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Informing Sustainable Urban Forestry Policy with Carbon Sequestration Analysis

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INFORMING SUSTAINABLE URBAN FORESTRY POLICY WITH CARBON SEQUESTRATION ANALYSIS

A Capstone Experience/Thesis Project Presented in Partial Fulfillment

of the Requirements for the Degree Bachelor of Science

with Mahurin Honors College Graduate Distinction

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By

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ABSTRACT

Urban forestry is an environmental solution for an increasingly city-centered world. The ecosystem services that trees provide in natural settings, including carbon sequestration, oxygen production and aesthetic beauty, also apply in urban settings. Every tree in the Western Kentucky University (WKU) urban forest provides these services and each tree was measured to determine how much carbon they sequestered a year on average between 2015 and 2020. With an interactive map of the forest and its carbon sequestration, the condition of the forest and change over the five year period was analyzed. Comparing the welfare of the forest with the plans and management strategies of WKU produced an understanding of the effectiveness of the WKU tree care policies. Consistent construction was found to be the main obstacle to growth of the forest and the main cause of tree loss. A lack of communication between departments was found to be the main barrier between the tree care plan and its realization.

ACKNOWLEDGEMENTS

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VITA

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Tree Survey Intern

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INTRODUCTION

In 2000, the United Nations released eight millennium development goals to be achieved or reevaluated by 2015. Out of these eight goals, the seventh was responsible for 'ensuring environmental sustainability', with four broad targets that covered reduction of slum dwelling, reduction of biodiversity loss, increase of access to drinking water, and integration of sustainable development into policy to preserve resources (FAO, n.d.). Forests are not specifically cited as a target in this broader goal; however, when the Millennium Development Goals Report was released in 2015, the entire first page of the Goal 7 evaluation is dedicated to the success and failure of forest preservation (United Nations, 2015). The report states that forests provide livelihood, homes for plants and animals, catchment for water, and clean air, and calls for "sustainable forest management worldwide to limit deforestation and allow forests to maintain their crucial role in ecosystem health," (United Nations, 2015, pp 52).

In 2015, the United Nations' Sustainable Development Goals (SDG's) were announced to continue the progress and success of the Millennium Development Goals (MDG's). 17 goals were created that address more specific targets to encompass the nuance of the world's problems, while adhering to the overall goal of global sustainability. Goal seven from the MDG's turned into several different goals that distinguish the need for sustainability in cities, life on land, water ecosystems, provision of drinking water, clean energy, responsible consumption, and production and climate action (United Nations, n.d.c).

SDG 11 seeks to encourage the development of sustainable cities in part through target seven, which is providing public access to green space (United Nations, Goal 11, n.d.a). Goal 15 provides for life on land, and targets one and two specifically call for the preservation and sustainable management of forests (United Nations, Goal 15, n.d.b). Urban forestry cultivates forest environments in city and urban areas that would usually be lacking those ecosystem services. Urban forestry is, therefore, a link between these SDG 11 and 15 that can be a realistic part of significantly contributing to, or achieving, the SDG's by 2030.

In 2012, the Food and Agriculture Organization of the United Nations published an article on the roles of forests in climate change and estimated that trees contribute about one-sixth of global carbon emissions when improperly cleared or degraded and that they could sequester and store one-tenth of global carbon emissions in forest biomass by 2050 (FAO, 2012). To prohibit the excessive release of carbon from mismanaged and dead biomass and maximize the carbon sequestered by global forests, sustainable management is crucial. Initiatives such as the Tree Campus USA program, run by the National Arbor Day Foundation encourage good management practices by requiring a tree care plan as part of the application (Arbor Day Foundation, n.d.); however, any plan must be well implemented and updated to help satisfy and achieve the SDG's.

Western Kentucky University (WKU) is a level one accredited arboretum and has successfully earned the Tree Campus USA designation annually since 2011 (WKU Office of Sustainability, 2020b). The campus wrote a tree care plan for the first Tree Campus

USA application, which was a collaboration between the WKU Department of Facilities Management, Planning, Design and Construction (PDC), and the Office of the President. That tree care plan is in effect, but the committee and resources listed are now incorrect, suggesting that the plan may not be properly communicated or utilized on campus. The purpose of this study is to evaluate the benefits of trees on campus and the effectiveness of the Tree Care Plan.

STUDY AREA

WKU is located in Bowling Green, Kentucky. The main campus of the university used for this study, is 186 acres, 27.82 of which are tree coverage based off the leaf-on season crown coverage (Campus Infrastructure and Data, n.d.; i-Tree, 2020). The original buildings on campus come from the 1911 Kentucky State Normal School takeover of the Pleasant J. Potter College, a merge with Ogden College in 1927 and a 1963 merge with the Bowling Green College of Commerce all leading to the naming of the University in 1966 (WKU Public Affairs, n.d.). Pictured in Figure 1 are 90 buildings that form the main campus of WKU. This includes education, athletic, and housing buildings.

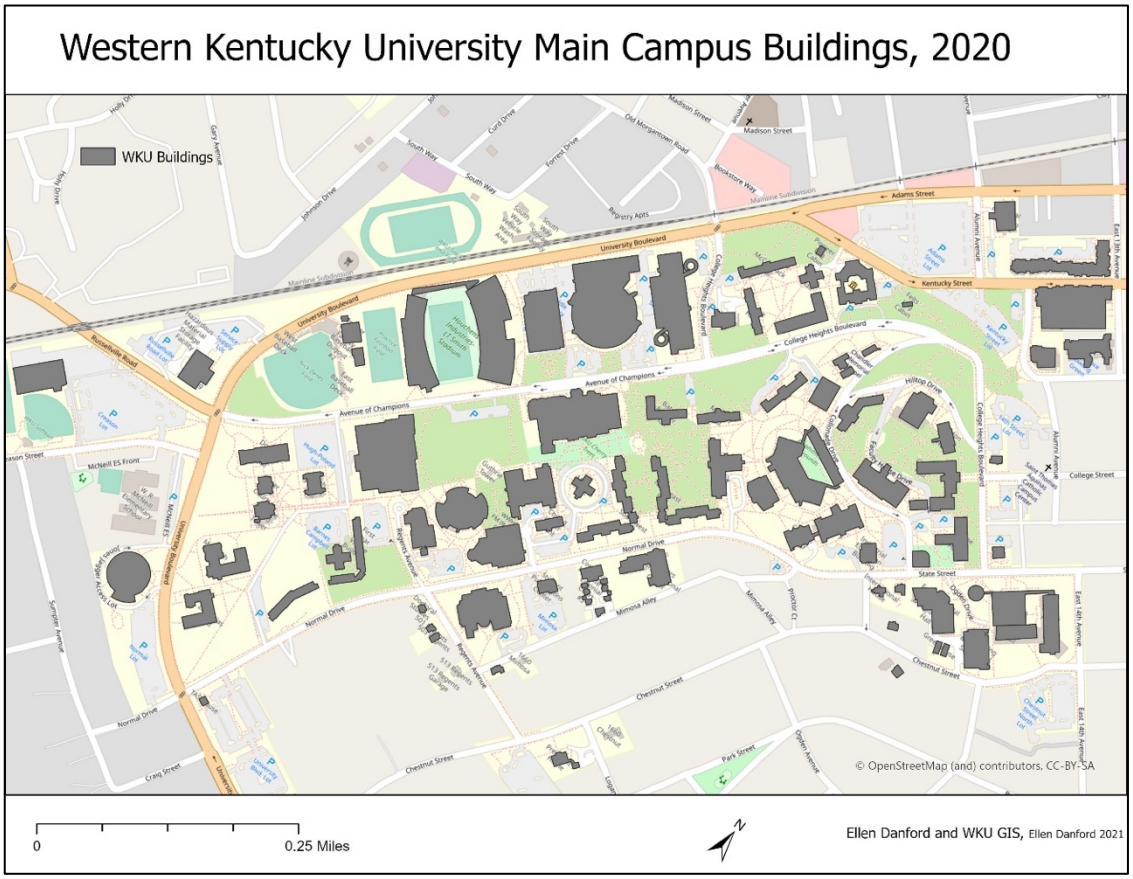

Figure 1. WKU Main Campus. Created by Author

The University is one of seven public universities in Kentucky and had the third highest enrollment in 2019 at 18,183 enrolled undergraduate and graduate students (Western Kentucky University, 2020). Students from Kentucky comprise 79% of the student body, with 19% out of state students and 2% international students and Kentucky has the highest concentration of WKU alumni (Western Kentucky University, 2020). Pictured in Figure 2 is the location of WKU within Kentucky. Campus housing is not utilized by most students; only 51% of freshman in 2019 lived on-campus and the percentages decrease to 7% of seniors that live on-campus (Western Kentucky University, 2020). However, students are present on campus through activism, student organizations and sporting events, as well as academic pursuits.

Figure 2. WKU's Location in Kentucky. Created by Author.

WKU has a history of sustainable development marked by copious accreditations, certifications, recognitions, and awards, as well as documented sustainable practices. In 2019, the campus was given a Silver Sustainability Tracking,

Assessment, and Rating System (STARS) recognition from The Association for the Advancement of Sustainability in Higher Education and was ranked on the UI Green Metric World University Rankings and Princeton Review's Guide to Green Colleges (Western Kentucky University, 2020). Additionally, WKU is a certified Tree Campus USA, an accredited Level One Arboretum, and a Certified Wildlife Habitat (Office of Sustainability, 2020a). The university also has five current LEED certified buildings and the first WELL Certified university laboratory building in America (Office of Sustainability, 2020b; WKU News, 2020a). These awards show a dedication to sustainability on campus.

The physical environment of WKU and Bowling Green geologically originates from the Mississippian era and mostly consists of limestone, sandstone, and shale (Noger and Dever, 2000). Kentucky geology differs by region, though most of the regions have limestone deposits from the Ordovician, Mississippian, and Pennsylvanian eras and an additional combination of limestone and shale (Noger and Dever, 2000). The city of Bowling Green and, more broadly, Warren County are in an area with high potential for karst development; accordingly, sinkholes are a hazard in the area (Paylor and Currens, 2002). The Barren River is one of the few above-ground streams in the Bowling Green/Warren County area; most water moves in underground streams and karst features (Public Works, n.d.). Due to the karst landscape and hilly geography of Bowling Green, there are some areas at risk for flooding, though the area in general is a minimal flood hazard (USGS, 2020).

DATA AND METHODS

In 2015, a tree survey of the WKU Arboretum was conducted by a student in the WKU Department of Geography and Geology. The result of this work was a shapefile with the identification, location, diameter at breast height (DBH) measured at 4.5 feet and annual carbon sequestration of each tree in pounds, as well as grounds data such as whether the tree has an identification sign. A five-year follow up of that survey which updated the DBH, carbon sequestration, and status of the forest was conducted as part of this project. The 2015 survey shapefile acquired from the WKU GIS Office had no metadata therefore, the methodology for this project is not necessarily comparable to the 2015 survey, especially multi-trunk measurements.

Trees were measured in inches with a cloth diameter tape. Data for the living trees was recorded in a field notebook then transferred to an ArcGIS Pro shapefile. Trees planted in the last 5 years were logged in the IOS ArcCollector app and transferred to a shapefile in ESRI ArcGIS Pro version 2.3. The two resulting shapefiles (one of the campus trees planted before 2015 and one of trees planted in the last 5 years) were merged to produce a shapefile of all the trees on campus. The 2020 DBH values were recorded in a new field, DBH 2020. Trees removed since the 2015 study were recorded with a DBH of zero and with the year removed denoted.

Determining how to conduct a new survey accurately without making it incomparable to the 2015 survey was difficult. To allow comparisons between forest

health and benefits in 2015 and 2020, the data had to be both accurate and conducted as similarly as possible to the 2015 survey. However, there was no indication of how the 2015 survey was conducted. Accordingly, the trees were measured following the recommendation of the U.S. Department of Agriculture Forest Service's i-Tree Eco handbook, at 4.5 feet from the ground (i-Tree, 2020).

Many trees could not be measured at 4.5 feet because they had multiple trunks, were pressed, or split below 4.5 feet. Trees with multiple trunks above the soil required each trunk to be measured at 4.5 feet (The City of Portland Oregon, n.d.). The DBH is calculated by adding each trunk diameter squared and then taking the square root of the sum (The City of Portland Oregon, n.d.; TreePlotter, 2019). The mathematic notation is $\sqrt{(x^2 + y^2)}$ for two trunks (TreePlotter, 2019). The DBH of multi-trunk trees in 2015 and 2020 were often incomparable, suggesting the 2015 survey measured multi-trunk trees differently.

Pressed trees were another exception to the standard 4.5-foot measurement guidelines. According to the American Forests guidelines, a pressed tree "actually represents two or more trees that have their trunks pressing together," in which case only the largest trunk is measured (Leverett and Bertolette, n.d., pp 9). For this study, pressed trees meeting this definition were denoted as "press" in the comments field of the resulting shapefile and excel table. Lastly, trees with multiple trunks that have a unified trunk above the soil level can be measured below the split of the trunks (Leverett and Bertolette, n.d.). The height of the measurement to the nearest foot was

denoted in the comments field. Metadata was created to detail these processes for the use of the surveyor in 2025.

The i-Tree Eco software utilized in this study was created by the U.S. Forest Service to evaluate and monetize forest resources, both in urban and natural settings. Though the program can analyze a wide array of variables, in this survey, only the carbon sequestration statistics were procured. The fields necessary were DBH, tree species, and the location. Furthermore, to set up the project in i-Tree Eco, the region, state, city, county, and municipality of the site were specified, as well as the nearest weather site to provide accurate data for the weather, climate, and native species ranges, as recommended by i-Tree (2020). This survey was a full-service analysis, not a partial survey, because every tree on campus was recorded. I-Tree service recommends that the crown health be included in a survey to avoid overestimation of carbon sequestration, but as dead trees were not included in this survey, it is not likely that carbon sequestration was overestimated (i-Tree, 2020).

A table of living trees on campus in 2020 was downloaded directly from ArcGIS Pro in excel spreadsheet format. Each species of tree was codified to match the i-Tree numbers, and trees of like species that were not included in i-Tree were codified with the closest tree of their genus. For example, a Weeping Redbud on campus was codified as an Eastern Redbud. The codified data was analyzed by i-Tree and returned with a report of the species diversity, pest-resistance (by species), and ecosystem services report. The purpose of this study is to evaluate the benefits of the urban forest on the WKU campus and assess the ability of the campus to protect the forest.

RESULTS AND DISCUSSION

Ecosystem Services

According to the National Wildlife Federation, ecosystem services are any positive benefits that ecosystems provide to humans (n.d.). In forests, these services include oxygen production, carbon sequestration, erosion control, watershed services, provision for biodiversity and recreational functions (Krieger, 2001). The WKU Forest i-Tree report revealed that the campus forest provides many of these ecosystem services. Over the past five years, the forest has removed air pollutants, sequestered, and stored carbon, avoided runoff, provided student recreation, and provided resources for wildlife diversity on campus (i-Tree Eco, 2021).

Air pollution removal is an increasingly important ecosystem service trees provide. I-Tree Eco models for the WKU urban forest indicate that the forest removed an average of 1291 pounds, or 0.646 tons of air pollution yearly (considering ozone (O3), carbon monoxide (CO), nitrogen dioxide (NO2), particulate matter less than 2.5 microns (PM2.5) and sulfur dioxide (SO2)) (i-Tree Eco, 2021). This estimate is based off the 2015 pollutant and weather data from the Bowling Green-Warren County Regional Airport. The benefit of this ecosystem service is improved air quality and lesser pollution in forested areas.

Urban forests help mitigate climate change by sequestering carbon as they grow (i-Tree Eco, 2021). The WKU forest is sequestering about 34 tons of carbon per year based off 2020 data and is estimated to store a total of 1,320 tons of carbon (i-Tree Eco, 2021). Carbon storage is carbon in woody vegetation while sequestration is the removal of carbon dioxide from the air by trees or plants (i-Tree Eco, 2021). Therefore, reducing removal of trees on campus can help avoid the release of carbon into the environment and allow the tree to continue sequestering carbon. As the WKU urban forest gains new trees and the existing trees grow, the carbon sequestration potential will increase and with it the sustainability of the campus.

Urban trees and shrubs reduced runoff on campus by intercepting precipitation before it can reach the ground (i-Tree Eco, 2021). According to the i-Tree Eco report 79,700 cubic feet a year of runoff are intercepted by the urban forest on campus. Stormwater runoff is a concern because it increases in urban areas and carries pollutants to local watersheds (Prahalad, Clagett and Hoagland, 2007). Therefore, reducing urban stormwater runoff, especially in a karst environment like Bowling Green, contributes to decreasing pollutants in waterways and the watershed.

Trees play a vital role in the aestheticism and recreation of college campuses. Cherry trees located in the heart of the WKU campus provide both beauty and a common hammocking and studying location for students when the weather is warmer. Furthermore, green spaces, like the one depicted in Figure 3, are a vital part of the Master Plan Goals for 2021-2031 because they provide places that are sustainable and encourage students to gather and collaborate (Gensler, 2021).

Figure 3. Campus Green Space. Taken by author.

Biodiversity on campus was greatly bolstered by the diverse and large forest on campus. WKU was granted the National Wildlife Federation 'Certified Wildlife Habitat' designation in 2017 in part due to the contributions of the urban forest (Office of Sustainability, 2020b). The trees at Western provide food for animals and insects, shelter to raise young, and a natural environment, which complies with the National Wildlife Federation standards and increases the sustainability of campus by promoting biodiversity (Office of Sustainability, 2020b).

WKU Tree Care Plan Goals and Policies

The WKU Tree Care Plan advises many good tree care practices. Successful execution of the plan should result in a forest with high carbon sequestration and storage. Despite guidelines set to prevent the loss of trees, WKU lost more trees than were planted from 2015-2020. On the other hand, the forest has the potential in 2020 to sequester 34.04 tons of carbon per year and produce 90.77 tons of oxygen per year (i-Tree Eco, 2021).

The WKU Tree Care Plan created a Tree Care Committee to communicate with the Planning, Design and Construction (PDC) and Grounds offices on campus to integrate tree care practices into plans for WKU. However, half of the members of the Tree Care Committee listed in the most current Tree Care Plan no longer work at WKU (Western Kentucky University, n.d.). The previous president of WKU is listed rather than the current president, and a previous Grounds Manager, Landscape Architect, and student contact are listed. Four out of the seven members of the Tree Care Committee listed no longer work at or attend Western. This suggests that the Tree Care Plan is not currently used in a meaningful way on campus. Article IV of the Tree Care Plan states the responsibility to change and update the plan is with the Tree Care Committee (Western Kentucky University, n.d.). However, as the committee is currently comprised mostly of members who do not work at Western, the responsibilities of the Tree Care Committee are not being fulfilled. The Tree Care Plan will have less effect without a Committee working to prolong its use.

Three main goals were listed in the Tree Care Plan; to conduct a tree inventory, to have the plan adopted by the Master Planning Committee, and to consider protecting the forest a strategic measure for attaining sustainability (Western Kentucky University, n.d.). The inventory was conducted in 2015 and again in 2020. The Tree Care Plan is not explicitly included in the Master Plan for 2021-2031, which suggests that it is has not been adopted by the Master Planning Committee. A principal objective of the 2021-2031 Master Plan is to create greenspace (Gensler, 2021). Working with the tree care guidelines established by the Tree Care Plan would help reduce costs for replanting and

removing trees that are poorly chosen or poorly planted. The third Tree Care Plan goal is not tangible, but persistent efforts by the campus and the Office of Sustainability to gain certifications such as the Tree Campus USA designation, Level 1 Arboretum Accreditation, and Certified Wildlife Habitat designation demonstrate an interest and action towards tree-minded sustainability practices (Office of Sustainability, 2020b).

The pruning and mulching care practices outlined in the fifth article of the Tree Care Plan are carried out by the Grounds Department (Western Kentucky University, n.d.). The WKU Grounds Office carries out regular mulching and does not use fertilizer (Office of Sustainability, 2020c). Practical protection measures included a pruning schedule, observation and irrigation for young trees, storm recovery, and mulching for young trees (Western Kentucky University, n.d.).

Tree Care Plan Section VI addresses tree protection practices on construction sites and with contractors. The four largest projects are the Science Complex, Hilltopper Hall, Helm Library, and the First Year Village. There is a mix of construction styles and strategies represented in those four projects and all four resulted in the loss and subsequent replanting of trees. Construction is a constant on college campuses, as universities strive to be competitive for new students and serve existing students. The impact of construction on the forest was noticeable yet varied at different construction sites.

The WKU Commons at Helm Library

Helm Library closed at the end of the Spring semester of 2019 for renovation and is scheduled to reopen in Spring 2021 (Western Kentucky University, 2019). The new space will be called the WKU Commons at Helm Library and is intended to be a space where students can study, eat, and meet (Western Kentucky University, 2019). The construction is currently underway, but there are forest impacts from the project. Section IV a. of the Tree Care Plan cites construction as a leading cause of tree death and decline and lists measures to protect trees from construction (Western Kentucky University, n.d.). Recommended measures include avoiding soil compaction, cutting of roots, smothering roots, and physical injury to the trunk and crown, which are to be carried out by educated contractors as directed in Appendix F (Western Kentucky University, n.d.). Though tree removal has been low at the site, workers have stored pipes and materials against tree trunks and cut soil close to roots to install different systems necessary for the building. These actions contradicted measure VI. a. of the Tree Care Plan that sought to prevent physical injury to the trunk and crown with barriers and contractor training (Western Kentucky University, n.d.).

The low loss of tree life caused by construction at Helm Library suggested that the site plan prevented unnecessary tree removal. Less trees were initially cleared for construction because the project is renovating an old building, rather than building a new one. Furthermore, Helm library is surrounded by sidewalks, which gave builders a mostly tree-free perimeter with which to work. Additionally, many of the landscapes being paved were previously impermeable and did not contain tree life. Though the reasoning may not have been specifically tree-motivated, using the same general building footprint and building in an area that already had impermeable surfaces did minimize forest impact at the Helm site.

Figure 4. The Commons at Helm Library Green Space Rendering. Gensler, Luckett and Farley.

Some goals of the construction portion of the Tree Care Plan were carried out at the WKU Commons at Helm Library site. However, protecting the health of remaining trees was not emphasized. Adoption of the Tree Care Plan practices could lead to better forest practices at the Helm Library renovation. It is evident that architect firms Gensler and Luckett & Farley are sustainably minded, as the building will be Silver LEED-certified, and the sketches shown in Figure 4 include green design on the outside (WKU News,

2020b). The Tree Care Plan would simply enhance the existing sustainability of the project.

The Science Complex Construction

Renovations connecting Kelly Thompson Hall, Snell Hall and Ogden Hall took place in between tree inventories. Ogden Hall specifically is the first WELL v2 Gold Certified university lab building in the United States (WKU News, 2020a). The WELL certification promotes sustainable design for the wellness of the occupants of the building (WKU News, 2020a). Building to attain this certification demonstrated a sustainable mindset with intentional planning that is reflected in the strategic preservation of tree life at the Science Complex sites. According to section VI. b. of the Tree Care Plan, to successfully care for the forest, trees must be evaluated, a plan prepared, contractors educated, and documents created to ensure restoration of the site (Western Kentucky University, n.d.).

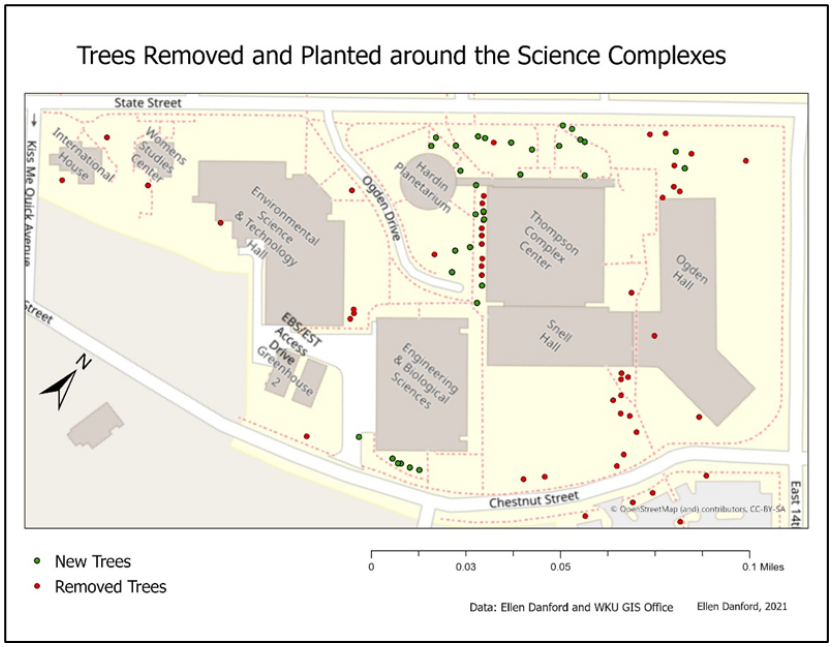

Figure 5. Tree Removal and Planting at the Science Complex. Created by Author.

Evidence of evaluation is clear in the preservation of tree life and replanting shown in Figure 5. Special consideration was given to one of the largest trees on campus, a gingko tree located between KTH and Ogden Hall which sequesters 109.7 pounds of carbon per year on average and has a DBH of 52.81 (i-Tree Eco, 2021). This tree was located in the middle of the buildings but was preserved. The preservation of the large gingko is evidence that some evaluation was completed at this site and the architects and contractors were able to build around the large tree.

Figure 6. Gravel Lot Caused by Construction. Taken by Author.

Figure 7. Arizona Cypress in Poor Soil. Taken by Author.

Though relatively few trees were removed through the Science Complex construction, not all landscapes affected by construction were restored as suggested in Appendix F of the Tree Care Plan (Western Kentucky University, n.d.). An area between the Snell Parking Lot and Hardin Planetarium, pictured in Figure 6, was not returned to a natural state. Additionally, Figure 7 shows a line of Arizona Cypress trees planted to replace a line of trees alongside the new KTH building. The ground those trees are planted in is a bed of gravel and rocks that is topped in weak grass and mulch. It is paramount that trees are replanted correctly in soil that will support them. According to a 2013 study, trees are commonly planted in poor soil because of a misconception that any soil will suffice, which results with heavy liability and need for management (Jim, 2013). Incorporating soil replacement in damaged areas as a finishing part of construction projects is a key part of providing trees that thrive and need less

maintenance. The other sides of the building were restored, and some trees replanted as represented by green dots in Figure 5.

Hilltopper Hall Construction

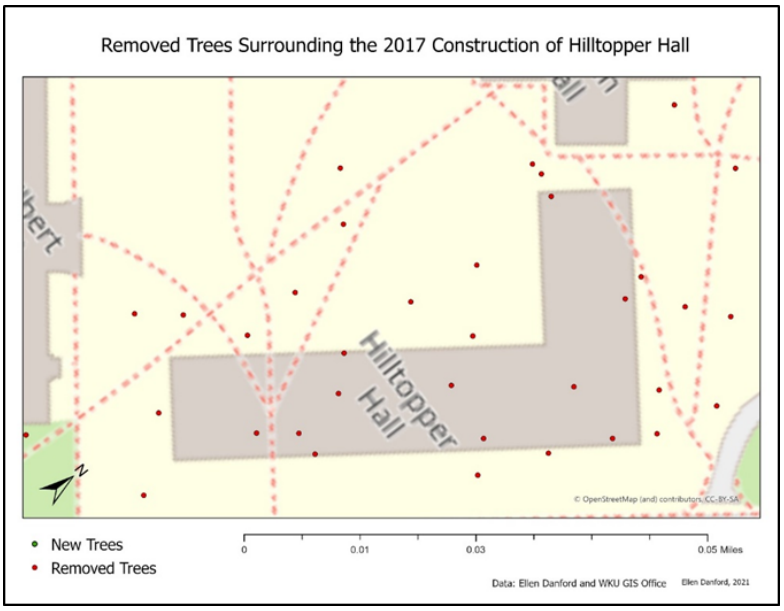

Figure 8. Removal of Trees at Hilltopper Hall Construction Site. Created by Author.

Hilltopper Hall had a high impact on tree life. The Hilltopper Hall construction site, pictured in Figure 8, shows removed trees in red that were in the way of the construction of Hilltopper Hall. This map does not show the trees in the area that survived the construction, only those removed. The new dorm was built on previously undeveloped land, which had a high impact on the forest. More trees had to be removed because the land for the new dorm had no other buildings previously.

Additionally, the construction site was previously a greenspace on campus called "The Valley." Construction of this hall had a visible impact on the forest, as shown in Figure 8, but also removed direct access to greenspace for three existing dorms on

campus. The impact of this dorm's construction, therefore, was both on the surrounding area and the ecosystem as a whole.

The First Year Village Construction

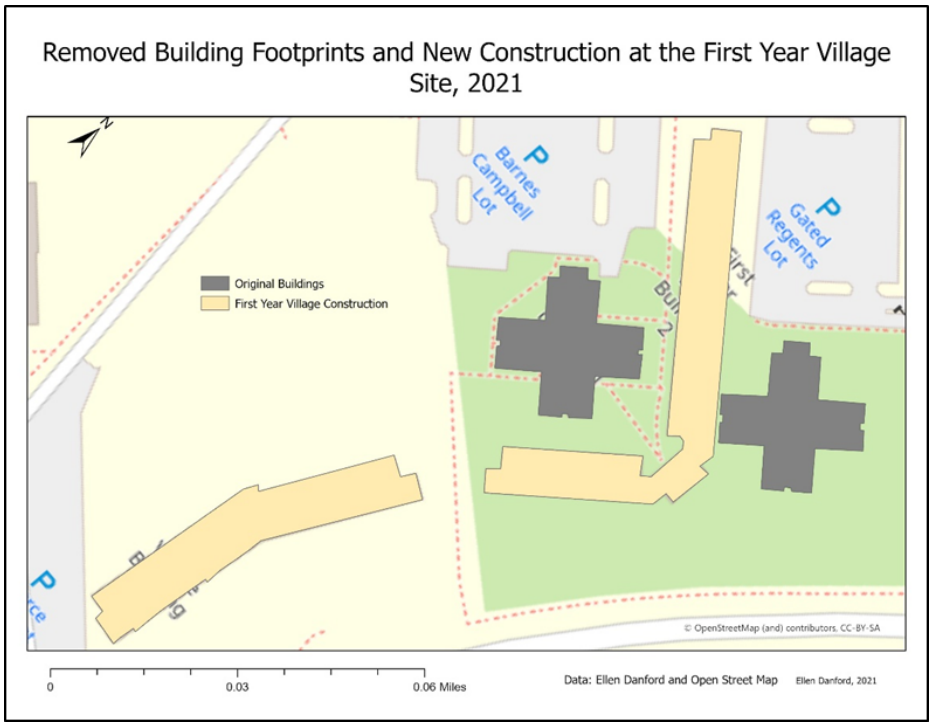

Figure 9. First Year Village Construction Site. Created by Author.

The First Year Village is the name of the construction project that involved the demolition of Bemis and Barnes resident halls and the construction of two new dorms on the land. Pictured in Figure 9, the newest construction project on campus will be complete in the fall semester of 2021. In Figure 9, the three parking lots at the far left, and top right were impermeable surfaces that will be converted to permeable green

spaces. The green spaces surrounding the demolished dorms in Figure 4 will also be restored following construction.

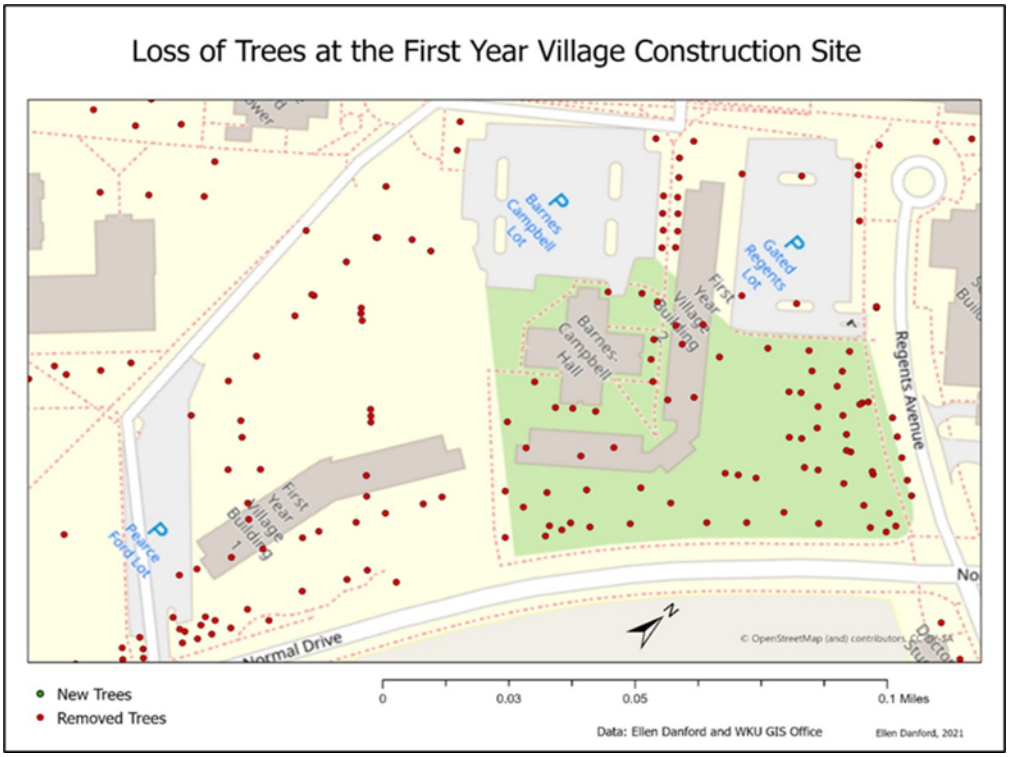

Figure 10. Tree Loss at First Year Village Construction Site. Created by Author.

The First Year Village project is not complete, but many trees have been removed. Figure 10 shows the trees removed in red. Besides the incredible loss of trees, the demolition of Bemis and Barnes turned the green space around the buildings into areas that housed concrete, brick, and other building debris. Plans for the future of the First Year Village include new greenspaces surrounding the new buildings, but the removal of so many trees suggested that the project was not planned with forest health in mind. When replanting is completed, the area will appear sustainable despite the massive removal of trees in the area.

Figure 11 is the visual rendering of the new green spaces at the First Year Village. The spaces will be an excellent place to involve students in the outdoors and to plant

trees. Furthermore, the parking lots and demolition debris will be turned into greenspace, which will allow spaces for trees to be planted and help lessen runoff. The plan shows consideration for environmental concerns and a desire to restore land at the end of the project. However, future projects would be more sustainable if mass tree removal were prevented, and green spaces were planned.

Figure 11. First Year Village Green Space Rendering. WKU Housing and Residence Life.

Recommendations for Improvement

Integrating the Tree Care Plan into the creation of the WKU Master Plan is a goal of the current plan that should be continued (Western Kentucky University, n.d). The WKU 2021-2031 Master Plan draft is full of goals for considerate growth that show a University-wide commitment to sustainability and communication. Guiding principles include a desire to “accelerate community building on campus” through green spaces, to “exhibit a culture of holistic thinking,” and to “unite teams around our common purposes” (Gensler, 2021, pp 7). These guiding principles are a platform for environmental action on campus, as communities that work together and employ systems thinking are better situated to act. However, the Tree Care Plan is not explicitly mentioned, nor is there any specific tree protections in the most recent Master Plan. As the draft is passed through the University offices, the reinstatement of the Tree Care

Committee and a commitment to tree care should be adopted under the existing Master Plan provision of creating and enhancing green spaces (Gensler, 2021).

A beneficial new goal for the University Tree Care plan would be to increase community involvement in forest activities. University-affiliated organizations have done tree planting projects in the past with different partners that serve as an example of a beneficial addition to the goals of the Tree Care Plan. For example, in 2012, WKU staff and students collaborated with Habitat for Humanity to plant 90 trees that would improve a drainage ditch and community walking trail (Center for Environmental Education and Sustainability, 2012). Projects such as this allow students to become involved and work with community partners. WKU can use their urban forest to positively impact the community around it and aim to further the urban forests of the city. Partners such as Habitat for Humanity, the City of Bowling Green, or campus offices such as the Mahurin Honors College and the Office of Sustainability are all great options for another partnership. Furthermore, this creates opportunities for students to lead their own projects and volunteer by planting trees, whether on campus or in the community. Working on projects like this and encouraging their development with grants and fundraising is a great way to develop student leadership and increase community involvement to create an environment of care for the forests.

One beneficial policy in the Tree Care Plan is that any tree over 12" DBH must be reviewed by the Tree Care Committee (Western Kentucky University, n.d.). Special review should be given to those cases, but also should be given to projects that propose removal of over a certain quantity of trees. Currently, as long as the trees are under 12"

DBH, there is no requirement to replace them. An amendment to the tree care plan requiring approval for projects removing over a certain number of trees and requiring replacement would prevent net loss in the forest due to construction.

The most important recommendation for improvement of forest care at WKU is to create a culture of communication about tree care and sustainable practices. The Tree Care Plan is a well-developed plan that encourages good management of the urban forest; however, it is not University Policy (Western Kentucky University, n.d.). Reevaluation of the plan is necessary going into the next decade of progress at WKU. The members of the Tree Care Plan need to be updated, as does the Tree Removal Request Form for trees over 12" DBH. The attainment of LEED and WELL certifications at different projects over the past five years demonstrates a desire to pursue sustainable buildings and construction at WKU. If forest care were also included in the planning process and considered part of a sustainable campus, WKU could become an even more holistically sustainable campus.

CONCLUSION

The goal of this study was to evaluate the health of the WKU urban forest and the policies meant to protect it. With a survey of trees on the main campus and corresponding i-Tree Eco report, this project took a holistic look at the functionality of the urban forest and its protection on campus. The ecosystem services offered on campus were numerous and could help the sustainable vision of campus if integrated into future plans. The trees of WKU offered natural wildlife habitats and added aesthetic beauty to the campus but were not seriously considered part of sustainability efforts on campus. There are several action steps and adjustments that could integrate the benefits of the existing urban forest with campus minded sustainability.

The ecosystem services of the urban forest should be considered when making plans for the university. The forest provides protection from runoff, air pollutant removal, carbon sequestration and is part of intentional green spaces on campus. Considering these services when planning construction and green space projects is critical to taking actions that will preserve the forest.

Construction plans should be assessed with an environmental perspective. The Tree Care Plan states that trees with a DBH greater than 12 inches must be approved before removing, but there is not protection for large quantities of smaller trees (Western Kentucky University, n.d.). Creating plans that intentionally avoid unnecessary

tree removal and aim to replant as many trees as possible will support the sustainability of campus and the forest. Additionally, there were several cases where “replacement trees” were planted on top of sites where the soil was either blocked or replaced by construction materials. These new trees will be harder to maintain and provide less carbon sequestration than the old trees, therefore a focus on the soil quality of post-construction sites for tree planting is necessary.

In terms of growth for WKU, the plans made to increase greenspace in the next ten years on campus speaks to the attitude of sustainability in leadership and suggests that the forest will be growing in the next ten years. Furthermore, by emphasizing a focus on community spaces and communication to achieve goals, the administration is creating an environment where the urban forest can be well cared for. However, the Tree Care Plan and Tree Removal Form are still listed under old personnel and should be updated and brought to the attention of the existing leadership. Reviving the use of this plan and its tree care policies could serve to bring awareness to the forest and make its health a priority.

Lastly, involving students and the surrounding community in the management and care of the campus forest is both beneficial and integral to maintaining a healthy environment. Partnering with students, organizations, and WKU offices to plant trees and promote forest care not only benefits the campus’ image, but also educates students and citizens so they can make informed tree decisions later in their life. Utilizing and advertising existing resources such as the WKU Arboretum walking trails, the online tree story map, and the Office of Sustainability can bridge the gap between a

beautiful campus and the students, staff, and community who live, work, and dream around it.

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