The Effects of Native Tree Species on Ambient Air and Surface Temperatures in Southeastern Michigan

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Abstract:

Gathering data is essential when developing strategies to improve our understanding of the impact urban trees potentially have in helping to mitigate the urban heat island effect. This research project was conducted near Crestwood High School in Dearborn Heights, Michigan; a relatively small suburban city approximately 17.2 miles away from the urban center of Detroit. Native tree species are more acclimated to local and regional conditions as they have evolved in this region since the last ice age. Native trees are also important to local wildlife because they also evolved an ecological interdependence. Using GLOBE protocols - temperature data, tree heights, and circumferences were collected from under a tree's canopy and also outside of its canopy during the 2019 summer. Commonly planted deciduous native tree species were chosen to investigate the shading effect they had on both surface and ambient air temperatures.

The GLOBE Observer App for trees was used to obtain tree height and circumference and a Pasco weather station was used to record weather data. Weather data was exported to an Excel spreadsheet for analysis. All of the data was entered through the GLOBE data entry portal. Preliminary analysis showed that of the trees sampled, basswoods (*Tilia americana*) had the largest ability to reduce surface and air temperatures while the red maples (*Acer rubrum*) appeared to have a smaller effect. This research seems to suggest that planting a greater proportion of basswoods in urban plantings might help to mitigate the warming effect that many anthropogenic structures and surfaces have in cities. Although most trees have the ability to reduce temperatures, this research sought to determine if some native tree species were a better choice than others. Further research needs to be conducted to evaluate other native tree species suitable for city plantings.

Keywords: Native, urban, temperatures, trees, and canopy

Research Questions:

- **Initial Research Question(s):**

1. How do different native tree species affect air and surface temperatures?
2. Which native tree species planted in urban areas are most effective at reducing urban temperatures during the summer? Which tree is the least effective?
3. Does overall tree form and leaf shape affect the ability of a tree to reduce temperatures?

These driving questions were used to focus and lead our investigation seeking to find optimal solutions for choosing trees to help mitigate urban heating.

Null Hypotheses:

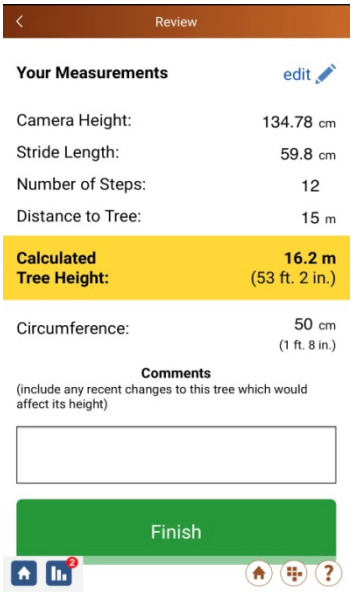
1. Tree height and circumference have no effect on surface and air temperatures.
2. Different tree species have no difference in their ability to modify air and surface temperatures.
3. The shape of specific leaves on different native tree species does not affect cooling temperatures.

Methods and Materials:

A total of four different native tree species were used to collect data from in a neighborhood in Northern Dearborn Heights. The data was collected on five different days during July, 2019 . Trees growing in the city right-of-way between the sidewalk and street were chosen for this investigation for easy access. Neighbors were also asked ahead of time for their permission to collect information on their tree. In order to take air temperatures, the PASCO wireless weather device was used to collect data for ten minutes per tree. While the PASCO device collected

weather data, an infrared thermometer was used to collect surface temperatures under the trees canopy near the base of the tree and outside of the canopy a total of nine times each. The trees growing in the neighborhood were probably planted sometime around when the homes were built and had consequently developed relatively large canopies. Because of this, surface and air temperatures taken outside of the shade were sometimes difficult to make. Tree diameters were measured using a Forestry Suppliers English steel diameter tape at DBH (diameter breast height) which was 1.372 meters up from the ground. Tree heights were determined using the GLOBE Observer Tree App, a Kesson Industries 50-foot tape was used to measure 15.37 meters from the base of the tree, a Suunto clinometer and the GLOBE Observer App were used to collect the heights of trees. A clinometer and the GLOBE Observer Tree App were both used to get the most accurate height measurements. Three measurements were collected from a Suunto clinometer by two people for a total of six angle measurements which was then imputed into an equation (TAN of clinometer reading x distance from the tree) + (Height from the base)) in order to find the tree heights. GLOBE Observer App measurements were taken by both group members once for a total of two heights collected per tree. The tree heights were then submitted through the GLOBE Observer App along with the data collected through using the Suunto clinometer and the average of both group members' data collected from the GLOBE Observer app. The weather data was then exported from the PASCO wireless device into an Excel spreadsheet for further analysis. By taking the data and averaging out both the tree heights and temperature information, it was possible to take a closer look at the information and view exactly how each aspect correlated to the research questions and hypotheses as well as to disprove or prove any null hypotheses made.

Figures 1-2: Figures 1 and 2 show the instruments used to collect tree heights and diameters. Figure 1 is the Kesson Industries 50-M tape in Figure 1 was used in order to measure an accurate 15.37 meters from the tree's base. The Suunto clinometer in Figure 2 was used to measure the tree heights.



Figures 3-4: To collect diameter the Forestry Suppliers English steel diameter tape, in Figure 3, was used and the data was entered through the GLOBE observer app, which is shown in Figure 4, as well.

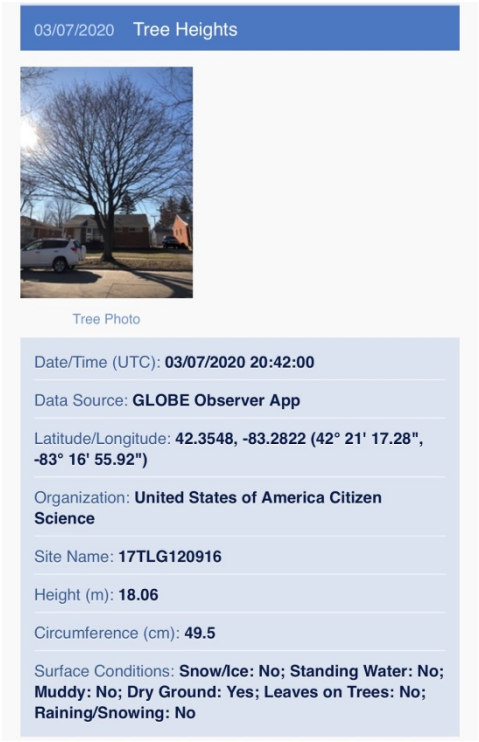
Figures 5-6: The infrared thermometer in figure five was used to take surface temperatures in nine locations around the tree. In figure six the PASCO wireless weather device was used to collect air temperature from under the tree for a consecutive ten minutes.

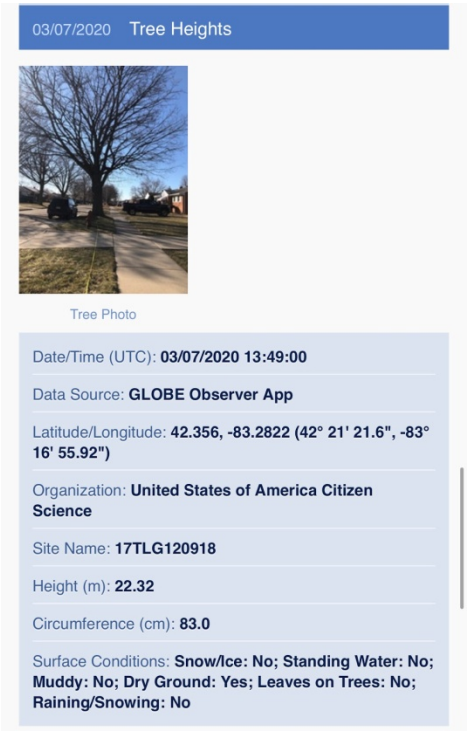
Introduction and Review of Literature:

Trees vary by age, health, height, circumference, overall form, etc. Each of these factors and more can determine the quality of shade a tree provides. Some peer reviewed research in England has investigated the quality of shade provided by specific trees (Armson). This research is an extension of research conducted on our high school campus during 2018-19 school year. Residential areas in our city have a greater density and planting of trees than our campus has. As old trees die or are cut down as a result of disease, our city needs a database of native tree species they can recommend for planting. Our city has earned the distinction of being named a "Tree City" by the National Arbor Day Foundation and yet, the city provides little information to residents regarding what trees to plant for particular uses. Research demonstrates that larger trees have a more significant role in shading than smaller trees (Mohammad A. Rahman, Astrid Moser, Anna Gold, Thomas Rötzer, Stephan Pauleit). Dearborn Heights lost much of its tree cover a decade ago when the invasive Emerald Ash borer killed 99% of all the ash trees planted in our city. This means that if one is going to choose trees to plant, a consideration should be

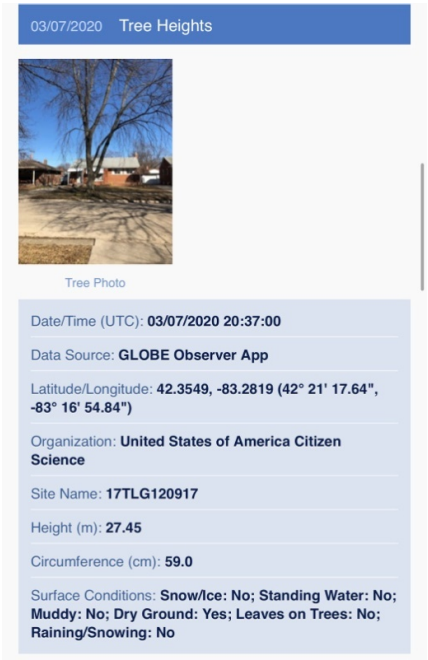
made for increasing the diversity of native tree species and not decreasing it by planting just a few species. Previous research demonstrates the undeniable affects trees have in their ability to alter temperatures. (Christopher P. Loughner, Dale J. Allen, Da-Lin Zhang, Kenneth E. Pickering, Russel R. Dickerson, and Laura Landry). This research is unique in that trees of approximately the same age were assessed in our suburban community to ascertain differences in the ability of specific native tree species to effect changes in temperature.

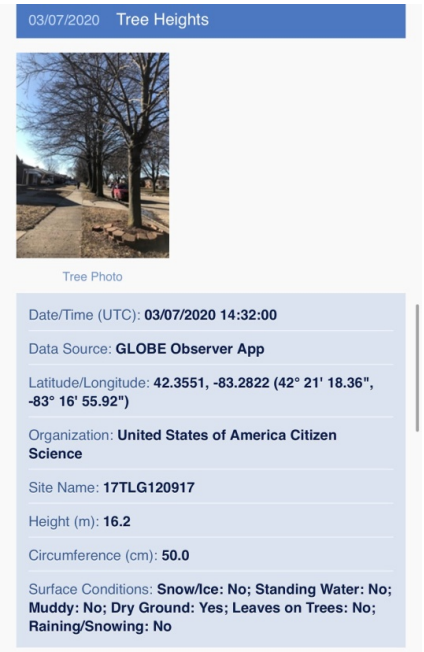
Results:



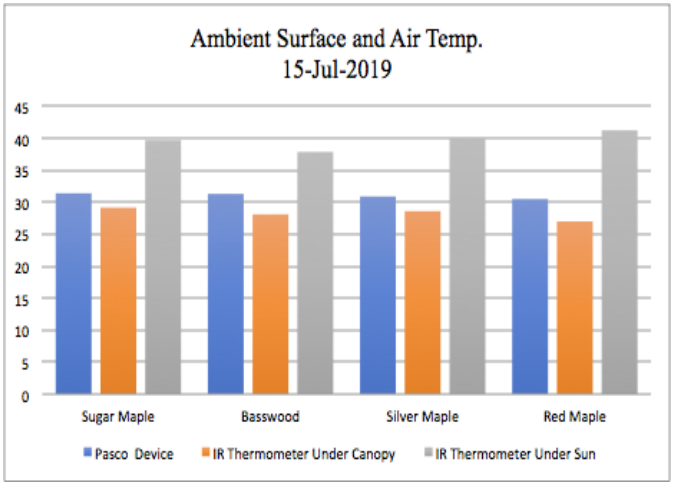


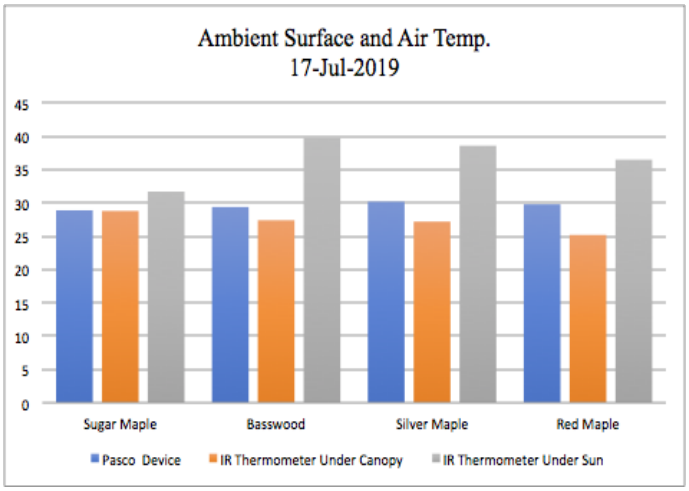
Figures 7-8: Figures seven and eight are from the GLOBE visual page in which data was entered in to. Figure seven showed the *Acer saccharum* which had a circumference of .83 meters and a height of 22.32 meters using the GLOBE observer app and an average of 19.6 meters using the Suunto Clinometer. Figure eight shows the *Tilia Americana* tree which had a circumference of .50 meters, a height of 16.2 meters using the GLOBE observer app, and an average height of 18.15 meters using a Suunto Clinometer.



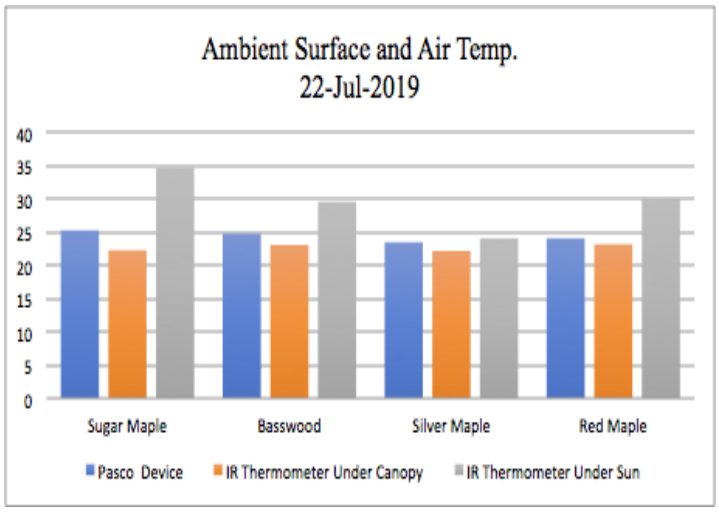


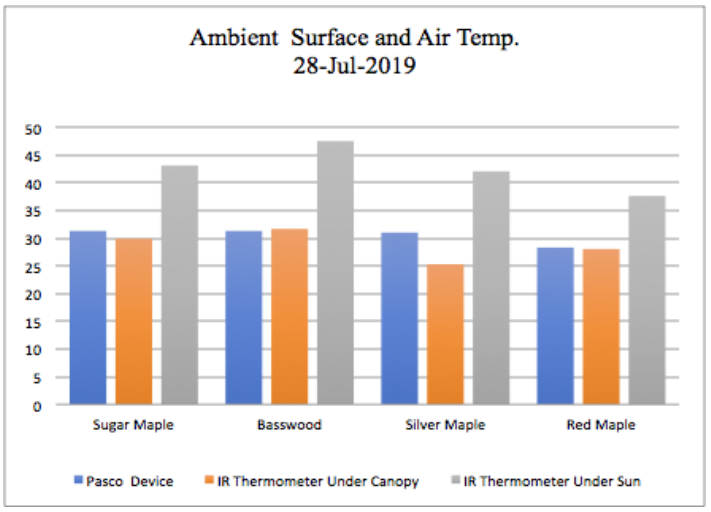
Figures 9-10: Figure nine shows the *Acer saccharinum* tree which had a circumference of .59 meters, a height of 27.45 meters using the GLOBE observer app, and an average height of 24.5 meters using the Suunto Clinometer. Figure ten shows the *Acer rubrum* tree with a circumference of .495 meters, a height of 18.06 meters using the globe observer app, and an average height of 15.89 meters using a Suunto Clinometer.





Figures 11-12: Figures eleven and twelve visualize the difference in heat reduction from each tree for the first two days. The data collected through the PASCO weather device and the Auto-Pro Raytek IR thermometer under the tree canopy tended to be extremely similar. Figure eleven visualized the data taken on July 15, 2019. It showed that the Red Maple had the largest effect while Figure twelve showed the Basswood had the greatest effect. The change between the greatest effect was caused by change in cloud positions and light distribution.





Figures 13-14: Similar as to what was stated above, figures thirteen and fourteen both visualize the effects in either heat reduction or gain. All data was consecutively collected through the PASCO device and Auto-Pro Raytek IR Thermometer, visually all the trees seem to be extremely similar but after all data points were considered and averaged, it was known that Sugar Maple had the largest affect in figure thirteen and once again Basswood had the largest affect in figure fourteen.

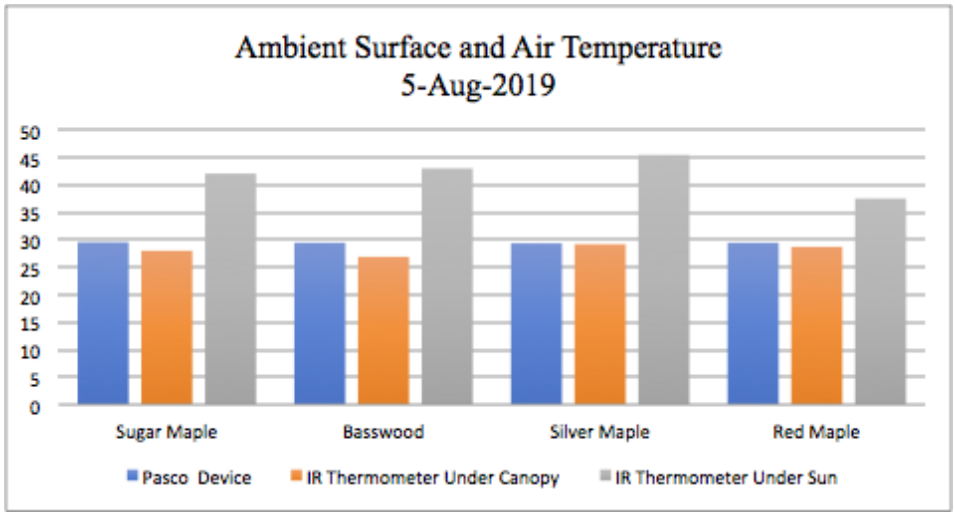


Figure 15: In figure 15, as it was one of the coolest days that the PASCO device and Auto-Pro Raytek, it was shown that the tree having the most effect was Sugar Maple, creating the correlation that the taller in height the tree the larger the change in surface and air temperature when weather is cooler.

Discussion:

The data taken showed that all trees had an effect on urban heat temperatures. Although all of the trees provided a significant difference, there were trees that performed better than others. The *Tilia Americana* had the largest effect on the temperatures with an average change of 10.3 degrees Celsius when using a PASCO weather device and a 12.1 degree Celsius difference when using an infrared thermometer. Although the data collected by the PASCO weather device was taken for a total of ten consecutive minutes per tree, and started at Solar Noon, the difference in the time from the first tree analyzed and the last tree analyzed. When taking tree heights, since it was approaching winter it became more difficult to measure tree heights easily. The clinometers were also not at the highest accuracy, and even though there were two partners measuring the trees, there could have been difficulties getting precise readings. A research study stated that the larger trees with a higher canopy volume tended to show an decrease in soil temperatures

(Mohammad A. Rahman, Astrid Moser, Anna Gold, Thomas Rötzer, Stephan Pauleit). Compared to the data, although the largest tree didn't have the greatest effect, it was shown that the red maple, which was the smallest, performed worst. The results supported one of our hypotheses as the smaller trees would be the worst at providing cooling against the urban heat island effect.

Conclusion:

Through further analysis of the data, it was figured that the Basswood - *Tilia Americana* tree species provided the largest effect on cooling with an average cooling of 11.214 degrees Celsius between surface temperatures and air temperatures taken by the PASCO wireless weather device. The *Acer rubrum* provided the least cooling with an average of 9.161 degrees Celsius. The *Acer saccharum* provided an average of a 9.74 degree Celsius cool down while the *Acer saccharinum* provided an average of 10.295 degrees Celsius. To improve accuracy in the results it would be improved if the temperatures were collected in multiple different ways and collected more often. By using more processes of collecting data on how temperatures were collected, there would be more to compare the results to. If more days were collected, it'd be possible to get a closer result as some may have been affected by the lack of days. To follow up this research, a plan could be taken into effect to plant more of the *Tilia Americana* tree species in order to further reduce the effect of urban heating and increase cooling provided by the trees. In the future, it is planned to continue this research, but gathering more air and surface temperatures as well as using new methods with the current ones. One way to improve this research would be to record data on as many of the same species trees, of the same age as possible. Increasing our sample size would allow us to reduce errors due to chance variation. Connections with students from the Princess

Chulabhorn Science High School in Thailand help to compare different native species that may not be available in our area. Through their research they chose to measure carbon dioxide stocks in trees as well as humidity which would be a future plan to see how the results could compare. Although tree canopy was not a specific form of research conducted in this project, through other connective studies it has been also shown there is a correlation between the two which will provide for future studies within this group and to allow consecutive research.

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Badges:

Be a Data Scientist: Taking the GLOBE measurements of trees in student researcher's neighborhoods and making inferences using the differences in the PASCO device versus hand-held taken temperatures through an AUTO-PRO Raytek Infrared Thermometer. We also discussed a plan to contribute and possibly plant more trees to process a larger impact on the Urban Heat Island Effect.

Make an Impact: We determined that trees can assist with the shading and light distribution. 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. Being able to spread our ideas through council members of the Dearborn Heights Community.