, which involves increasing the tree canopy. Our team goal is to help Ohio State reach this in an economically efficient manner, while also considering the nonmonetary benefits of trees. Our research objectives are divided into four separate parts:

I. Analyze the existing tree inventory
II. Identify future Ohio State development plans and underutilized areas on campus
III. Develop an implementation plan and funding sources
IV. Determine overall costs & benefits

Our purpose in performing this research is to assist Ohio State in developing a framework that will help to increase the tree canopy to meet the canopy cover goal of their choosing. This will increase aesthetic and use value, boost energy savings, decrease maintenance costs, and help sequester carbon. Accomplishing this goal will help to raise the prestige of the university in the campus sustainability world, provide a stream of benefits for years to come, and specifically fulfill Resource Stewardship Goal 7d via effective resource management.

Through our research, we found that while Ohio State's goal of doubling the tree canopy was nearly viable, it overestimated the amount of campus available for planting by about 2% of the total land area. This caused us to revise the goal to maximizing (24%) the tree canopy versus

doubling it (26%). In order to meet this new goal, Ohio State should consider changing their policy regarding tree preservation and planting. The new policy should stress the importance of maintaining mature trees on campus. Over the last few decades, there has been a decrease in mature trees throughout the campus in order to meet the space demands of the growing university, as illustrated by Figure I in the Appendix. This decline is detrimental to the campus tree cover and campus community alike because of the comparatively large benefits extracted from mature trees, which are illustrated in Figure II in the Appendix. It is commonly accepted that benefits generated from trees often become significant at age twenty-five (Sydnor, 2014). According to Mary Maloney, the Director of Ohio State's Chadwick Arboretum, the university often cuts trees down before they can reach age seventeen. This is a significant issue that our project seeks to address. In order to maximize the tree canopy at Ohio State by 2025, we must make significant strides in planting more trees in designated areas on campus, while maintaining and placing an importance on the current mature canopy.

III. Research Objectives

IIIa. Methods

The methods we used in our research were based on the requirements of each objective. For research objective I, which involved analyzing the existing tree canopy, the primary method used was The City of Columbus' Tree Canopy Planner tool to obtain our baseline data. This tool uses remote sensing data from The City of Columbus to calculate the percentage of current tree cover and the percentage of possible planting area. Based on this tree cover data, the tool allows for the creation of different planting scenarios, and gives the number of trees needed to reach the desired canopy coverage percentages. We also used Chadwick Arboretum's tree inventory system and iTree to compile all available tree data. This data included tree type, amount of trees

per type, and location. For objective II, which involved identifying future Ohio State development plans and underutilized areas on campus, we referenced Framework 1.0 and Framework 2.0 as released by Ohio State Planning and Real Estate. Framework 1.0 and 2.0 represent Ohio State's future development plans. We then used QGIS to identify open space and compile a map of suitable tree planting areas that avoided future areas of development. For objective III, which sought to develop an implementation plan and a source of funding, we relied on our contacts for inspiration and came to the conclusion that a policy change would be most valuable for increasing the tree canopy. As part of this step, we also performed a literature review and case studies of Indiana University, University of Connecticut, University of Michigan, and Clemson University, as these are campuses of similar size that have tree management plans. Finally, for objective IV, which seeks to decipher impacts to the university in the form of costs and benefits, we referred to T. Davis Sydnor and Sakthi Subburayalu's 2011 report, *Environmental Benefits Analysis of Trees for The Ohio State University, Columbus Campus*, and cost information divulged in Ohio State's Tree Campus USA submission and documents from Tree Campus USA Advisory Team meetings.

IIIb. Data Collection & Analysis

Our data collection, as described under section IIIa, involved a review of various reports, the use of inventory databases, and interviews with important contacts. The information extracted from these sources is available in the attached Appendix. Our quantitative data analysis took place in QGIS and Microsoft Excel.

IIIc. Data & Findings

The following data will be presented by objective. For objective I, the data collected involved a Microsoft Excel file (in Appendix as Dataset #2) containing the tree inventory on

campus, which was then translated into Figure III in the Appendix. This illustrates the species diversity of the canopy. Figure IV, which is also attached in the Appendix, represents the data extracted from The City of Columbus' Tree Canopy Planner tool. This data served as our baseline data for further analysis. We also found the number of trees needed to reach the 24% planting goal with this tool. In fact, 15,645 trees would need to be planted if trees with a 20-foot average crown diameter were planted, and 3,843 trees would need to be planted with a crown diameter of 40 feet.

With regards to objective II, our analysis of Framework 1.0 and Framework 2.0, as well as QGIS analysis, led us to create a map with highlighted possible planting areas. We then totaled the highlighted area using QGIS applications, which equaled 1,046,918 square feet. This map is presented in Figure V in the Appendix. Although we believe these areas are suitable, they are simply a suggestion to Ohio State.

Our data for objective III was more qualitative when compared to the other objectives. This step, which sought to find a way to actually implement a tree canopy increase on campus, focused on a literature review of similar campuses with generally successful campus tree canopy plans. We chose to analyze these Tree Campus USA universities with regards to four parameters: community value of trees, clear penalty for damages, a construction management policy, and an easily accessible, practical tree canopy goal. In Figure VI, a green checkmark represents the successful implementation of the selected parameters, while a yellow triangle means the parameter is mentioned or acknowledged, but has partial or failed implementation. This triangle can also mean the parameter is not feasible for the university's current situation. A red "x" means that this parameter is lacking or fails to be mentioned in the campus tree policies reviewed.

Figure VI: University Case Study Comparison of Tree Canopy Policies

University	Tree Campus USA	Construction Policy	Community Value	Penalty for Damages	Tree Canopy Goal
Ohio State University	✓	Δ	✗	✗	Δ
University of Michigan	✓	✓	✓	✗	✓
Clemson University	✓	✓	✓	✓	Δ
University of Connecticut	✓	Δ	✓	✗	✓
Indiana University	✓	✓	✓	Δ	✓

This literature provided the team with a multitude of information on best management practices. It is clear that campuses with successful tree management plans have multifaceted, multi-tiered policies. The intrinsic value placed on trees by the campus community, as well as the enforcement of damage penalties, both play key roles in the success of campus management plans. Because Ohio State is lacking in these categories, this case study led us to consider the possibility of a new policy proposal to maintain and increase the tree canopy. The new proposed policy consists of two main components: accountability for construction projects, and changing the campus culture of tree management. With regards to the construction component, the new policy would outline clear penalties and fines for removal or accidental destruction of trees for which the contractor would be held responsible. Likewise, if a tree was planned for removal during construction, a tree (or trees) of equal or greater value must be planted to offset the removal. Since such replacements are difficult to accomplish, this should deter the removal of many trees, especially those of mature age. Building remodel projects would also have to take place within the existing footprint of the building to mitigate damage as much as possible. The second component involves changing the campus culture and the general perception of trees. As

of now, trees seem to be viewed as replaceable entities when they should actually be valued as assets to the campus for the many benefits they provide. In fact, according to Mary Maloney, the Director of Chadwick Arboretum, trees are the only form of infrastructure that actually appreciates in value as time progresses. Instead of being viewed as obstacles to development, trees should be valued for the monetary and nonmonetary benefits they provide. Overall, this policy change would promote the creation of a campus culture that sees trees as permanent infrastructure.

Objective IV focuses on the quantitative analysis of the costs and benefits of such a project. Using both 20 and 40-foot average crown diameters, we found the number of trees necessary to maximize the tree canopy using The City of Columbus' Tree Canopy Planner tool. We used these numbers to calculate the costs and benefits of each planting scenario. On average, each tree contributes about $81.17 per year of benefits according to T. Davis Syndor and Sakthi Subburayalu's research (Sydnor & Subburayalu, 2011). For the purposes of this analysis, benefits are comprised of carbon sequestration, energy savings, air quality improvements, aesthetics, and rainfall interception (Sydnor & Subburayalu, 2011). Yet, the benefits calculated assume that the trees will reach the mature age of at least twenty-five years old. As previously stated, this seldom occurs at Ohio State, and most trees are removed long before this. We then calculated the yearly planting costs that Ohio State would incur until 2025 when the planting initiative is intended to reach its goal. This calculation was based on the cost of Ohio State's past planting in 2014, which is around $111 per tree ("The Ohio State University Campus Tree Care Plan", 2014). The maintenance cost, which was $22.59 per tree annually, was calculated in the same manner, as data was available for the university's maintenance costs from 2011 (Sydnor & Subburayalu, 2011). Both of these cost values were inflated to 2016 dollars. Our results indicate that the

benefits of the proposed project outweigh the costs significantly in both scenarios explored, as illustrated by Figure VII below.

Average Crown Diameter	# of trees planted (by 2025)	Annual Benefits	Annual Planting Costs (Until 2025)	Annual Maintenance Costs	Annual Total Costs	Annual Net Benefits
20 feet	15,645	$1,296,905	$173,833	$354,046	$527,879	$769,026
40 feet	3,843	$311,936	$16,988	$86,967	$103,955	$207,981

Figure VII: Cost-Benefit Analysis for Two Average Crown Diameter Scenarios

IIId. Research Barriers

Throughout the research process, our team encountered several barriers. First, we found that there was a lack of quantitative tree information available for us to use for the cost-benefit analysis portion of our project. We also had a difficult time finding baseline tree canopy data. We eventually had to turn to The City of Columbus' Tree Canopy Planner tool for this data. Furthermore, our project required knowledge of specific GIS functions. While we all have a rudimentary knowledge of the software, none of the group members were entirely proficient in QGIS. As a result, we relied on other students, faculty, and Internet manuals to help obtain our data. This took a significant amount of time and effort. Our research was also limited to information accessible online and published by other universities, such as Tree Campus USA reports, tree canopy care plans, and canopy increase plans. Some information used was also not completely up-to-date, and some helpful information was not made available to students, such as Ohio State's Tree Campus USA report that we obtained instead through our contacts. Finally, another primary barrier to research was conflicting views from leaders within the university concerning tree canopy plans. While some university individuals see trees mainly as an aesthetic

addition, others clearly think that trees should be incorporated into the existing infrastructure and become more permanent. Because of it this, we found ourselves conflicted with regard to the advice we were given. In summary, our research was limited by a lack of time, technical knowledge, and access to necessary information.

IV. Recommendations

IVa. General Recommendations for Ohio State

For Resource Stewardship Goal 7d to be reached, the university can either transform impervious areas or focus on increasing the tree canopy on satellite campuses to generate the final 2% canopy increase needed. If Ohio State feels that these two options are infeasible, the university can revise the goal to simply maximize the tree canopy to its full potential of 24%. Secondly, it is vital for mature trees to be maintained and cared for properly, especially during times of construction, since benefits are maximized as time passes. Our group recommends the university continue to focus on maintaining diversity by upholding the 10-20-30 rule depicted in T. Davis Sydnor and Sakthi Subburayalu's 2011 report, *Environmental Benefits Analysis of Trees for The Ohio State University, Columbus Campus*, and to make sure that all tree species are native to this area. The 10-20-30 rule ensures species diversity by requiring that the canopy consist of no more than 10% of any single species, no more than 20% of the same genus, and no more than 30% of the same family (Sydnor & Subburayalu, 2011). To aid in the aging of trees and to guarantee the growth of the tree canopy, the university should create a new tree policy based off leading universities' tree care plans. In the policy, persuasive diction needs to be utilized to express the importance of viewing trees as permanent infrastructure and to have clear penalties attached to tree destruction, as mature trees have significantly more non-monetary benefits than young trees.

An application to Ohio State's Sustainability Fund is currently being drafted, and after the application is submitted, the university needs to consider long-term, creative funding options, as funding is always an issue. One possibility is a "Buckeyes for Buckeyes" ticket program that would add a $1 fee to certain football tickets, and the proceeds would go towards maintaining and increasing the tree canopy. Matching the capacity of the stadium, this funding option has the potential to generate approximately $105,000 at each home game (Lesmerises, 2016). Unlike grants, this would be a sustainable source of funding. We have also discussed with our contacts other funding possibilities, such as taxing faculty and athletics travel for carbon emissions. The money from this "tax" would go to offsetting this carbon through tree planting initiatives. Whichever option is ultimately chosen, it should be innovative and effective, as Ohio State lacks funding for most aspects of its tree care and management. Many employee positions that deal with tree planning and management are paid for by private donors and are pre-approved yearly due to a lack of funding, and this makes Ohio State's tree planning and management plans vulnerable. Finally, we feel that Ohio State could increase the total net benefits provided by trees through a new tree management policy that could encompass all of our recommendations.

IVb. Action Prioritization for Ohio State

Going forward, Ohio State first needs to create and implement a stricter policy focusing on the relationship between development projects and mature trees. There is a direct correlation between a mature tree canopy and the benefits provided. These benefits can be sooner realized with a stricter policy. In order to maximize the canopy, the trend of development and construction on campus needs to view trees as permanent fixtures and adapt construction plans accordingly. Once this is implemented, changing the culture takes precedence in the tree canopy platform. In order to change the culture, transparency to students and faculty needs to be

increased regarding the benefits provided by an increasing tree canopy. Indiana University Bloomington's ex-President Herman B. Wells took the initiative to change the culture surrounding trees by describing every tree as sacred and penalizing indiscriminate actions towards trees ("Indiana University Bloomington Campus Tree Care Plan", 2011). Ohio State's athletic department has the ability to increase campus knowledge and change culture by agreeing to implement the Buckeyes for Buckeyes funding option. Buckeyes for Buckeyes, or any other feasible, innovative source of funding, should be prioritized by the university, not only as a source of funding, but also as a means to educate the students and faculty alike about the benefits a mature tree canopy generates. A way to incorporate education into this initiative would be the inclusion of facts on the football tickets themselves about the benefits of increasing the tree canopy and maintaining mature trees on campus. Lastly, throughout implementation, invasive species should be avoided and the tree canopy's diversity upheld. If Ohio State focuses on these sequential recommendations, the success of the tree canopy should increase. Regardless of overall results, Ohio State should focus on implementing a stricter tree policy first.

With regards to the other sustainability goals Ohio State has expressed interest in achieving, we feel that increasing the tree canopy should be a priority due to the associated benefits that come with such an action. Besides the benefits we have included in our calculation (energy savings, runoff interception, carbon sequestration, air quality improvements, and aesthetic value), increasing the tree canopy would provide Ohio State with a degree of prestige within the campus sustainability world. This, coupled with the fact that trees provide a stream of benefits and actually appreciate in value over time, indicates that Ohio State should prioritize this goal, as it is a great investment for the university in the long run. Likewise, Ohio State should also prioritize this goal because it has the potential to assist the accomplishment of other

interrelated goals, such as achieving carbon neutrality (goal 7a) and reducing energy consumption (goal 7b). Goal 7d could help accomplish goal 7a through sequestering and offsetting carbon, and could help Ohio State move towards reducing energy consumption through shading buildings.

IVc. Distribution of Costs & Benefits

Our team analyzed the costs and benefits associated with our suggested tree planting numbers to better understand the project's funding needs and the value of the tree canopy. The benefits provided by the campus tree canopy range from important ecosystem services, to energy savings and social value. The associated costs of the tree canopy are the initial purchasing and planting costs and the annual maintenance. The calculation of these costs and benefits are discussed in Section IIId and are shown in Figure VII.

As previously mentioned, it is critically important to note that trees need to reach twenty-five years of age in order to retrieve the maximum benefits (Sydnor, 2014). On average, trees at Ohio State are removed years before they reach this age. This should signify a problem with the policies surrounding tree preservation and university development and policies regarding tree removal. It is clear that careless removal of trees for construction projects is costing the university money in the long run. If trees are planted and maintained but removed before the return on investment can be realized, the university is spending money planting trees that will provide little benefit in their short lives. In this way, the costs are being wasted before the true benefits are realized.

If Ohio State were to allow trees to reach a mature age, the benefits of any of the tree planting scenarios explored in this report would certainly be worth the costs. For example, the average benefit per year per tree is $81.17 on Ohio State's campus (Sydnor & Subburayalu,

2011). This is based on the average size of the trees on Ohio State's campus. However, mature trees exhibiting larger diameters provide greater benefits over time. For example, an American Sycamore generates about $270 in benefits per year (Sydnor & Subburayalu, 2011). This indicates that if Ohio State were to plant larger trees and let them grow, the stream of benefits would be even greater. However, even when using the modest average annual benefit estimate of $81.17 per tree for our calculation, the final benefits far exceed the costs of the proposed project. This was also true of a small series of case studies conducted across Ohio by Emeritus Professor T. Davis Sydnor. In each of Sydnor's reports the return on investment was 200-300% (Sydnor & Subburayalu, 2011). Again, for these benefits to be fully realized and the costs of planting and maintenance to be worth the investment, trees must be allowed to grow to maturity. As previously stated, trees are the only infrastructure on campus that actually appreciate with regards to the value of benefits extracted over time, unlike buildings and roads. This distribution of benefits is illustrated by Figure II in the Appendix and is one of the main reasons that Ohio State should consider the aforementioned recommendations.

IVd. Limitations of Analysis

One major limitation to our analysis was the pressing time constraints of a semester project. In the time frame we had to complete the project, there were vast amounts of research tasks to complete. This led to a narrowing of our scope in order to achieve results in the time frame of the semester. Because of this, we decided to limit the scope of our project only to Ohio State University's Main Campus, as it would be too difficult to find accurate and up-to-date information about all the regional campuses and analyze their tree care policies as well. Since one of our recommendations is for Ohio State to look to satellite campuses to fulfill the initial goal of doubling the canopy, it would be very helpful if we could access and analyze this data.

We simply did not have the time to do so, and satellite campus tree inventories are substantially lacking.

Our results were further limited by technical information gaps. At first, we thought we could pick specific tree species, place them in one of the designated tree areas, and assign them benefits using iTree. This would give Ohio State a very detailed and valuable tree plan that could be easily followed. However, our team found that we did not have the technical knowledge of tree species' needs and could not perform this analysis. Even if we did have this type of specific knowledge, it would take a significant amount of time to perform this, and Ohio State would likely need to hire a dendrologist to perform such a task. Overall, our main limitations of analysis were different from our research barriers in that they limited the scope and scale of the research tasks performed.

IVe. Recommendations for Further Research

Our main recommendation for further research on this important topic is for Ohio State to perform baseline tree canopy analysis at satellite campuses. This would involve calculating the current tree canopy and the maximum planting area of these campuses. This would give the university an idea of where the final 2% of the canopy increase could be planted and would help further our team's research. We would also recommend that a dendrologist or tree-planting specialist research and choose specific, appropriate tree types for planting on both Main Campus and satellite campuses.

With specific regard to goal 7d, the scope of our research consisted mainly of how to simply increase the canopy all around, and did not focus as much on the second part of the goal, which involves increasing multifunctional and productive acreage by 10% by 2025. Further research will need to be conducted to see what areas of the campus can be transformed into

multifunctional areas. This may include creating a learning garden focused on growing plants and trees that can be observed and studied by students in forestry courses or a multipurpose adventure/leadership center that contains a ropes course centered around the trees themselves. Likewise, reduction of maintained acreage will require an additional change in campus culture, where decreased maintenance is seen as acceptable. In addition to a culture change, research will need to be conducted to identify plants that require less maintenance and are able to survive in the local climate.

Our final recommendation for further research is to decipher the mental health benefits of trees, which are not fully expressed by the monetization of aesthetic values. The inclusion of these health benefits has the ability to make a tree planting initiative even more worthwhile since it will raise the annual non-monetary benefits per tree. According to Berman et al. (2008), several studies at the University of Michigan "demonstrate the restorative value of nature as a vehicle to improve cognitive functioning," (p. 1211). In this study, students who took a fifty-minute walk through Ann Arbor Arboretum experienced an improved mood and could recall a digit sequence faster than those who did not participate in the walk (Berman et al., 2008). Similarly, in a study of 145 urban public housing residents, Kuo (2001) found that "green space enhances residents' effectiveness by reducing their mental fatigue," (p. 5). While there is evidence to support the consideration of the mental health benefits of trees, these benefits are not often included in cost-benefit analysis. The addition of such benefits in these calculations could be particularly useful at the university level, where stress, mental illness, and a lack of access to mental health services due to a growing number of students are all too common (Kitzrow, 2003).

V. Conclusion

The research provided by this report analyzed the current status of the Main Campus tree canopy and outlined a proposed approach to accomplishing Research Stewardship Goal 7d. It was suggested by this report that the goal be revised from doubling the canopy to maximizing it based on data collected from The City of Columbus Tree Canopy Planner tool. Otherwise, the university should either look to satellite campus planting initiatives, or consider replacing parking lots and other impervious surfaces with tree areas to reach the initial goal. In order for Ohio State to reach whichever goal it ultimately chooses, it is proposed by this report that the university develop a comprehensive policy which encourages the growth of the tree canopy, prioritizing and protecting mature trees from the expanding development of the campus' built environment. Trees are an important infrastructural component to the campus and the surrounding community, as they are one of the only components that appreciates in value over time. As trees age, their benefits increase, and our research indicates the importance of leaving mature trees rooted in the ground to maximize their return on investment.

In order to develop and build the natural infrastructure provided by the tree canopy, our team dedicated a portion of its research towards identifying suitable planting locations through the use of GIS. Our work towards this objective is simply a suggestion and further analysis by specialists would improve the accuracy of proper site locations. All of the research results regarding the costs and benefits of our project, as well as other canopy assessment reports, indicated large returns on investment and noted the importance of preserving mature trees.

One of most the prominent findings from our team's research was the need to develop a sustainable funding mechanism that would help relieve management stress and ensure a stable source of funding for the tree canopy. We developed a concept for a funding mechanism called

Buckeyes for Buckeyes that would add $1 to select football game ticket prices to raise money for the tree canopy. It was concluded that this program could potentially deliver $105,000 per game and would be a sustainable source of funding.

The campus tree canopy is a valuable asset in terms of the benefits that it provides to the university, which include storm water mitigation, energy savings, air quality improvements, landscape aesthetics, carbon sequestration, etc. Simply planting more trees to expand the canopy is not a sustainable or viable solution. For this reason, it is imperative to not only plant more trees, but to preserve the mature tree population as well. Developing a preservation policy for the canopy and a sustainable funding program would be a valuable endeavor for the university. Yet, the limitations of our team's research capabilities and time constraints for this report made it difficult to fully develop all the details of our extensive recommendations, which include a tree preservation policy, accurately identifying planting locations using GIS, a complete cost-benefit analysis, and the establishment of a sustainable funding mechanism. The final recommendation of this report is that Ohio State uses our study as the foundation and framework for further research to extend ideas and accomplish all parts of Research Stewardship Goal 7d outlined in the University Sustainability Goals. We feel that our report substantially illustrates the many benefits of achieving such a goal, as this would truly be a worthwhile investment if Ohio State allowed the trees to reach their full potential. If the tree canopy increased, not only would the prestige of Ohio State's campus increase, but campus itself would also be a better place to work, live, and study.

VI. References

Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychological science*, *19*(12), 1207-1212.

Campus Forest Management Plan (pp. 1-22, Rep.). (2011). The University of Michigan Plant Building and Grounds Service.

Indiana University Bloomington Campus Tree Care Plan (pp. 1-42, Rep.). (2011). Indiana University.

Kitzrow, M. A. (2003). The mental health needs of today's college students: Challenges and recommendations. *NASPA journal*, *41*(1), 167-181.

Kuo, F. E. (2001). Coping with poverty impacts of environment and attention in the inner city. *Environment and behavior*, *33*(1), 5-34.

Lesmerises, C. D. (2016). Ohio Stadium will have a new capacity, is the Buckeyes' football home the right size? Retrieved March 26, 2016, from http://www.cleveland.com/osu/index.ssf/2016/03/ohio_stadium_will_have_a_new_c.html

Main Campus Urban Forest and Landscape Management Policy (pp. 1-6, Rep.). (2011). Clemson, SC: Clemson University Urban Forest Management.

The Ohio State University Campus Tree Care Plan (pp. 1-10, Rep.). (2014). Ohio State Campus Why Trees Matter Committee.

Sydnor, T.D. (2014). Fruits of Ohio State's "No Net Loss of Trees" Policy (1997-2013). [Presentation]. Research presented to Ohio Agricultural Research and Development Center. Wooster, OH.

Sydnor, T. D., & Subburayalu, S. (2011). Environmental Benefits Analysis of Trees for The Ohio State University, Columbus Campus (Rep.). Columbus, OH: The Ohio State University School of Environment and Natural Resources.

University of Connecticut Campus Tree Care Plan (pp. 1-74, Rep.). (2014). Storrs, CT: University of Connecticut.

VII. Appendix

VIIa. Figures

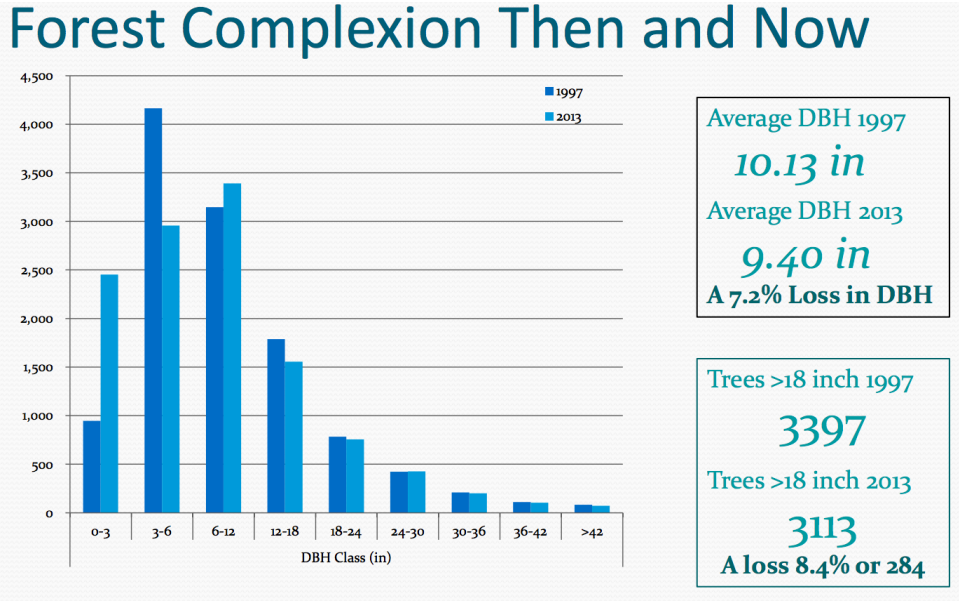

Figure I: Sydnor, T.D. (2014). Fruits of Ohio State's "No Net Loss of Trees" Policy (1997-2013). [Presentation]. Research presented to Ohio Agricultural Research and Development Center. Wooster, OH.

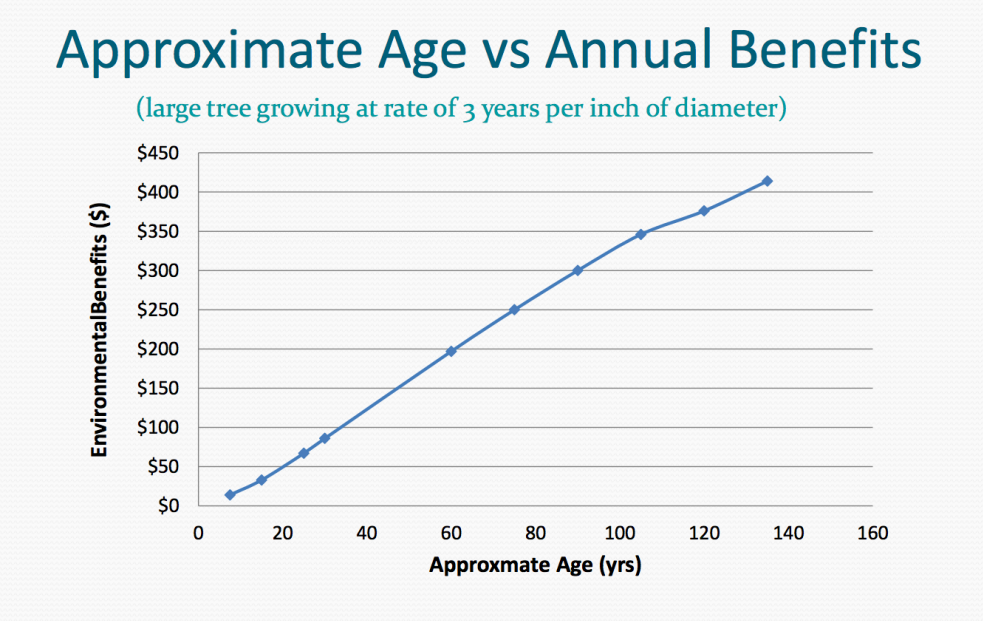

Figure II: Sydnor, T.D. (2014). Fruits of Ohio State's "No Net Loss of Trees" Policy (1997-2013). [Presentation]. Research presented to Ohio Agricultural Research and Development Center. Wooster, OH.

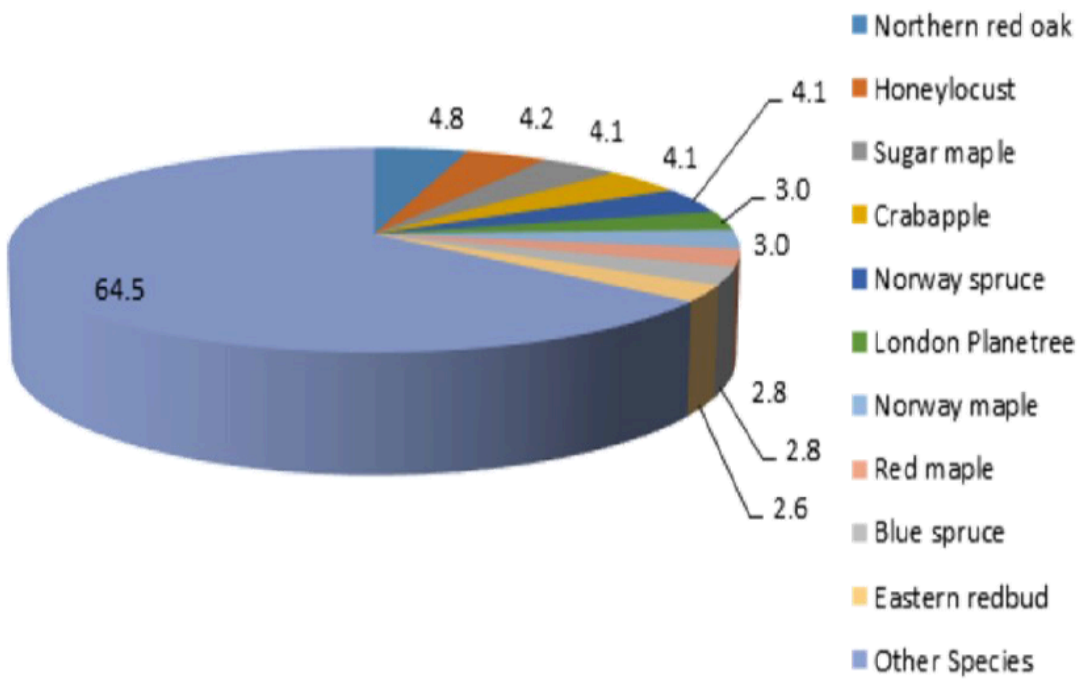

Figure III: Campus Species Diversity Compiled from iTree

Neighborhoods	
Neighborhood: The Ohio State University	**Value**
Percent Urban Tree Canopy	13%
Possible Planting Area Impervious	26%
Possible Planting Area Vegetation	24%
Possible Planting Area Total	50%

Figure IV: Baseline Data from The City of Columbus' Tree Canopy Planner Tool

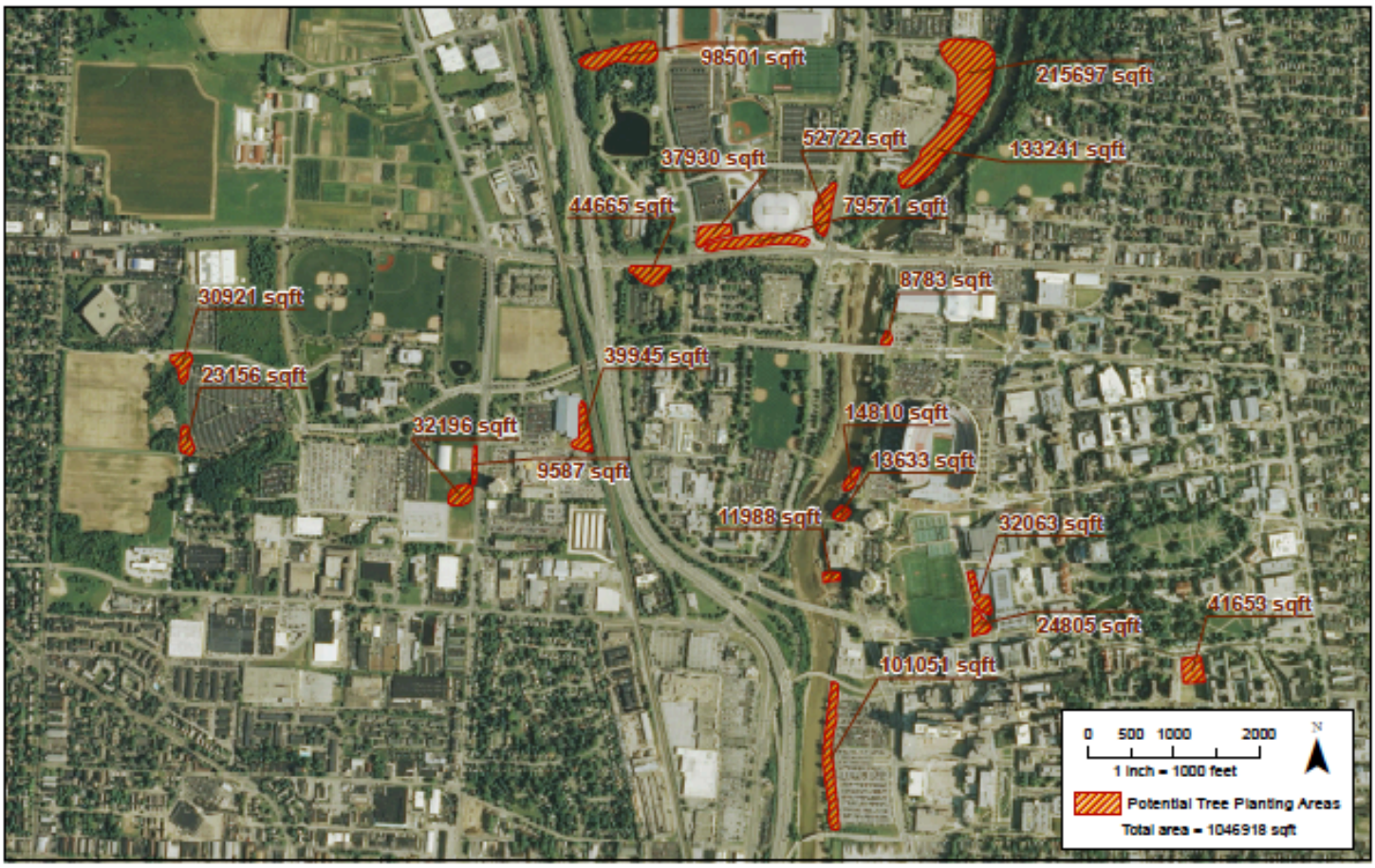

Figure V: Possible Planting Areas

VIIb. Datasets

Dataset #1: interview_notes.docx

Sources: In-person interviews with Steve Volkmann, Steve Schneider, Erin Miller, Christina Voise, Larisa Kruger, and Mary Maloney

Description: This dataset is a compilation of the information extracted from many interviews over the course of the semester. These interviews informed all of our decisions with regards to our objectives and recommendations.

Dataset #2: tree_types.xls

Sources: iTree and Chadwick Arboretum's tree inventory system

Description: This dataset is a compilation of the current types of trees on Ohio State's campus. We used this data to create Figure III.

Dataset #3: campus_trees.shp

Sources: Chadwick Arboretum's GIS inventory system

Description: This dataset is a QGIS shapefile of the current trees on campus. We used this to compile the map on the cover page, and to get a general sense of where most open areas that could harbor future trees were located.

Dataset #4: framework1.pdf, framework2.pdf

Sources: Ohio State's Department of Planning and Real Estate

Description: This dataset represents Ohio State's future development plans. We referenced it when making planting area recommendations.

Dataset #5: OSUCampusTreeCarePlan.pdf

Sources: Mary Maloney, Director of Chadwick Arboretum

Description: This dataset is Ohio State's current tree care policy and Tree Campus USA submission, and is what many of our recommendations were based off of.

Dataset #6: OSUTreeInventoryStatusReport.pdf

Sources: Christina Voise, GIS and Accessions Specialist at Chadwick Arboretum

Description: This dataset illustrates the extent of the current tree inventory and future tree planting plans. We used this to assess the current tree canopy and future development plans.