Possible Effects of River Flooding on Soil Parameters and Tree Growth Along an Urban River

Student Researchers:

Itidal Bazzi, Zeina Jebara, and Sana Taleb

School:

Crestwood High School, Dearborn Heights, MI 48127

High School Science Teacher:

Mrs. Diana John

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Abstract:

Biometry and soil protocols are a significant and essential consideration to implement when conducting strategies to develop an advanced understanding of the tolerance of tree species growing in Southeastern Michigan. Understanding the relationship between sediments, soils, and tree growth on floodplains is an important issue to investigate to better understand the impact of frequent river flooding. This research project was conducted at the Wallaceville area of Edward Hines Park in North Dearborn Heights. Several GLOBE protocols were used to collect data between August 20, 2020 through August 25, 2020. The parameters incorporated in the investigation varied between soil pH, soil particle density, surface temperatures, and canopy size. During the investigation period, rainfall and river water levels often varied due to heavy precipitation events. A Pasco wireless weather sensor to record a variety of atmospheric parameters. The GLOBE Observer App for trees was used to obtain tree height(s) and circumference(s). This research suggests that of the trees and soil sampled, the physicochemical environment of pH varies somewhat daily and seasonally. Soil porosity and density appear to be heavily dependent on the distance between the tree and the Rouge River itself. Soil density is important in determining how deep roots are grown on a floodplain. This research attempted to determine how different floodplain locations affect soil pH, vegetation differences, and tree tolerance to frequent flooding.

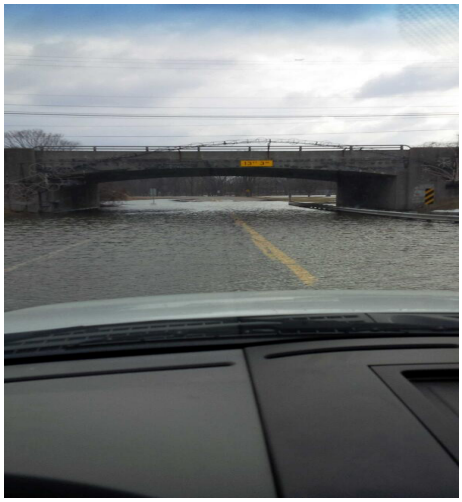


Figure One (left): Flooding taken place on Hines Drive near the location of the soil sample and tree observations.

Key Words: Soil Nutrition, River Level Fluctuation, Surface Temperatures, Soil pH, Canopy Size, and Soil Particle Density.

Background:

Urban flooding is an all-too-common occurrence for many residents of the Rouge River Watershed in Southeastern Michigan. With so many impermeable surfaces in this region, even moderate amounts of rain can lead to flooding and wild swings in the height of river water. Edward Hines is a major roadway that gets closed frequently because of repeated flooding. In the past high-water levels have released raw sewage into the river along with runoff full of oil, grease, pet feces, fertilizer, pesticides, etc. Record floods that were uncommon a few centuries ago has become a commonplace for this watershed. The Middle Branch of the Rouge River flows through a heavily populated portion of the watershed. When the glaciers melted back 10,000 years ago, they left a landscape with poor drainage and many wetlands. Unfortunately, early settlers drained these wetlands for easier farming. Without many natural wetlands remaining, precipitation that would normally soak in, becomes runoff. The regions relatively flat (low) topography has allowed communities to develop in a sprawling fashion rather than within the confines of an urban center. Because the data in this investigation was collected for only a week, any analysis or conclusions must be viewed with caution and remain tentative.

Initial Research Question(s):

- Is the pH of soil directly proportional to the intensity of climate in the specific region?
- Does soil particle density have any relation, whether proportional or inversely, to soil compaction? Does that affect uprooting/bulk density/ nutrient penetration?
- Is the distance between the Tree itself and the Rouge River impactful to the Tree's tolerance?

Null Hypotheses:

- Large Canopy Cover does not reduce air temperatures when compared between under the canopy and the control (outside the canopy).
- Proximity of tree location has no correlation in decreasing or increasing pH levels due to leaching and weathering.
- Particle density does not vary along floodplain gradients.

Why this is Important/Research Implications:

Due to Southern Michigan's topography being rather extensive, flat, and full of fertile plains not only being a contributing factor of perpetual flooding, the urban area of Detroit is congested with impermeable surfaces due to infrastructure. In correlation of flooding, vegetation becomes at great risk, a term known as "Plant Drowning" typically seen in fully submerged plants, which are posed at the greatest risk. As flooding occurs and vegetation is submerged after a three-to-ten day, it is then decided whether the plants survival is deemed fit. Due to the flooding after moisture is soaked, vegetation is left in crop residue, decreasing the vegetation and tree's ability to conduct photosynthesis and creating oxygen deprivation further accelerating the decrease in survival rates. Continuing on, not only are vegetation placed at risk after floods but as well as the tolerance of the soil itself. Flooding significantly alter the level of vegetation nutrients, pH, and soil particle density, are all damaged and taken away through floods by erosion. If flooding was to continue on a flood plain, trees are more likely to fall into the river due to erosion. It would be difficult and expensive to add more trees to the location to hold the soil in place; however, floods may bring other associations with it such as increased phosphorous, silicon, potassium, and nitrogen levels. soil pH levels, soil particle density, and a multitude of other atmospheric parameters allow us to keep a thorough track of weather behaviors that affect these species specifically.

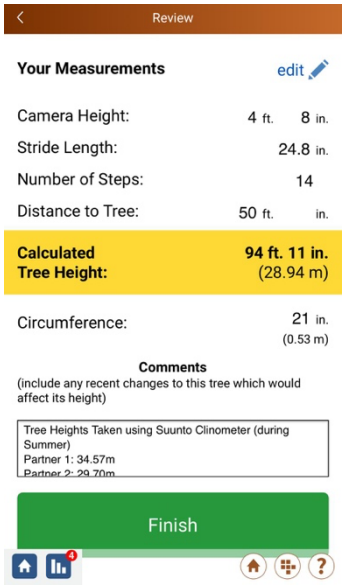
Review of Literature:

Water-level fluctuations in rivers, especially The Rouge River, are very common. With Michigan's unnaturalized weather conditions, water level heights change very quickly. Due to the fluctuations the surrounding ecosystems were not immune to the damages. Manel Leira and Marco Cantonati, natural science researchers, conducted research on the effects of water level fluctuations. Our research extends on this topic and presents how it could be a problem to the soil and the tree growth surrounding. Depending on the proximity of the trees to the Rouge River is all within the effects they endure. After rain showers Edward Hine can be left flooded for days. The Rouge River plays an important role in the city of Dearborn Heights. It causes the city to be recognized as a green space as a lot of new initiatives are correlated with it (Jessica Strachan). The Friends of the Rouge River have been coming together in order to solve a lot of harms the river has endured. Recognizing how The Rouge River affects its surrounding trees would help keep the community surrounding content. Research shows that one of the ways to help with water fluctuations is having a lot of surrounding trees. Trees with bigger canopies slow down the flow of waterfall ultimately slowing down water level fluctuations (Vincent Cotrone). Depending on the water level ranges and frequencies, tree growth can be affected. Some peer reviewed research exemplifies how after testing different tree species near a river, a little over 50% of the species survived with the river level fluctuation present (Wei G-W, Chen Y, Sun X-S, Chen Y-H, Luo F-L, Yu F-H). This research is unique because it tests the effects of the tree growth, the soil, and the soil nutrient. Trees from a variety of species and distances were selected and tested to see how the river water level fluctuations can have an impact on them.

Research Methods:

Edward Hines Drive is a nearby recreational park located approximately 20.7 miles away from the urban city of Detroit in the northern end of Dearborn Heights, Michigan (precise location: 42.347151, -83.276734). Having the ability to conduct research, we examined a total of four trees that neighbor the Rouge River in Edward Hines Drive that often gets flooded. The data was collected for a total of four days in August 2020 while practicing COVID-19 restrictions and social distancing. Two PASCO wireless weather devices were left to run for 10 minutes each in order to collect air temperatures and absolute humidity. One device was stationed under the

tree's canopy while the other was used as a control (outside the canopy) at the same time in order to be as precise and accurate as possible. 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 while tree heights were determined using the GLOBE Observer Tree App. To begin collection of data 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 receive the most accurate height measurements. Tree heights were taken by all three members a total of three times each. After, the data was submitted through the GLOBE Observer app including the measurements taken manually. A densitometer was used in order to collect canopy data to view the effects they may have had on the environment around the tree. Collection of soil was taken daily from under each tree, the weight of the soil was recorded both before and after being placed in a drying- oven for 24 hours. For the Soil pH Protocol equal amounts of water and soil were mixed for 3 minutes in 5 intervals, after letting sit for 5 minutes the water and soil will separate and then the pH is resulted. For Soil Particle Density, the weight of soil and water mixture were taken and boiled then left to sit for 48 hours. After the water and soil dispersed, the temperature and weight were taken again.



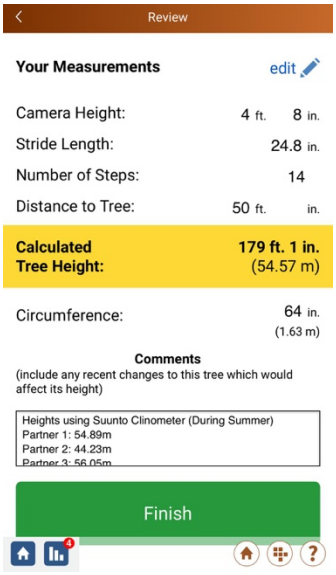


Figure Two and Three: Two examples of data that was entered through the GLOBE observer app for Tree 2 and Tree 3.

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

Figures Five and Six: To collect diameter the Forestry Suppliers English steel diameter tape, in Figure five. In Figure six the PASCO wireless weather device was used to collect air temperature from under the tree for a consecutive ten minutes.

Figures Seven and Eight: Sana Taleb and Zeina Jebara analyzing the soil after being boiled and left to sit for 24 hours.

Figure Nine: Itidal Bazzi weighing the flasks before being boiled and recording the temperatures.

Figure Ten: The geographical map of the study site

Results:

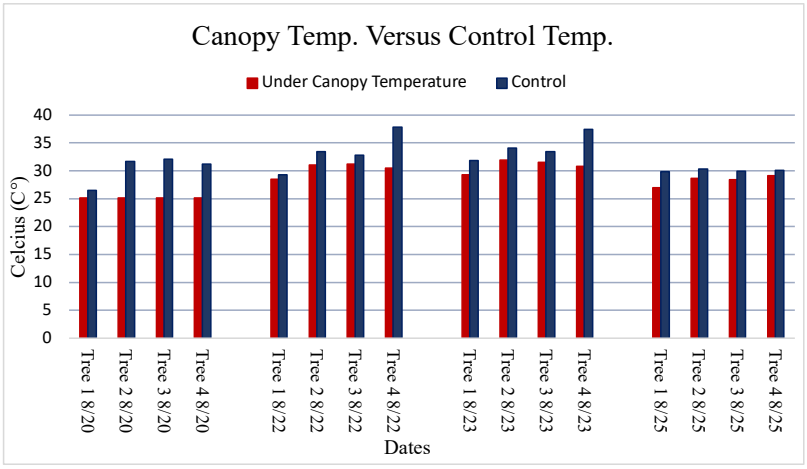


Figure 11: It is shown that canopy size is effective when being compared to under canopy air temperatures and air temperatures taken outside of the canopy (control) the data being collected through the PASCO weather device. The visualization in heat reduction is physically noticeable within the graph. As Tree 4 had the largest percent of canopy cover (83.5%) while also having the largest difference in temperatures of Canopy vs. Control (approx. 7.34 C°).

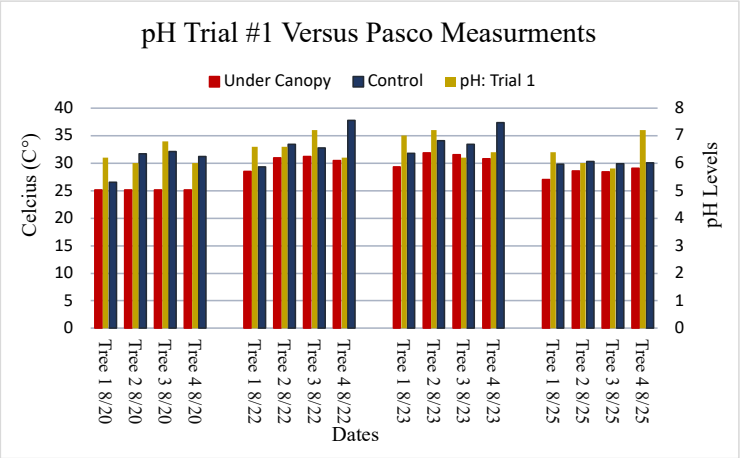


Figure 12: Within the graph due to the flood water on 8/21, examining Tree 4, while not only being the tree with the closest proximity to the Rouge River and the lowest elevation it was also heavily affected by visible leaching and weathering of the soil. The pH read as 6.2 which may have been lowered due to the acidification. However, on 8/25 the pH read as 7.2 due to a possible decrease in weathering and leaching.

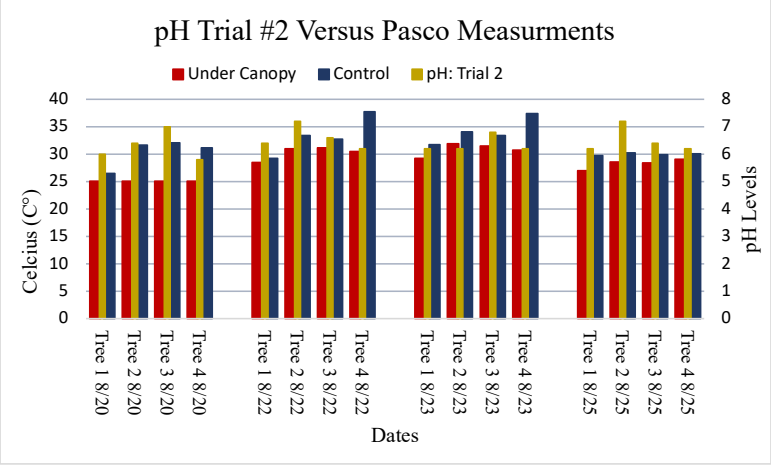


Figure 13: Similar to figure 12, most of the pH readings throughout stayed consistent and match along trial #1. Therefore, establishing a directly proportional form that higher water elevations cause pH to decrease due to possible acidification altering soil to be alkaline and vice-versa; With the exception of the date 8/25, although the soil was collected and tested from the same gathering of soil, the pH readings are significantly different. This may be from a procedure mistake or limitation done when conducting the lab.

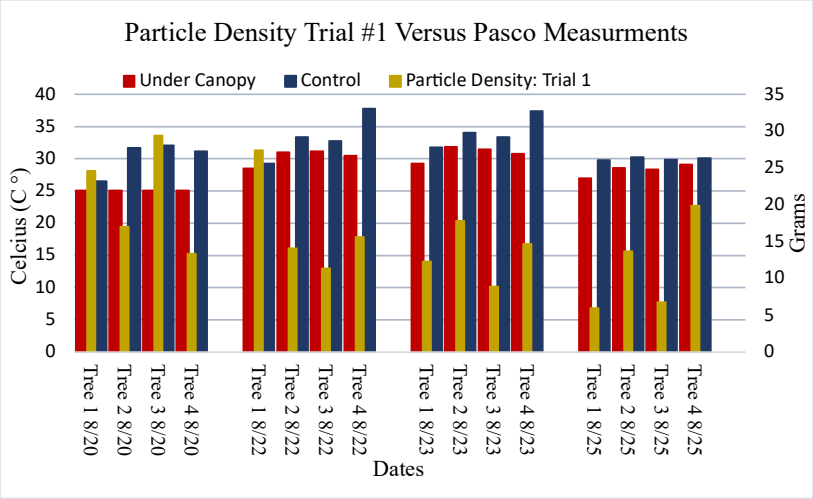


Figure 14: Within the figure, Tree 3 has the lowest particle density with the exception of 8/20 (which was a rainy day). The other trees present an average particle density which may likely correlate with moderate soil porosity and soil compaction. However, Tree 3 having unusually low particle density alters the soil may causing a decrease in porosity and compaction.

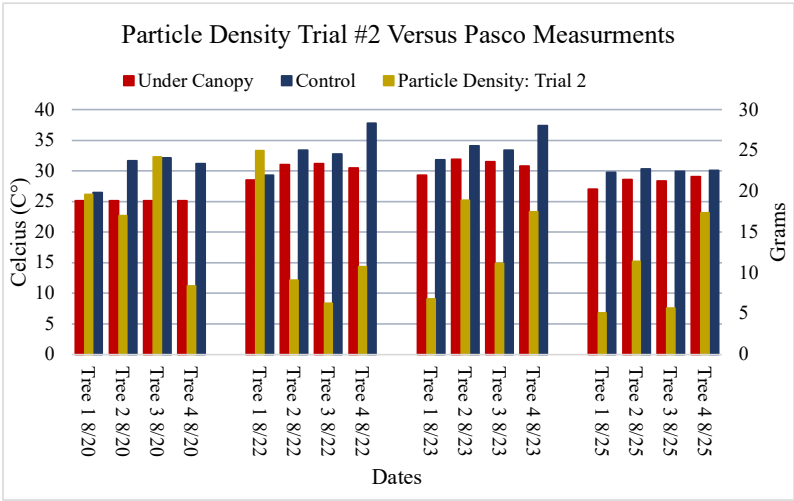


Figure 15: While conducting the second trial of the particle density lab, the soil being from the exact same collection as the first, was precisely accurate. Each soil particle density is < 1 in difference compared to trial 1.

Discussion:

Conducting research during a pandemic has a few disadvantages to it, but as a team we were able to establish that any of the data that was collected would still benefit the research and the Rouge River Watershed community. Data was only collected over a period of four (4) days that were unable to be done consecutively due to the variation of weather Michigan endures or events, one date had (8/21) had flooding and the other (8/24) Edward Hines was closed. Ideally, it would have been significant to do a month's analysis rather than a week, but this also being a limitation due to Covid-19 restrictions. Due to the Rouge River anytime it rains Hines Drive is left to be flooded for days. Days where the street is flooded it is left to be blocked off where it would be a struggle to get to our locations. Adding as well the virtual learning and unpredictable availability of not only the researchers but as well as faculty which was dependent on whether accesses was granted to the school or availability or in-person combined effort. A larger and more varied data set would have been taken, but with the Covid-19 restrictions we were not able to go out and collect data using safe measures. The clinometers were also not at the highest accuracy, and even though there were three researchers measuring the trees, there could have been difficulties getting precise readings due to each researcher being a different height. Woefully, we were not able to go back in order to figure out our tree species. Lab space was hard to come by because if the state was in lockdown, it meant we were locked out of the labs as High Schools were not allowing students and at time even faculty into the building. Unfortunately, due to this we had to cut down our trials from three (3) to two (2) and could not add more parameters to our research such as dew point, absolute/relative humidity, barometric pressure, wind speed, wind chill, and humidex. Be-that-as-it-may the time period of data collection be minimal creating a decline in accuracy and precision, the data collected may still be used to predict following trends; Nonetheless, we established that canopy cover is effective in decreasing the levels of air temperature recorded, uprooting is correlated to the proximity of the tree and the Rouge River affecting not only its pH but the particle density furthermore creating a possibility that porosity and compaction will be decreased as well.

Conclusion:

The locations of trees and their associated soil conditions were found to be somewhat - related to air temperature. This was true for areas both under the canopy and the control (outside of the canopy). These parameters being air temperature collected by two PASCO Wireless Weather Systems for ten (10) consecutive minutes, canopy size effectiveness, tree height, soil pH, and soil particle density. Comparing trees of multiple species in river-fluctuated ecosystems helps create clarification between the effects each tree must endure. This research determined that air temperature and consistent rainfall affect the ability to cause possible leaching and weathering in soil floodplain soils. Although, in dry periods of time, since leaching and weathering are to be less intense it may cause soil pH be neutral, which was concluded in our research. However, due to not being fully educated on all soil parameters, the data collected and examined for particle density is to be taken as an estimate rather than a precise scientific conclusion. Information on particle density is valuable for estimates of other soil parameters such as, porosity, air-filled voids, settling rates of particles in fluids, nutrient transportation. All are proportionally correlated but cannot be confidently concluded and will be considered for future conducted research on soil parameters.

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Badges:

- **I am a Data Scientist:** Students took temperatures in four locations within a park both under the canopy of each tree, as the experiment, and outside of the canopy as a control. The students also collected soil samples each day from under each tree as well as a control variable. They proceeded to use GLOBE pedosphere protocols for pH and soil particle density.
- **I Make an Impact:** Students originally determined that the canopy of a tree can assist in shading within light distribution. Wanting to take the research a step further and look into if the canopy is able to assist in soil quality through using GLOBE pedosphere protocols. Making the choice to go locally and perform our investigation in a local park, which is also a floodplain, in order to see the relation between tree species, canopy, and soil quality.
- **I am a Stem professional:** Students collaborated with Lisa Perez, a forester from the USDA (United States Department of Agriculture) forest service. Students and Mrs. Perez discussed the importance of the issue and ways that our project could be implemented with the use of resources provided by the USDA Forest Service.

Acknowledgements:

- We'd like to thank our adviser, Mrs. Diana Johns, for assisting us throughout this project and helping to supply the necessary materials, with whom we would not be able to accomplish as much as we had without her.

- We would also like to thank Mrs. Lisa Perez with the USDA for offering her expertise in biometry and the pedosphere and also offering aid and support with resources provided by the USDA Forest Service.