An Analysis of the Effect of Land Cover Type on Mosquito Populations

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STEM Enhancement in Earth Sciences Internship:

Mosquito Mappers Research Group

Abstract:

Mosquito-borne diseases pose a significant danger to public health, making it important for us to understand the factors that affect mosquito populations. We decided to compare mosquito populations within two land cover types: woody wetlands and deciduous forests. In order to study this relationship, we used mosquito data from the National Ecological Observatory Network (NEON).

The NEON mosquito data set catalogs various features of mosquito collection sites, including land cover type and mosquito counts. These data categories encouraged our team to explore two primary questions: How do environmental factors such as land cover affect mosquito populations? Does the prevalence of standing water in woody wetlands lead to greater mosquito presence in comparison to deciduous forests? We explored these questions with the ultimate goal of mapping and modeling any correlations (or lack thereof) as a means to better understand the factors that affect mosquito populations.

By parsing through NEON mosquito count data from June to September 2019 for two separate locations which both contained woody wetlands and deciduous forests, our team generated average mosquito counts for each land cover type. Graphing this data allowed us to conclude that there is not a significant correlation between land cover type and mosquito population for the two land cover types we studied.

In order to better understand the relationship between land cover types and mosquito populations, a broader range of land cover types must be studied. We also recommend that variables such as precipitation and temperature be factored in when analyzing this relationship. Finally, we do not recommend using NEON data to study mosquito population counts and instead recommend using it to study mosquito species richness and diversity.

Keywords: mosquito population, land cover, National Ecological Observatory Network, environmental factors, mosquito-borne diseases

Research Questions:

1. How do environmental factors such as land cover affect mosquito populations?
2. Does the prevalence of standing water in woody wetlands lead to greater mosquito presence in comparison to deciduous forests?

We hypothesized that different land cover types would have mosquito populations of different sizes due to their differing environmental characteristics. We also hypothesized that the prevalence of standing water in woody wetlands would lead to greater mosquito presence in comparison to deciduous forests, as standing water is an important factor for mosquito oviposition. We believe that our research questions are important because answering them will help us better understand the factors that impact mosquito populations. Mosquito-borne diseases have a severe negative impact on public health, and many scientists believe that climate change will exacerbate this issue. By gaining a greater understanding of the environmental factors impacting mosquito presence, we can create better solutions for decreasing mosquito populations and curbing the spread of mosquito-borne diseases.

Introduction:

As climate change grows in severity, mosquitoes will likely have a greater impact on human life. Scientists predicted that mosquito-borne diseases significantly burden society as rising temperatures create ideal conditions for mosquito growth and reproduction (Rocklöv, et al. 2020). Therefore, it is important to study what factors impact mosquito populations to better focus efforts to lower disease rates. Some research has already been done about this topic, especially in regards to mosquito populations in urban areas (Little, et al. 2017).

By setting up traps in our neighborhood and studying them with the GLOBE Observer Mosquito Habitat Mapper, we began our study of the factors that impact mosquitoes. Some factors we looked into were the proximity of the mosquito habitat to water, the proximity to urbanized locations, the type of artificial container, and the nutrients present (Parker, et al. 2020). This work exposed us to the complex nature of mosquito oviposition and inspired the following research.

Photos of Our Mosquito Traps; Credit: Nico Bers, Garima Bansal, Aminata Kamara

Land cover type is another important factor that can impact mosquito presence in areas across the globe. Our work studying the land cover in our neighborhoods with the GLOBE Observer Mobile App showed us how different land cover types vary in key environmental factors, such as standing water, shade, and tree cover. These factors greatly impact mosquitoes, which lay their eggs in water. Mosquito larvae are more likely to survive in shaded areas with nearby vegetation to provide nutrients as well as sustenance for adult mosquitoes (Parker, et al.

2020). Woody wetlands and deciduous forests have characteristics that would make them prime mosquito habitats. The foliage provides necessary shade and prevents significant water evaporation. In addition, their high humidity levels can lengthen mosquito lifespans (Yamana, et al. 2013). However, there are key differences between these two land cover types, such as the amount of standing water present. We wanted to investigate whether these differences would affect mosquito populations or not. Based on knowledge of the factors impacting mosquito oviposition, we hypothesized that there are greater mosquito populations in woody wetlands compared to deciduous forests because the standing water in woody wetlands may promote mosquito oviposition.

Preliminary Approaches:

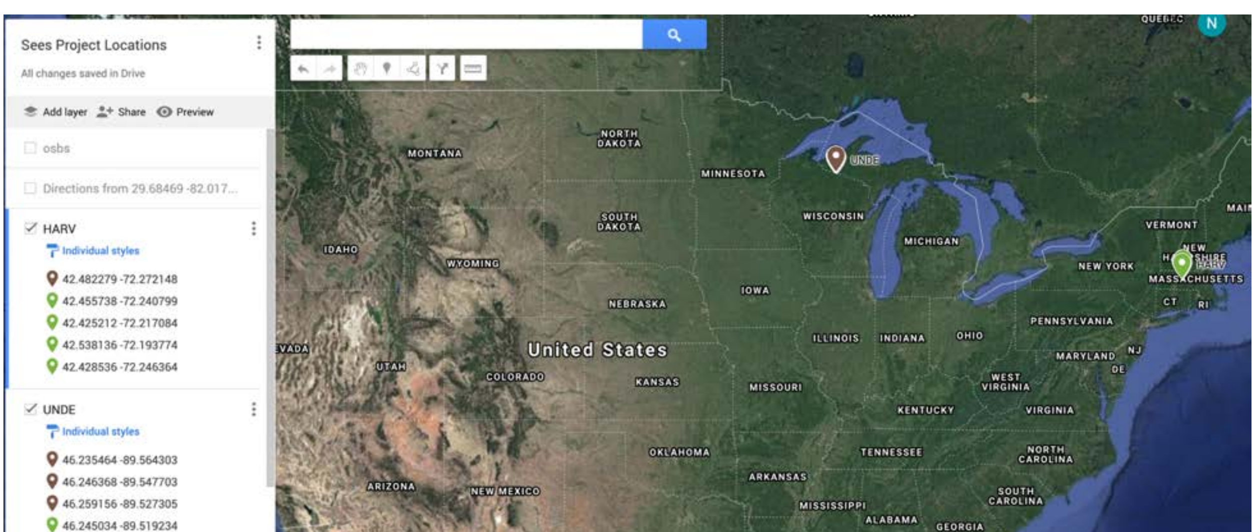
Before arriving at our final research questions, we attempted to investigate whether mosquito populations were impacted by natural disasters such as wildfires and hurricanes. After finding locations for NEON data collection in California where wildfires had occurred, we discovered that there was insufficient data before and after to make a conclusion. After talking with our mentors as well as exploring more of the NEON data, we were not able to pursue a research question on the subject of natural disasters due to a lack of appropriate data.

After narrowing in on our research questions and downloading the necessary NEON data, we attempted to analyze it with Python libraries such as Pandas, Numpy, and Matplotlib, but the organization of the files, as well as the CSV file naming patterns, made this very difficult. So, we eventually decided to use Google Sheets to analyze our data.

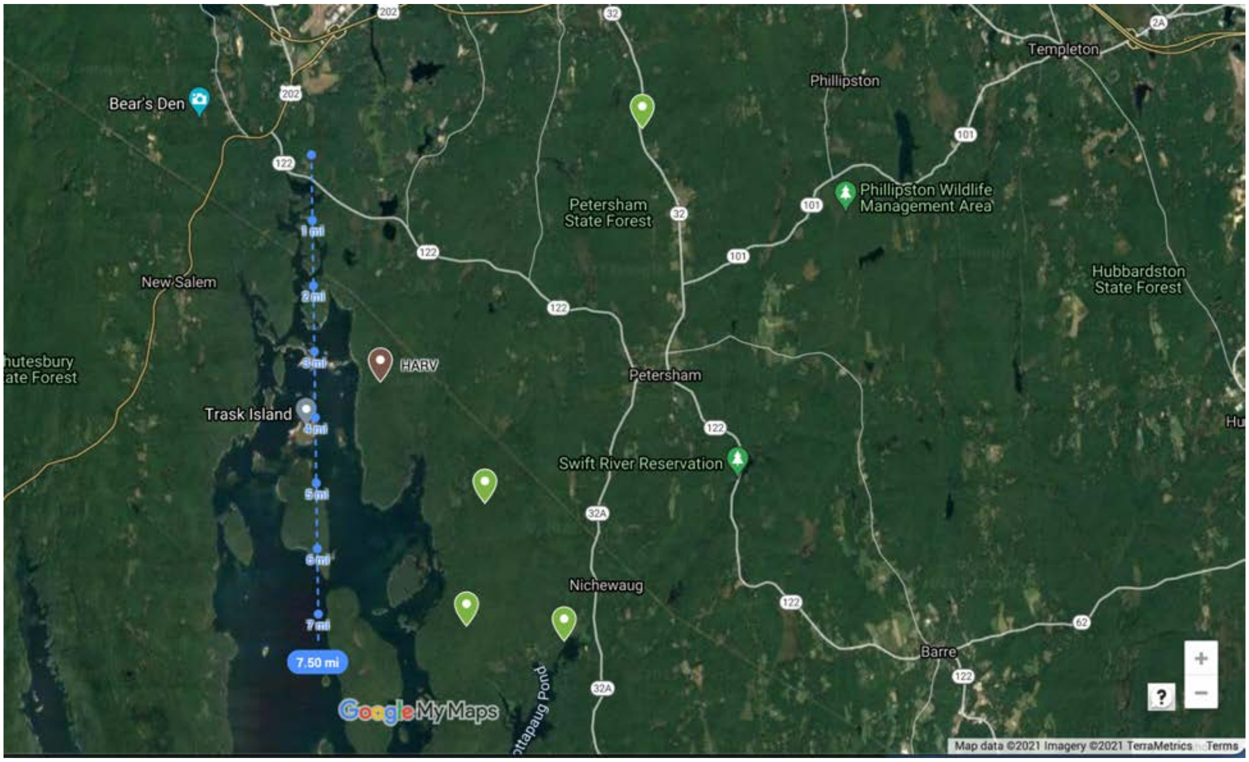
Research Methods:

We used data collected by the National Ecological Observatory Network (NEON) to measure mosquito presence. We chose this data source because, to study the effect of land cover type on mosquito populations, we needed data from mosquito traps in locations with similar climatic characteristics but different land cover types. These requirements made NEON an ideal data source. In contrast, when we set up our traps and tracked them using the GLOBE Observer Mosquito Habitat Mapper, each of us set up our traps in a single land cover type. As a result, the data we collected was unsuitable for answering our research question. More information about NEON's data collection protocols is included in the "Carrying Out Investigations" section.

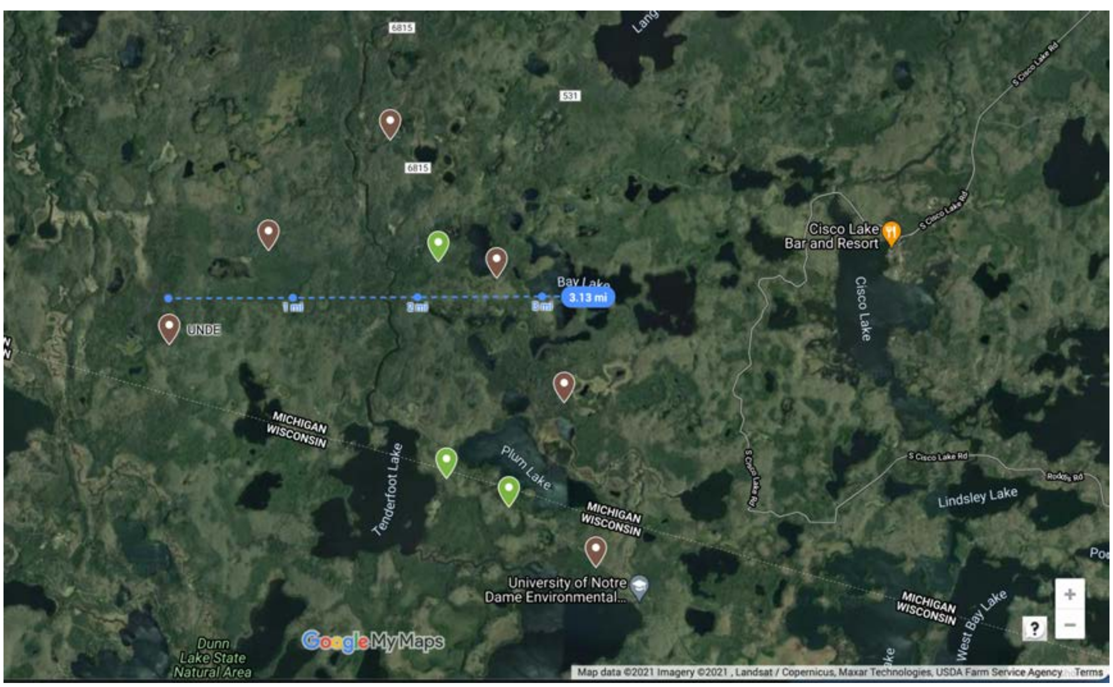
We chose to study two locations where NEON set up mosquito traps. The first location includes traps in Marenisco Township, MI, and Land O' Lakes, WI. This location is referred to by NEON as UNDE, and we will use this label as a reference to the location throughout this report. The second location is Petersham, Massachusetts, which we will refer to as HARV. We chose these locations because they both include traps in woody wetlands and deciduous forests. In each location, the traps are only a few miles away from each other, so climatic characteristics such as precipitation and temperature should not vary significantly.



Large Overview of Locations Along with Coordinates



HARV



UNDE

We focused on the period from June through September 2019. We chose to study the summer months because mosquito populations tend to be highest during the summer. In addition, we studied our mosquito traps and nearby land cover using GLOBE during the summer months. Accordingly, we were more familiar with summer conditions.

The National Ecological Observatory Network (NEON) uses CDC carbon dioxide light traps to collect mosquito specimens. They have two types of sites - Core and Relocatable Sites. We chose to study core sites, in which mosquito sampling occurs every two weeks. As a result, some of the months we studied had two sampling events, while others had three. For the months during which three sampling events occurred, we used the data from the latter two sampling events in our research.

The NEON Data Collection Protocol is designed to obtain the most accurate results possible. Therefore, its sampling protocols are the same across its core sites. The sampling plots are randomly located and they are within 30 meters of a road. For each sampling event, the traps are put out for 24 hours. NEON then sends the samples to an external lab. At some locations, a maximum of 200 mosquitoes is identified from each collection sample. This limitation is addressed in our conclusion section. However, in the locations we studied, we did not find that mosquito counting stopped at 200.

Results:

To see if the two land cover types vary significantly in the mosquito population, we calculated the monthly average mosquito count for each environment, as well as the total monthly mosquito count for each plot. The monthly average is the sum of the mosquito counts during the month for the plots of that land cover type divided by the number of plots, while the total for each plot is the sum of the mosquito counts for the individual plot per month. Figures 1a and 1b display the monthly average mosquito counts for the two locations we studied: UNDE and HARV. In figure (1a), the monthly mosquito count averages for June and July were very similar for the woody wetland and deciduous forest land cover types. The June averages were 429.67 and 429.33 mosquitoes, and in July, the deciduous forest average mosquito count was 21.83 mosquitoes more than that for the woody wetlands. For August and September, the averages for woody wetlands were decently higher than those for deciduous forests, with a 33.66 count difference in August and a similar 27 count difference in September averages. In figure (1b), the June totals were all in a very close range, just under 500 mosquitoes. The July counts showed similar but slightly lower figures, except for the woody wetlands plot 67. August showed the widest range of mosquito counts with the lowest being deciduous forest plot 76, having just under 500, and the highest being woody wetlands plot 67, containing near 875 mosquitoes. The majority of the plots had approximately 625 mosquitoes. In September, the woody wetlands plots had higher mosquito totals of approximately 125.

In figure (2a), the June average for deciduous forest populations was almost two times greater than that of woody wetlands. The July counts were within the same range of just under 700 mosquitoes, but the woody wetlands had a slightly greater average amount of mosquitoes. In August, the mosquitoes were within the same range, but the deciduous forest had slightly higher counts. September's averages had a sharp decline in quantity, but woody wetlands had a slightly higher number. In figure (2b), there was a wide range of mosquito totals in June, with the woody wetlands plot was lowest near 180 mosquitoes and the deciduous forest plots spanning 500 mosquitoes. All the July plot totals were in the 600-725 count range, except for the deciduous forest plot 74, whose count was near 375. All the plot totals in August were between 200-300 mosquitoes except for the deciduous forest plot 73, which had close to 550 mosquitoes. Finally, all the September totals were very low and in a close range.

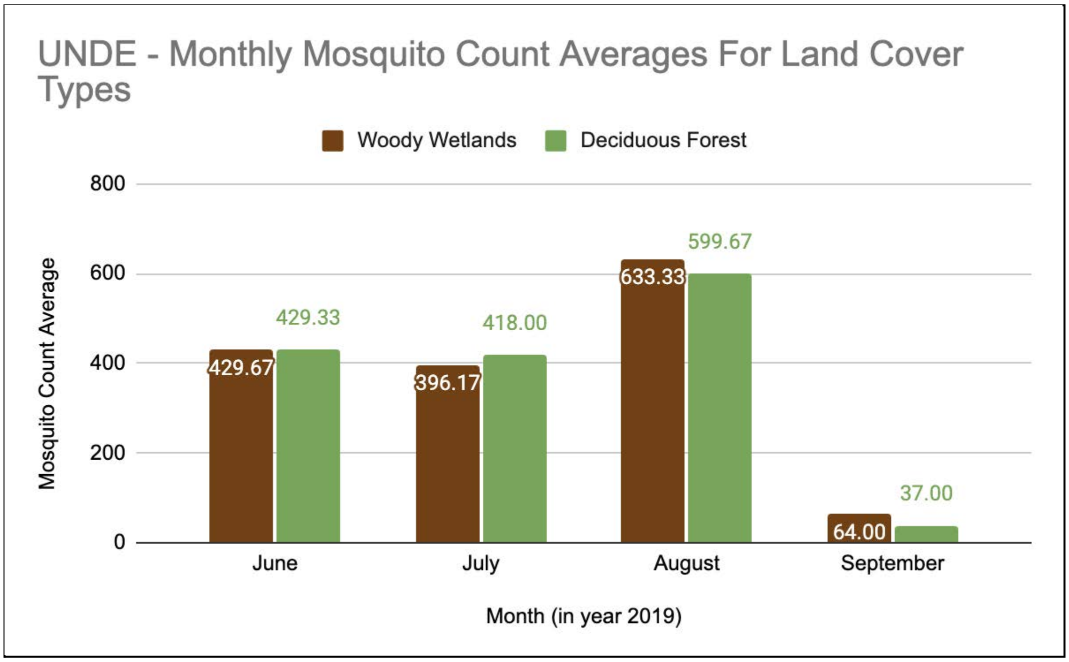


Figure 1a: UNDE Mosquito Totals Summer 2019

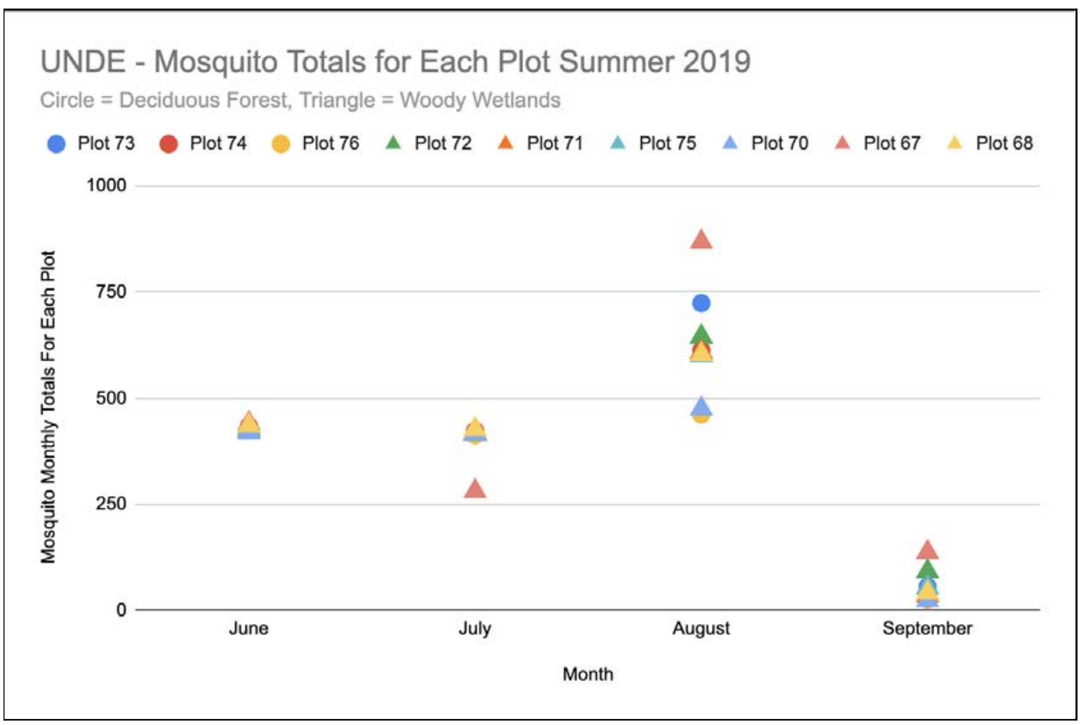


Figure 1b: UNDE Mosquito Totals Summer 2019

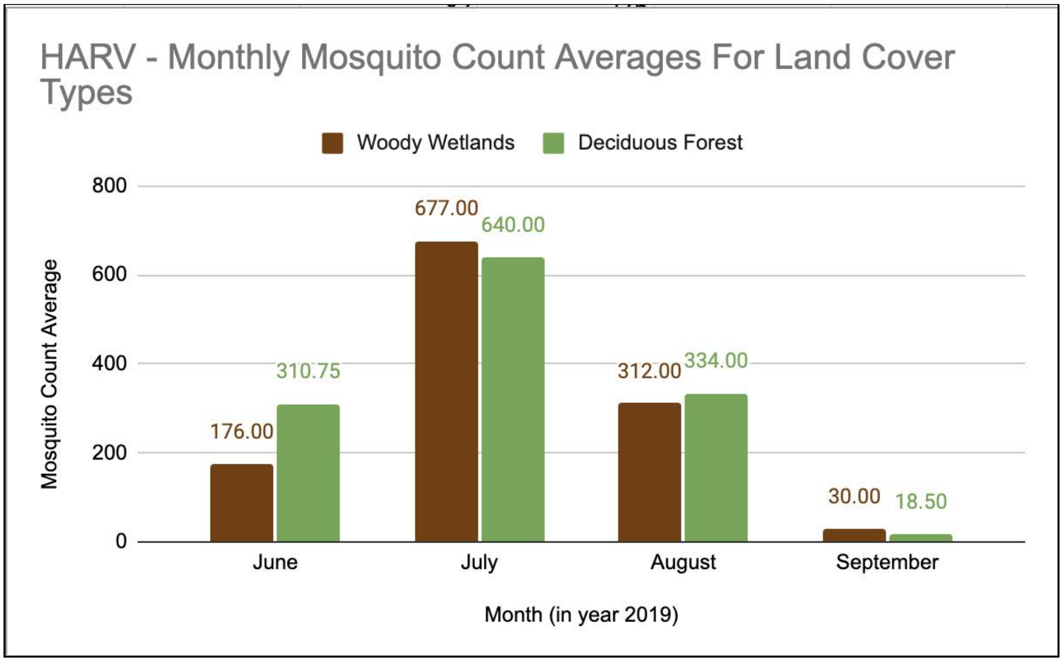


Figure 2a: HARV Mosquito Totals Summer 2019

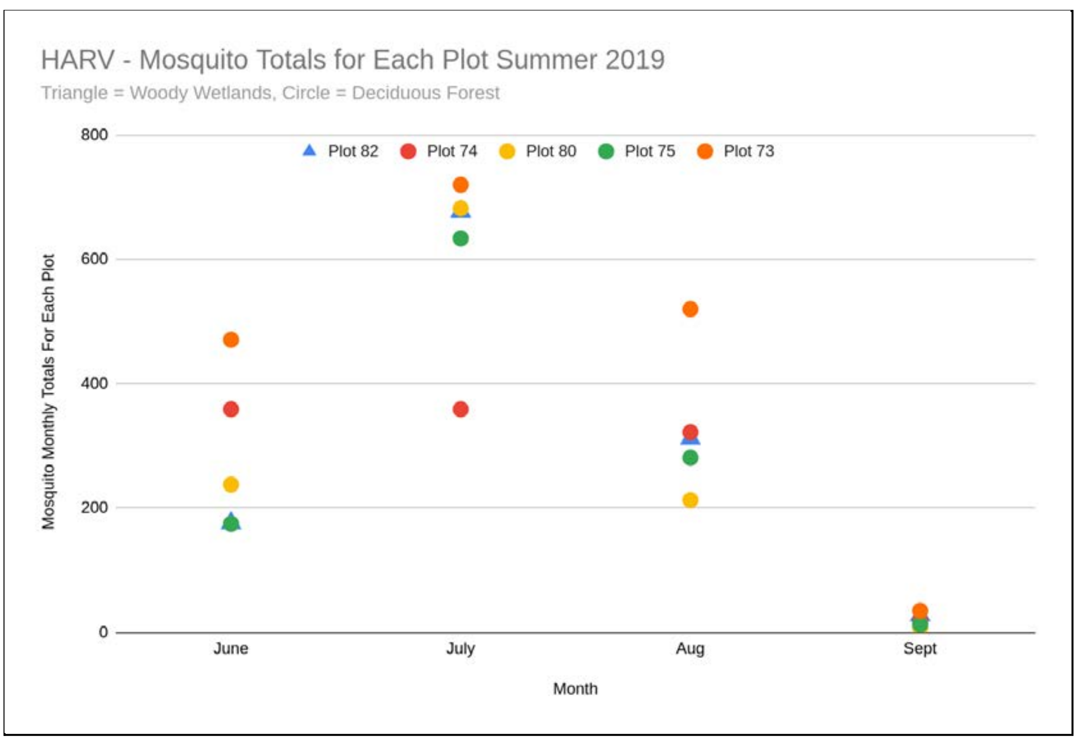


Figure 2b: HARV Mosquito Totals Summer 2019

Discussion:

After conducting research on the effect landcover has on mosquito populations in the HARV and UNDE NEON testing sites, our hypothesis was invalidated. As shown in our bar graphs and discussed in our results section, there was no significant difference between mosquito populations in deciduous forests and woody wetlands. We found no clear correlation between land cover type and mosquito population and we were not able to determine that the woody wetland land cover has higher mosquito populations.

Our data portrayed the deciduous forest land cover type and the woody wetlands land cover type as similar in mosquito populations because all averages were within the same range, or if there was a large difference, it was not consistent. However, in our research process, we found out that a 200 mosquito sampling cap placed on NEON data could have been a major limitation in verifying our hypothesis.

Furthermore, NEON indicated that they utilized CO2 traps to collect mosquitos. A study conducted by research from Southern Nazarene University suggested that "CDC-CO2 light traps arguably collect the greatest mosquito diversity of all common traps and are regularly used in mosquito-borne parasite surveillance (Sudia and Chamberlain 1962, Meyer et al. 1991, Service 1993), which maximizes comparability with other data sets. However, they have some limitations and may not provide comprehensive representations of the mosquito community structure or relative abundance" (Hoekman, et al.). Similarly, "other logistical challenges associated with standardization and transport of the fetid water for attracting ovipositing mosquitoes also may limit their suitability for NEON" (Hoekman et al.) and the overall scope of our research project.

Other factors that could have contributed to errors in data sampling could be natural disasters, trap type, wildlife interference, and other elements. As previously discussed, in similar studies, such as Heokman, et al., comparable results were found. Overall, due to these factors, the results of our study disproves the hypothesis that the woody wetland land cover has a greater abundance of mosquitoes as compared to deciduous forests.

Conclusions:

Based on our results, we concluded that there is not a significant difference in mosquito populations between deciduous forests and woody wetlands. We found that in some months, traps in woody wetlands had a greater number of mosquitoes than those in deciduous forests while, in others, the converse was true. Despite the huge distance between our two areas of study, this inconsistency was found in both locations, which strengthens our confidence in our findings. The fact that our hypothesis was incorrect and the greater presence of standing water in woody wetlands did not lead to higher mosquito populations demonstrates the complexity of the factors that affect mosquito oviposition and longevity.

An improvement that could be made to our research project would be to factor in variables like precipitation and temperature when studying the effect of land cover type on the mosquito population. We believe that this would result in more accurate and rigorous findings.

As we were conducting our research, we noticed that in many locations, NEON mosquito counting stopped at 200. Therefore, NEON is not an ideal data source for studying mosquito population counts. However, NEON does record the mosquito species present in its traps. A possible future study that would better utilize NEON data could involve analyzing overall mosquito species richness and diversity in different areas and how this relates to land cover type.

Another possible future research project could involve comparing mosquito populations in a broader range of land cover types, especially those that have a greater variation in key environmental characteristics.

Working with project mentors was advantageous because it allowed us to better understand the limitations of the data and navigate unfamiliar data structures. They also helped us narrow down our project scope and minimize the effect of external factors.

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This project included: Garima Bansal, Nico Bers, Aminata Kamara, Grace Tilley, and Amehja Williams.

Garima Bansal, Nico Bers, Aminata Kamara, Grace Tilley, and Amehja Williams analyzed data from NEON and plotted the findings on a google sheet. We also learned more about the relationships mosquitoes have with environmental factors by reading research papers and watching presentations given by the SEES mentors.

Garima Bansal is credited with corresponding with project mentors, researching, creating charts, writing the introduction and conclusion, and editing the report. *Nico Bers* is credited with researching, compiling data, creating charts, writing the results and bibliography, and editing the

video. *Aminata Kamara* is credited with researching, creating charts, writing the discussion and research questions, and editing the video. *Grace Tilley* is credited with writing the investigation planning section. *Amehja Williams* is credited with researching, writing the abstract and discussion, creating charts, and editing the report.

Badges

We earned the data scientist badge because we utilized our globe data to formulate our research questions and we analyzed data from The National Ecological Observatory Network (NEON) data for our project. We discussed the limitations of our data in the conclusion and determined that the data we used was sufficient for the areas we analyzed in our project but was not ideal for the scope of our investigation and in further research a different approach would be used.

We earned the STEM professional badge because we collaborated with the STEM professional, Dr. Alyson Parker, to enhance our knowledge of the NEON data set. We were able to investigate NEON's collection methods and their two hundred mosquito caps on mosquito identification with her help.