An Assessment of Tree Attributes with Their Consequences and Impacts on a High School Campus

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Abstract:

Trees are often one of the most prominent natural features in an urban environment. By measuring the heights and circumferences of trees, scientists are able to determine how factors such as carbon uptake and surface runoff are affected. This research attempted to answer the question of what tree species on our campus provide the greatest ecosystem services. Using GLOBE protocols, data was collected on the heights and circumference of eight trees on the Crestwood High School campus. Identification of each species was made using a field guide and verified by a professional. Data was entered in the GLOBE database and a U.S. Forest Service (USDA) i-Tree online program that quantifies the benefits and values of trees. Using i-Tree algorithms it was possible to determine the approximate amount of carbon dioxide taken in by each tree, the amount of stormwater runoff which has been avoided, potential energy savings to our high school building, and the amount of air pollution removed each year by the specific species of the measured trees. After analyzing the effects of the trees on the surrounding environment, it was determined that some species provide more ecosystem services than others and how much they contribute varies depending upon size and age. Where trees are planted in relationship to a school building also contributes to increased energy savings and increased comfort. We discovered that each tree species investigated sequesters carbon at different rates making some species more suitable as a way of offset anthropogenic carbon emissions. The data we collected and analyzed showed that the Honey Locust (*Gleditsia triacanthos*) did the best job of storing carbon.

Key Words: carbon, diversity, trees, energy, runoff

Research Question(s) and Null Hypotheses:

How do different tree species affect the amount of carbon dioxide absorbed? Do trees sequester more carbon dioxide during youth or maturity? How does a tree's height and circumference affect surface runoff? How can the planting of more trees affect the heating and cooling effects on various sections of our high school? How does the size of the measured trees affect both amount of carbon dioxide absorbed each year and how much air pollution is removed?

Null Hypothesis 1: The type of tree species has no effect on the amount of carbon dioxide absorbed and air pollution removed.

Null Hypothesis 2: The circumference and height of a tree species has no effect on surface runoff.

Null Hypothesis 3: Planting more trees have no effect on the heating and cooling effects of high school buildings.

Null Hypothesis 4: There is no limit to the amount of carbon dioxide a tree can sequester once they reach a certain height, circumference, and maturity.

Introduction and Review of Literature:

This research project was initiated because there are very few mature trees on the Crestwood High School campus (our school was built over 50 years ago). Many of the original trees that weren't cut down when our campus was established, died during the last two decades primarily due to the invasive emerald ash borer, oak wilt, and gypsy moths. Some trees were replaced but they were either mowed down inadvertently or even stolen soon after planting. A review of the literature says that diversity of tree species is better on a school campus (Bassett), but Crestwood High School and our district have not invested in or shown an interest in developing a comprehensive plan to plant more trees. This is partially due to finances (costs to purchase and maintain trees and extra time to mow around trees) and a lack of suitable planting areas (most of our school's outdoor space is dominated by practice fields where trees can't be planted). Lack of tree cover along the periphery of our campus affects the school in many ways, one of them being sports. Since we don't have trees in the right places, there is nothing to stop the wind from blowing at full force which affects the runners on the track team. For instance, because the wind was blowing at full force during practice, it can throw off a pole-vaulter, messing up their jump in the process. Trees are needed around the school to help with slowing down the wind and acting as buffers to reduce heating and cooling costs for the school. However, there are constraints to planting trees in some locations. Based on the way our school was planned and built, we don't sufficient planting space to put deciduous trees on the south and east sides of the school. Research in England (Armson) demonstrates that trees in the summer can cool nearby buildings, substantially reducing cooling costs. A well-landscaped campus full of trees gives a positive aesthetic to nearby homes (Moll) and mature trees in a neighborhood increase home values as well.

Research Methods and Materials:

Although 24 mature deciduous trees can be found on our campus only the eight (8) largest trees were analyzed. Our data was collected during the winter months and snow and cold temperatures interfered with our tree measurements. In addition, some trees are not large enough be measured using GLOBE protocols. Trees were not physically marked but their locations were noted on Google Earth. All trees had been identified to genus and species previously by other researchers using an online field guide from the Arbor Day Foundation (and also verified by Stanley Johns, forester). Pictures were taken of each tree for future reference. Using GLOBE biometry protocols, we measured the circumference of each tree 1.3 meters up from the ground at DBH using a Forestry Suppliers English steel diameter tape. We then measured fifteen meters from the trunk of the tree in a straight line. We held the clinometer at eye level and sighted to the top of the tree, taking three measurements (by both students). We used

two methods to determine the angle to the top of the tree, a Suunto clinometer and also a HAGLOF EC II-D electronic clinometer. This led to six measurements per student and ninety-six total measurements. The new GLOBE Observer Trees app was not used as we noted an error that gave us incorrect data. We discovered later that others experienced this same error and it has subsequently been fixed. We then used the equation (TAN of clinometer reading x distance from tree) + (Height from base) to get total height of each tree. The results were put into a spreadsheet on Excel for organization then entered into the GLOBE database to share with others doing similar research.

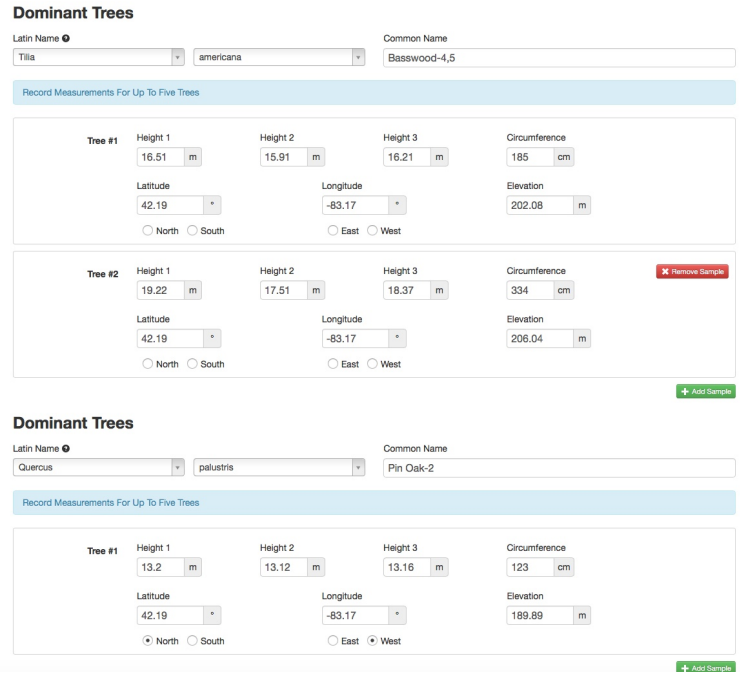

Figure 1: Figure 1 shows the data entry page from GLOBE website.

Figures 2-5: Figures 2,3,4, and 5 show the devices that were used in order to get the tree height measurements. Figure 2 shows the Kesson Industries 50M tape used to measure 15M from the tree trunk. Figure 3 shows both clinometers used to get the tree height. The Suunto clinometer on the right and the HAGLOF EC II-D electronic clinometer on the left. Figure 4 shows the Forestry Suppliers English steel diameter tape used to get the circumference. Figure 5 shows the Biometrey protocol that was followed.

Research Significance and Implications:

Why Trees? Regardless of what people think, trees are some of the most important living organisms in the world. Not only do they provide oxygen for us to breathe, but according to a study by William Sullivan, ASLA, professor of landscape architecture at University of Illinois at Urbana-Champaign, and Dongying Li, a PhD student there, trees are also shown to relieve stress and improve personal health by their mere presence along. We need more GLOBE schools to join this study and the GLOBE *Trees Around The World Campaign* in order to compile and compare more data on trees in our local communities. We now realize what effects trees have on our school campus, and would like to extend the research to the trees in our neighborhoods to see how they can positively impact our daily lives. Our school is almost a biological desert when it comes to tree cover. We plan to use our research to make a case for why more trees and trees of different species need to be planted on our high school campus.

Investigation Plan:

Two students took measurements of the tree heights and circumferences of trees from the front of the school and from the student parking lot, measuring eight trees total out of twenty-four. Measurements were taken six times by each student, using two different clinometers on the Crestwood High School campus in Dearborn Heights, MI. The students then used the formula (TAN of clinometer reading x distance from tree) + (Height from base) to get total tree height. The results were recorded in a notebook and spreadsheet to keep organized. All data was the uploaded into GLOBE to share their findings.

Figure 5: Figure 5 shows the key for locations of trees on Crestwood High School Campus in the order listed. **Honey Locust** (*Gleditsia triacanthos*), **Honey Locust** (*Gleditsia triacanthos*), **Pin Oak** (*Quercus palustris*), **Basswood** (*Tilia americana*), **Basswood** (*Tilia americana*), **Bur Oak** (*Quercus macrocarpa*), **Bur Oak** (*Quercus macrocarpa)*, **Bur Oak** (*Quercus macrocarpa).*

Figure 6-7: Figures 6 and 7 show the students using the clinometers following the GLOBE biometery protocol to measure the tree heights.

Results:

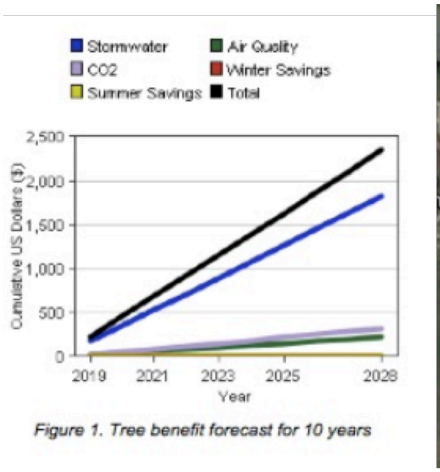

Figure 1. Tree benefit forecast for 10 years

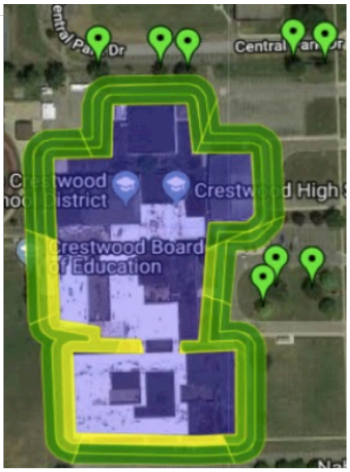

Figure 8-9: Figure 8 shows the areas and effects of where the trees can be planted. The green areas show that those are beneficial places to plant trees and that placing them there will help improve our school with energy and carbon intake. Figure 9 shows the projected results of the amount of money Crestwood High School will save in the next ten years from carbon intake, stormwater runoff, heating, and cooling with the trees marked in Figure 8.

Table 1: The table uses the Shannon Wiener Index from the species of viable trees at Crestwood High School to figure out the biodiversity of our school. The Shannon-Weiner Index calculated two decades ago showed a greater diversity of trees present as compared to the index calculated in 2019 due to invasive insect pests and various tree diseases.

Creestwood High School Tree Shanon Wiener Index

Species of Trees i	number of each species n_i	P_i	$\ln(p_i)$	$p_i (\ln(p_i))$
Bur Oak	3	0.125	-2.07944	-0.25993
Red Bud	1	0.0417	-3.17725	-0.132491
Norway Maple	7	0.2917	-1.23203	-0.359383
Tulip Tree	1	0.0417	-3.17725	-0.132491
Pin Oak	1	0.0417	-3.17725	-0.132491
Honey Locust	4	0.1667	-3.17725	-0.529648
Honey Maple	1	0.0417	-3.17725	-0.132491
Red Maple	1	0.0417	-3.17725	-0.132491
Silver Maple	1	0.0417	-3.17725	-0.132491
Crimson King Maple	3	0.125	-2.07944	-0.25993
Besswod	2	0.0833	-2.48531	-0.207026
				-2.410863

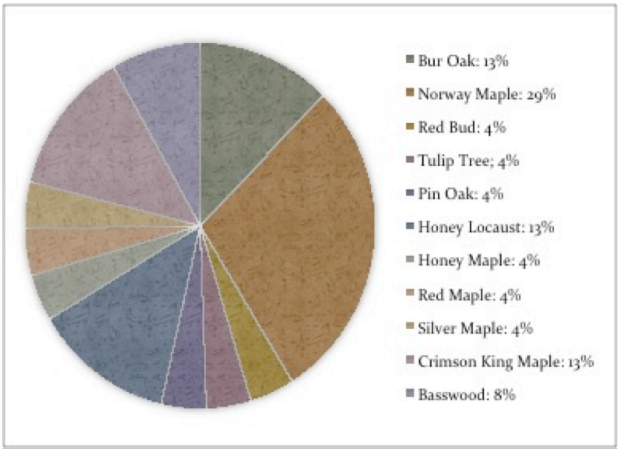

Figure 10: Figure 10 also shows the diversity of the twenty-four trees at Crestwood High School. There are eleven different tree species.

Discussion:

The outcome of our results rejected our null hypothesis. Our outcomes show that the tree heights and size do infact affect the amount of carbon sequestered by the tree. It also affects the amount of stormwater runoff that can be avoided. The bigger the tree, the more it intakes. They also proved that the amount of carbon sequestered is affected by the species. On our campus there is a Basswood tree with a diameter of 1.05-m. We placed a hypothetical Honey Locust tree with the same measurements and factor affects into i-Tree only to find that even with the same factors the Honey Locust had more carbon dioxide being absorbed than the Basswood. The results could have been affected by some sources of error including the fact that height and circumferences were measured for only 8 of the 24 trees on campus. Some of the other trees are non-native species and will be included in subsequent research. The tree heights varied by approximately one meter, it was very difficult to get height measurements that varied less. The cold temperatures also may have caused the researchers to rush more than they should have. Accuracy may also have been affected by an unsteady holding of the clinometer. Some trees had multiple high points that could have led to measurement errors. There are researches done in other places on biometery protocol, however we searched in archives but we didn't find any studies similar to ours.

Conclusion:

After retrieving the measurements for the trees and inputting them into i-Tree and the GLOBE database, we were able to reject all of our null hypothesis and provide support for our research questions. We determined that the species of the tree definitely affects the amount of carbon dioxide absorbed by each tree and the circumference of the tree also helps to determine the amount of surface

runoff. In other words, larger trees intercept and slow down more rain, allowing the water to be more likely to absorbed by the soil and less likely to become surface runoff. Also depending on the area where the trees are planted, the effects can either be negative or positive towards the location. If trees are planted to the far right of the school, the costs of electricity can decrease, but if planted near, behind, or to the left of the school the costs can increase due to the shade provided by these trees to require the usage of air conditioning less often as well as absorbing some sunlight through their leaves during the cooler months to reduce the use of a heating system. A tree takes in carbon dioxide for photosynthesis during its yearly growing season. Trees store a great deal of carbon dioxide when they are young and actively growing. As trees mature, their ability to store carbon slows down and eventually plateaus. Improvement in the methods would be to measure more than eight trees and to measure each tree more than twice. Follow up actions would be to find the proper sites to plant more trees on our campus. Companies benefit from a healthier, happier workforce if there are parks and trees nearby. We recently learned at a GLOBE Student Research Symposium about an augmented reality app called ARIS, that can help identify trees and explain the benefits of them. This can help get students interested into learning more about the ecology around them. In addition, we plan to use all of the GLOBE Carbon Cycle protocols in the future so that our data is sharable with other GLOBE researchers.

Bibliography and Citations:

Armson, David, Rahman, Mohammad Asrafur, and Ennos, Anthony Roland. A Comparison of the Shading Effectiveness of Five Different Street Tree Species in Manchester, UK. Arboriculture & Urban Forestry 39(4): July 2013.

Bassett, Corinne G., The Environmental Benefits of Trees on an Urban University Campus" (2015). *Master of Environmental Studies Capstone Projects*. Paper 66. http://repository.upenn.edu/mes_capstones/66

Google Earth . (n.d.). Retrieved March 17, 2019, from https://earth.google.com/

Moll, Gary and Ebenreck, Sara, ed. (1989) *Shading Our Cities: A Resource Guide for Urban and Community Forests*. Island Press, Washington D.C.

MyTree by i-Tree. (n.d.). Retrieved from http://mytree.itreetools.org/

Protocol eTraining. (n.d.). Retrieved from https://www.globe.gov/get-trained/protocol-etraining/etraining-modules/16867717/3099387

Tree Design v6.0. (n.d.). Retrieved from http://design.itreetools.org/

What Tree Is That? Online. (n.d.). Retrieved from http://www.arborday.org/trees/whattree/whatTree.cfm?ItemID=E6A

Why are trees so important? (n.d.). Retrieved from https://www.royalparks.org.uk/parks/the-regents-park/things-to-see-and-do/gardens-and-landscapes/tree-map/why-trees-are-important

Badges:

Be a Data Scientist: We took the GLOBE measurements of our trees and made inferences using i-Tree on what the future impacts on our environment could be in the future. We also discussed a plan to solve the lack of biodiversity in trees by mapping out the parts of our school to best plant them.

Make an Impact: We determined that trees can assist with the energy conservation in the buildings on our campus. We created a plan to map out the best areas to plant trees and proceed to plant them and increase our campus's biodiversity. We also learned about the positive mental impacts that trees have on people. We are going to add onto our project by hopefully planting trees in the suitable areas. We plan to discuss our results with our district's school board and administration.

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