Using GLOBE Observations to Analyze the Effect of Hurricanes on Mosquito Population Patterns

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Abstract

Each year, hurricanes hit the United States coastline and disrupt ecosystems in the area. This research aimed to analyze the effect of hurricanes on mosquito population patterns. The scope of this research was the city of Miami, Florida from the time period of 2017 to 2022, in which GLOBE Mosquito Habitat Mapper data was collected. Data from the GLOBE Mosquito Habitat Mapper, local data from Miami-Dade, data from the EM-DAT international disasters database and other data collected from hurricanes that affected Florida from 2017 to 2022 was utilized. This research compiled these datasets and mapped the relationships between them to reveal a trend. Maps of mosquito density and mosquito observations in the five-year time frame were compared to specific hurricane data to determine how mosquito populations react after an extreme weather event. Additionally, through utilizing GLOBE Mosquito Habitat Mapper data, this research determined how frequently citizens of the affected area will observe mosquitos after a disaster. Ultimately, this research analyzed the relationship between the intensity of hurricanes and mosquito population patterns where they hit, as well as how they influence the occurrence of citizen science contributions. The outcomes of this research can be used to predict how future hurricanes can influence mosquito populations and subsequently inform public health policy decisions.

Research Question

How do hurricanes affect mosquito population patterns in Miami, Florida from 2017 to 2022 and the frequency of citizen science contributions through GLOBE Mosquito Habitat Mapper observations?

Introduction

Mosquitoes are flying insects that can be vectors, which spread various pathogens to humans and animals alike (CDC, 2020). Across the world, vector-diseases account for more than 700,000 deaths each year (WHO, 2020). In order to reduce the transmission of vector-diseases by mosquitoes, it is essential to understand the patterns of mosquito populations.

Hurricanes are large storms that form over warm ocean waters. Strong wind, heavy rain and storm surge caused by hurricanes can all have detrimental effects (NASA, 2014). Hurricanes tend to result in a variety of long-lasting damages that can contribute to causing or exacerbating various diseases (Waddell et al, 2021). Such damages and changes have the potential to greatly affect mosquito populations, especially in areas such as Miami, Florida.

The term citizen science is frequently used to describe situations in which the public voluntarily helps to conduct research. Citizen science in the field of mosquito population studies is most seen in the Global Learning and Observations to Benefit the Environment (GLOBE) application, which is an international program that allows citizens and scientists to collaborate in monitoring changes in various Earth systems (Low et al., 2021).

This research focused on the city of Miami specifically, due to its location on the southeast coast of the state of Florida. Through focusing on this area, more hurricane data and history was available for analysis. Additionally, due to it being an urban area, comparatively more Mosquito Habitat Mapper observations were made on the GLOBE Observer app.

Research Methods

This research was conducted by collecting simultaneous field observations from several sources. Firstly, data from all hurricanes that affected the Miami-Dade county of Florida from the years of 2017 to 2022 were gathered from NOAA Historical Hurricane Tracks database, National Hurricane Center Reports and National Centers for Environmental Information International Best Track Archive for Climate Steward.

Secondly, mosquito count surveillance data from Miami-Dade County, where Miami is located, was collected from several local sources and research. In their research paper about the community composition and abundance of vector species mosquitoes in Miami-Dade County, Wilke et al. established a mosquito surveillance system in the county and were able to find the prevalence of each mosquito species per season (Wilke et al. 2019). Their results are shown below in Figure 1.

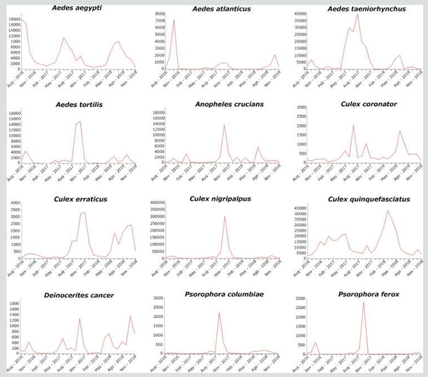

Figure 1: Seasonal mosquito surveillance counts in Miami-Dade County from August 2016 to November 2018. Adapted from "Community Composition and Year-round Abundance of Vector Species of Mosquitoes make Miami-Dade County, Florida a Receptive Gateway for Arbovirus Entry to the United States" by Wilke et al., 2019.

Lastly, research from the GLOBE Mosquito Habitat Mapper database was used to determine how hurricanes also influence mosquito habitat reporting in the affected area. Prior to analyzing the data, the data set was cleaned and condensed in order to reduce the amount of memory and time used to parse the dataset. The final data set included the latitude, longitude, time the data was collected, and the larvae count that was collected. Data cleaning was performed via Microsoft Excel, utilizing mostly the functions to delete columns and add filters to columns. Once data cleaning was complete, the data was saved as a CSV file for parsing.

After collecting data from these three areas, a python script was written to analyze the differences and similarities between them. The code was written with the Jupyter Notebook computing platform, using the matplotlib and pandas libraries and the OS and datetime modules. Both methods parse a CSV file that has a table with columns for latitude, longitude, larvae count, and time in that order and drop the data from the file that is not relevant to the location to be analyzed, including only data from the region bounded by latitudes 24.5o N and 31o N and longitudes 80o W and 87o W. Both methods then create graphs, which are then used to analyze the relationship between mosquito populations and hurricanes.

GLOBE IVSS Badge

Data Scientist- We analyzed multiple data sets, comparing them to reveal trend lines. The data was used to investigate and answer our research question. We also pointed out the limitations of the data like limited time frame or limited data volume.

Results

The script written was able to produce several results. The first result can be seen in Figure 2 below, which depicts the dispersion of larvae counts observed through the GLOBE Observer app in Florida from 2017 to 2022. Due to this map demonstrating a relatively high concentration of data in certain locations and the information found about hurricanes that passed through Florida between 2017 and 2022, the Miami-Dade region was chosen to be analyzed.

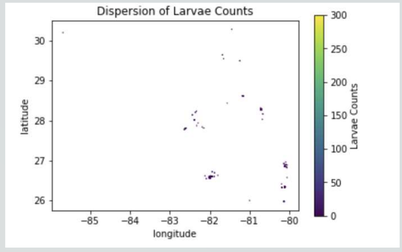

Figure 2: Dispersion of larvae counts observed through the GLOBE Observer App in Florida from 2017 to 2022

Then, this information was demonstrated on a scatter plot and a line graph. Figures 3 and 4 show the relationship between the time of the mosquito habitat observation and the larvae count recorded for the observation as a scatter plot and line graph, respectively.

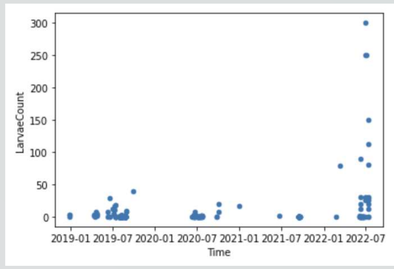

Figure 3: Relationship between the time of a mosquito habitat observation and its recorded larvae count as a scatter plot

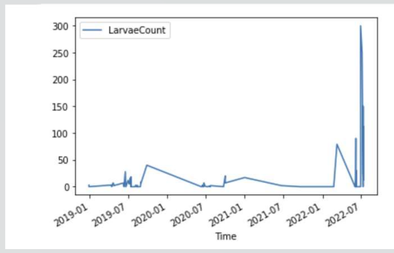

Figure 4: Relationship between the time of a mosquito habitat observation and its recorded larvae count as a line graph

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Discussion

Our research revealed a trend connecting hurricane occurrences and mosquito populations. Firstly, the mosquito populations of the most abundant mosquito species in Miami-Dade County appear to experience rapid population growth following intense storms. During the dates of hurricanes and large storms, many species experienced a local maximum in the following months. The increase in mosquito populations due to hurricanes could be the effect of flooding. The CDC states that floodwaters give rise to floodwater mosquitoes. Secondly, the data on mosquito habitat observations also show bumps in the data near the dates of hurricanes and tropical storms. An increase in mosquito habitat observations could be the result of damaged infrastructure creating breeding sites.

The storms that we studied occurred around similar times of the year, during August and September. With no mosquito data for storms that appeared earlier or later in the year, it is possible that our data coincidently lined up with natural seasonal population growth of mosquitoes. More data is needed to confirm our findings.

Conclusion

The results of this research show that hurricanes increase mosquito population based on their intensity. Data showed large increases in mosquito population following intense hurricanes, and minor increase in mosquito population following less intense tropical storms. However, the data only covers a few storms, and there is a lack of seasonal variance between the storms investigated.

This research can be used to inform future research done on mosquito population patterns in any area, in relation to air temperature, wind speed and rainfall levels. In the future, this research can also be used to create simulations that take data from a hurricane, such as its severity and predicted rainfall levels, and return how many mosquitoes of different species will be present in the months following the event. This can then be used to inform public health policy decisions, such as increased precautions of vector-borne disease spread at certain points throughout hurricane season.

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