# Analyzing the Effects of Urbanization on Mosquito Population Dynamics Using Citizen Science Data

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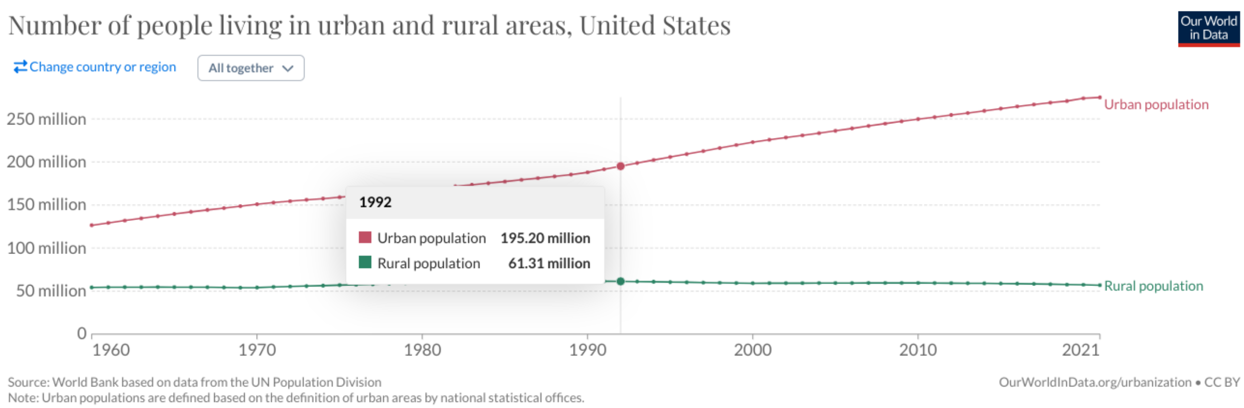
# Abstract

Mosquito behaviors have changed drastically over the last few decades due to changes in environments in which mosquitoes inhabit. Urbanization is a leading factor in the alteration and modification of natural environments, and mosquito breeding populations are influenced by various known environmental factors, prompting the questions: 1) How consistent is citizen science data for finding an association? and 2) How do mosquito population dynamics vary depending on urbanization?




The number of people living in Urban Areas in the U.S. greatly exceeds the number living in rural areas, making them prime areas for mosquitos to feed.
~ Our World in Data: UN Population Division

The goals of this project were to analyze citizen science data and use the findings to provide additional insight into one of the key contributors of mosquito population growth. During this investigation, researchers gathered mosquito larvae and land cover data from GLOBE Observer datasets, comparing the larvae population variance to determine the extent to which urban settings affect mosquito breeding. Socioeconomic and other environmental factors were not taken into consideration during the investigation. It was found that the association between urbanization and breeding varied greatly depending on the scope of the citizen science data gathered. Depending on the states filtered in the data access tool, the correlation coefficient ranged from 0.077 to 0.55. Overall, it can be concluded that citizen science is not consistent enough to prove an association between urbanization and mosquito breeding, which could be for a variety of reasons, including lurking variables that were not taken into account and the subjectiveness of data collection. To fix this issue, in the future, scientists could integrate NASA/government datasets with citizen science programs like GLOBE to increase the effectiveness of citizen science in research.

# Research Questions

1. How useful is citizen science in helping to inform/predict mosquito outbreaks?

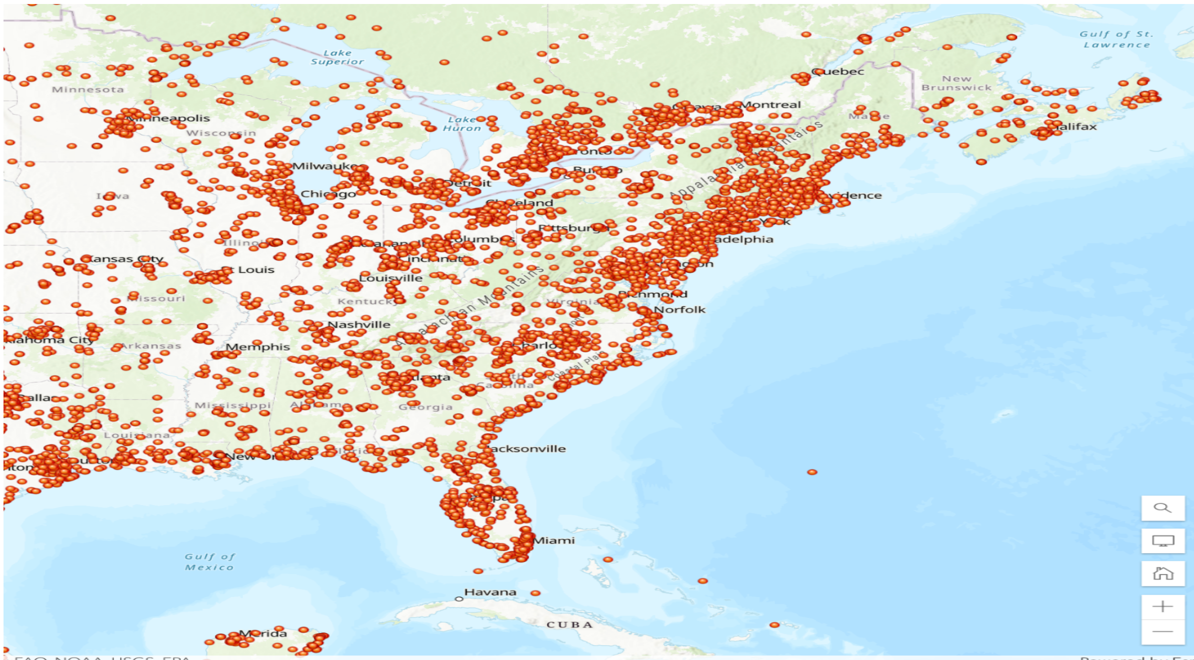
Citizen science has become increasingly useful for both the inclusion of the public in advancing science and also for the quality of data provided in a variety of scientific fields. For the purposes of this project, creating a predictive model based purely on citizen science may not have been very accurate due to the subjectiveness of the data contribution process on platforms such as GLOBE Observer, and also other factors that may affect mosquito breeding. To test the applicability of citizen science data, researchers used multiple scopes of data, from a very small part of the U.S. to an entire climate zone. If the correlations varied greatly, this would be an indication that citizen science may not be the best tool to gather data to create models.

2. To what extent does urbanization affect mosquito population dynamics?

In this research paper, "urbanization" refers to the process of rapid growth, increased land use/development, and the presence of heat islands in an area. Researchers were constrained by a three-week time limit, which prevented them from considering every variable of urbanization in the study, but they were able to use land cover classification to represent the degree of urbanization at a given site. Based on this, if the citizen science data was consistent enough through multiple iterations of data collection, a correlation could have been found between mosquito population and urbanization by graphing data and performing linear regression.

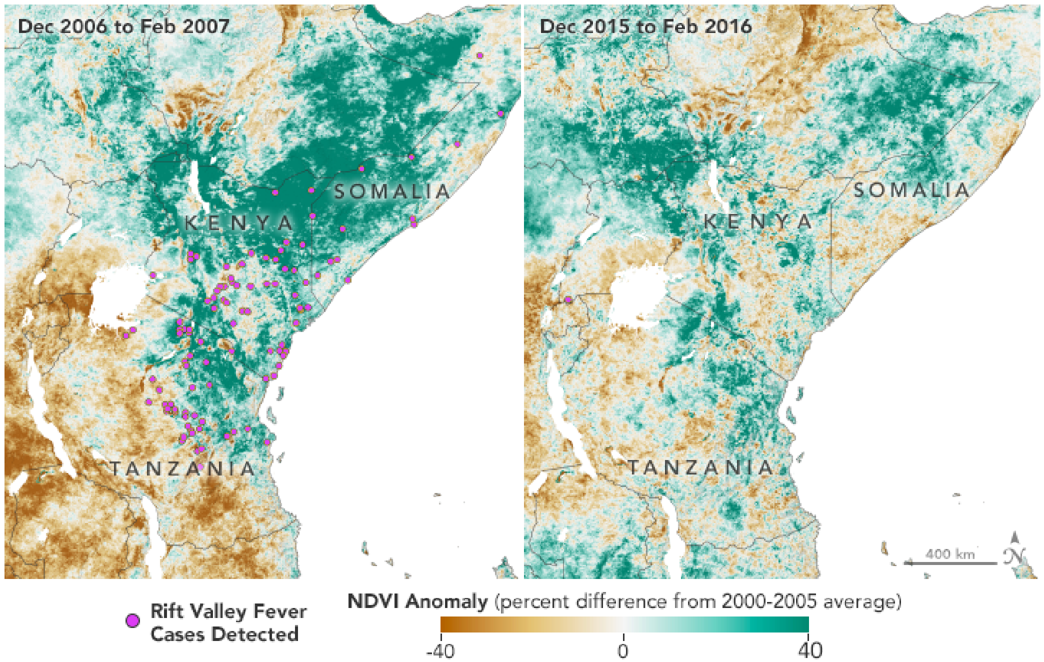
## Introduction

Insect vectors such as *Aedes Aegypti*, *Culex*, and *Anopheles genera* are common throughout the world and are tied to disease outbreaks such as West Nile Virus, Dengue, and Zika. Mosquitoes have been coined the nickname “world’s deadliest animal” because their “vector-borne diseases cause more than 700,000 deaths worldwide” every year (Pfizer Inc., 2023).




The image displays a map from ArcGIS, with locations with mosquito datasets within the area of interest.
~ ArcGIS

Informing the public of the patterns, distribution, and breeding hot spots of these mosquitoes based on urbanization is critical in the prevention of major outbreaks and saving lives. The most efficient way to combat the prevalence of vector-borne diseases is to track these vectors. There are existing disease risk models that use NASA data, weather and climate data, for example, to track mosquito population dynamics, and these findings will aid in the future creation of such models by evaluating the efficacy of citizen science in data collection.




Model depicts NDVI and fever cases detected in Rift Valley. Greener areas are usually wetter, suggesting better habitat for mosquitoes. Favorable conditions for mosquitoes in 2006 led to Rift Valley fever (RVF) outbreaks in eastern Africa. The region greened again in 2015, but early warnings helped officials prevent the spread of RVF. NASA Earth Observatory maps by Lauren Dauphin, using NDVI anomaly data from Terra MODIS. (NDVI and fever cases detected in Rift Valley, 2017)

~ NASA Earth Observatory

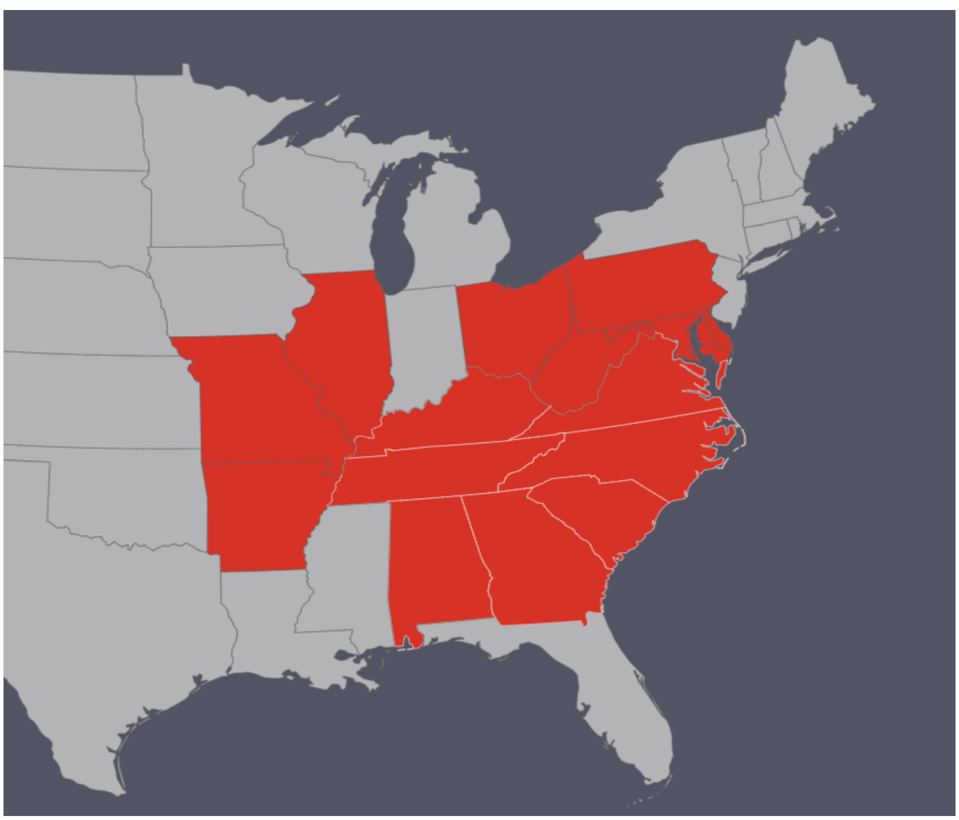
There are a plethora of factors that affect mosquito population dynamics and breeding preference, such as soil moisture, air temperature, surface temperature, proximity to blood sources, and land-usage to name a few. In fact it is widely known that “Aedes aegypti population dynamics are driven by a range of environmental factors, including temperature, sunlight, humidity, and rainfall” (Cavany 2023). The goal, by concentrating the team’s efforts on urbanization in a specific climate zone of the continental United States, is to combine several of these factors to justify attempting to find a correlation. Certain factors, such as temperature, can be held constant in an attempt to make urbanization the independent variable. By focusing on and researching the relationship between urbanization and the presence of mosquito larvae, scientists can accurately predict mosquito borne disease outbreaks based on land cover classifications to ensure the safety of the public.

By using citizen-science programs, scientists can “capture more widely spread data without spending additional funding” (Ullrich, 2023). While the collection of accessible and quality data is important, citizen science also empowers the public to take part in research initiatives that could save lives. Citizens, however removed from the scientific field, can now make an impact on causes important to them and “promote new ideas to advance our understanding of the world” (Ullrich, 2023). Using GLOBE data in particular, researchers had access to data spanning a decade back and from a variety of locations all over the world. In a way, citizens are contributing to a project that can benefit both themselves and their communities.

## Methodology

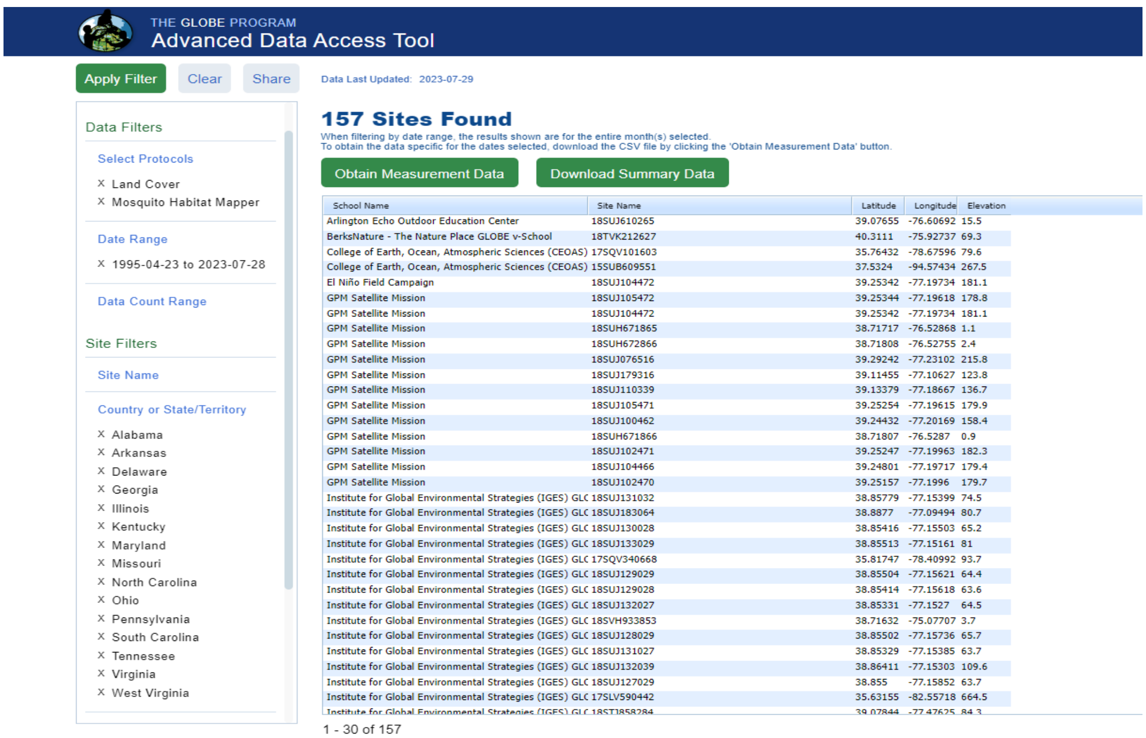
Citizen science-based land cover and mosquito larvae datasets were gathered first. This allowed researchers to determine how consistent the citizen science data would be for the project. A simple and effective citizen science tool was preferred, with large amounts of public data readily available. The entire project was based on this citizen science data, which helped to determine how well publicly contributed data can help with research. Next, by simply filtering the datasets by key protocols, the team could graph and find relationships in the data in order to determine the extent to which land cover classification could inform mosquito breeding.

For the study site, the team chose as many states in the same mixed-humid/subtropical climate zone in the southern and eastern portion of the United States to hold that variable constant. This involved the states Alabama, Arkansas, Delaware, Georgia, Illinois, Kentucky, Maryland, Missouri, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Virginia, and West Virginia. This many states were included in the scope of the data because researchers wanted the most amount of data on hand without sacrificing the variables that could be held constant. Because the scope was so large and not very localized, land cover differed drastically across observations, from greenbelts and trees to urban developments, which helped in obtaining valid data points for the study.



This image features a map indicating our area of interest for the study.

Researchers utilized the GLOBE Observer Advanced Data Access Tool in order to obtain citizen science data, with the protocols "Land Cover" and "Mosquito Habitat Mapper", allowing them to directly answer research questions. Data was utilized from around 50 sites - each individual site involved a fieldwork process of land cover classification and mosquito habitat mapping, the combination of which allowed for researchers to determine whether an association existed.




| School Name | Site Name | Latitude | Longitude | Elevation |
|---|---|---|---|---|
| Arlington Echo Outdoor Education Center | 18SUJ610265 | 39.07655 | -76.60692 | 15.5 |
| BerksNature - The Nature Place GLOBE v-School | 18TVK212627 | 40.3111 | -75.92737 | 69.3 |
| College of Earth, Ocean, Atmospheric Sciences (CEOAS) | 17SQV101603 | 35.76432 | -78.67596 | 79.6 |
| College of Earth, Ocean, Atmospheric Sciences (CEOAS) | 15SUB609551 | 37.5324 | -94.57434 | 267.5 |
| El Niño Field Campaign | 18SUJ104472 | 39.25342 | -77.19734 | 181.1 |
| GPM Satellite Mission | 18SUJ105472 | 39.25344 | -77.19618 | 178.8 |
| GPM Satellite Mission | 18SUJ104472 | 39.25342 | -77.19734 | 181.1 |
| GPM Satellite Mission | 18SUH671865 | 38.71717 | -76.52868 | 1.1 |
| GPM Satellite Mission | 18SUH672866 | 38.71808 | -76.52755 | 2.4 |
| GPM Satellite Mission | 18SUJ076516 | 39.29242 | -77.23102 | 215.8 |
| GPM Satellite Mission | 18SUJ179316 | 39.11455 | -77.10627 | 123.8 |
| GPM Satellite Mission | 18SUJ110339 | 39.13379 | -77.18667 | 136.7 |
| GPM Satellite Mission | 18SUJ105471 | 39.25254 | -77.19615 | 179.9 |
| GPM Satellite Mission | 18SUJ100462 | 39.24432 | -77.20169 | 158.4 |
| GPM Satellite Mission | 18SUH671866 | 38.71807 | -76.5287 | 0.9 |
| GPM Satellite Mission | 18SUJ102471 | 39.25247 | -77.19963 | 182.3 |
| GPM Satellite Mission | 18SUJ104466 | 39.24801 | -77.19717 | 179.4 |
| GPM Satellite Mission | 18SUJ102470 | 39.25157 | -77.1996 | 179.7 |
| Institute for Global Environmental Strategies (IGES) GLC | 18SUJ131032 | 38.85779 | -77.15399 | 74.5 |
| Institute for Global Environmental Strategies (IGES) GLC | 18SUJ183064 | 38.8877 | -77.09494 | 80.7 |
| Institute for Global Environmental Strategies (IGES) GLC | 18SUJ130028 | 38.85416 | -77.15503 | 65.2 |
| Institute for Global Environmental Strategies (IGES) GLC | 18SUJ133029 | 38.85513 | -77.15161 | 81 |
| Institute for Global Environmental Strategies (IGES) GLC | 17SQV340668 | 35.81747 | -78.40992 | 93.7 |
| Institute for Global Environmental Strategies (IGES) GLC | 18SUJ129029 | 38.85504 | -77.15621 | 64.4 |
| Institute for Global Environmental Strategies (IGES) GLC | 18SUJ129028 | 38.85414 | -77.15618 | 63.6 |
| Institute for Global Environmental Strategies (IGES) GLC | 18SUJ132027 | 38.85331 | -77.1527 | 64.5 |
| Institute for Global Environmental Strategies (IGES) GLC | 18SVH933853 | 38.71632 | -75.07707 | 3.7 |
| Institute for Global Environmental Strategies (IGES) GLC | 18SUJ128029 | 38.85502 | -77.15736 | 65.7 |
| Institute for Global Environmental Strategies (IGES) GLC | 18SUJ131027 | 38.85329 | -77.15385 | 63.7 |
| Institute for Global Environmental Strategies (IGES) GLC | 18SUJ132039 | 38.86411 | -77.15303 | 109.6 |
| Institute for Global Environmental Strategies (IGES) GLC | 18SUJ127029 | 38.855 | -77.15852 | 63.7 |
| Institute for Global Environmental Strategies (IGES) GLC | 17SLV590442 | 35.63155 | -82.55718 | 664.5 |
| Institute for Global Environmental Strategies (IGES) GLC | 18STJ858284 | 39.07844 | -77.47625 | 84.3 |

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Every observation site that met these specified filters was meticulously reviewed and analyzed to ensure comprehensive and up-to-date information. They were able to accurately determine the degree of urbanization at each site by averaging the percentage of urban characteristics in all four cardinal directions. This process was repeated over 50 times with each site. Analysts then analyzed this data with mosquito data in the same location/area to determine the correlation between urbanization and mosquito population dynamics. The correlation coefficient is a measure of the strength and direction of a relationship between two variables. It ranges from -1 to 1, with 1 representing a perfect positive correlation, -1 representing a perfect negative correlation, and 0 representing no correlation. The closer the coefficient is to 1 or -1, the stronger the correlation between the two variables.

The correlation coefficient formula was utilized to determine the association between urbanization and mosquito population because it is a widely used statistical tool to measure the strength of a linear relationship between two variables. The formula takes into account the variability in both variables and produces a single value that reflects the strength and direction of the association. This helps the team to better understand the relationship between urbanization and mosquito population.

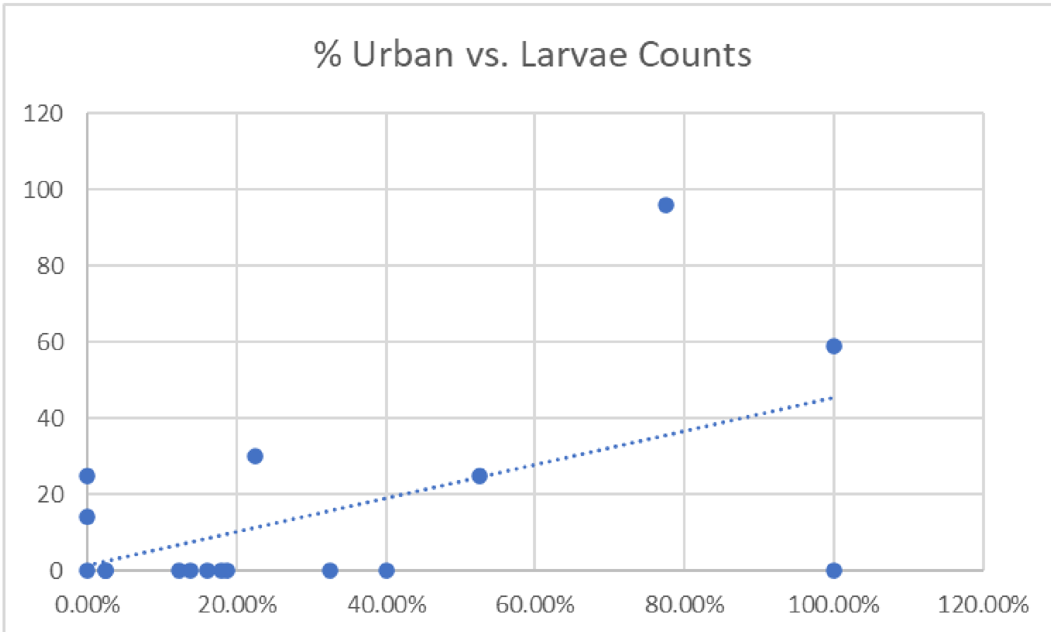
Analysts utilized Microsoft Excel to quantify the data from GLOBE Observer using the correlation coefficient formula.

| site_id | land cover | land cover | land cover | land cover | mosquito | mosquito | mosquito | mosquito | mosquito | mosquito | mosquito | mosquito | mosquito | mosquito | mosquito | mosquito | mosquito | mosquito | mosquito | mosquito | mosquito |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| The GLOBE ID assigned to the site | | | | | | | | | | | | | | | | | | | | | |
| 98946 | | | | | 25-Jan | FALSE | | TRUE | TRUE | identify-siphon-pecten | | | FALSE | | https://data.globe.gov/system/photos/20 | | | | 39.07655 | -76.60692 | 15.5 |
| 98946 | | | | | 25-Jan | | | TRUE | TRUE | identify-siphon-pecten | | | FALSE | | https://da | https://data.globe.gov/system/ | | | 39.07655 | -76.60692 | 15.5 |
| 98946 | | | | | | | | | | | | | | | | | | | | | |
| 98946 | | | | | 16 | FALSE | | FALSE | TRUE | identify-siphon-shape | | | TRUE | | https://da | https://data.globe.gov/system/ | | | 39.077 | -76.6068 | 0 |
| 98946 | | | | | | FALSE | | FALSE | FALSE | identify-basal-tuft | | | TRUE | | https://da | https://data.globe.gov/system/ | | | 39.0771 | -76.6059 | 0 |
| 98946 | | | | | 42 | FALSE | | FALSE | TRUE | identify | | | TRUE | | https://da | https://da | https://data.globe.g | | 39.0774 | -76.6062 | 0 |
| 147899 | | | | | | | | FALSE | | identify | | | FALSE | | https://data.globe.gov/system/ | | | Too cold f | 35.7647 | -78.6756 | 0 |
| 147899 | 50% MUC ( | 50% MUC ( | 10% MUC ! | 40% MUC 02 (b) [Trees, Closely Spaced, Deciduous - Broad Leaved]; 10% MUC 11 (n) [Trees, Loosely Spaced, Evergreen - Needle Leaved]; 10% MUC 43 [Herbaceous/Grassland, Short Grass] | | | | | | | | | | | | | | | | | |
| 36194 | | | | | 25-Jan | FALSE | | FALSE | FALSE | identify-siphon-pecten | | | TRUE | | https://da | https://data.globe.gov/system/ | | | 39.25342 | -77.19734 | 181.1 |
| 36194 | | | | | | | | | | | | | | | | | | | | | |
| 144543 | | | | | | | | FALSE | | | | | TRUE | | https://data.globe.gov/system/photos/20 | | | | 38.7175 | -76.5278 | 0 |
| 144543 | | | | | | | | | | | | | | | | | | | | | |
| 171619 | | | | | | | | FALSE | | identify | | | FALSE | | https://data.globe.gov/system/photos/20 | | | | 38.7185 | -76.5277 | 0 |
| 171619 | | | | | | | | FALSE | | identify | | | FALSE | | https://data.globe.gov/system/photos/20 | | | | 38.7183 | -76.5277 | 0 |
| 171619 | | | | | | | | | | | | | | | | | | | | | |
| 171619 | | | | | | | | FALSE | | identify | | | FALSE | | https://data.globe.gov/system/photos/20 | | | | 38.7185 | -76.5278 | 0 |
| 144544 | | | | | | | | FALSE | | | | | TRUE | | https://data.globe.gov/system/photos/20 | | | | 38.7184 | -76.5271 | 0 |
| 144544 | | | | | 11 | FALSE | | FALSE | FALSE | identify-later | | | TRUE | | https://data.globe.gov/system/photos/20 | | | | 38.7185 | -76.5271 | 0 |
| 144544 | | | | | 3 | FALSE | | FALSE | FALSE | identify-later | | | TRUE | | https://data.globe.gov/system/photos/20 | | | | 38.7182 | -76.5274 | 0 |
| 144544 | 50% MUC : | 10% MUC : | 60% MUC : | 40% MUC 12 (b) [Trees, Loosely Spaced, Deciduous - Broad Leaved]; 70% MUC 43 [Herbaceous/Grassland, Short Grass]; 10% MUC 72 [Open Water, Marine] | | | | | | | | | | | | | | | | | |
| 144544 | | | | | | | | | | | | | | | | | | | | | |
| 144544 | | | | | | | | FALSE | | identify | | | FALSE | | https://data.globe.gov/system/photos/20 | | | | 38.7189 | -76.5275 | 0 |
| 144544 | | | | | | | | | | | | | | | | | | | | | |
| 144544 | | | | | | | | FALSE | | identify | | | FALSE | | https://data.globe.gov/system/photos/20 | | | | 38.7189 | -76.5275 | 0 |
| 144544 | | | | | 0 | | | FALSE | | | | | TRUE | LarvaeVisi | https://data.globe.gov/system/photos/20 | | | | 38.7185 | -76.5272 | 0 |
| 144544 | | | | | | | | | | | | | | | | | | | | | |
| 150914 | | | | | | | | FALSE | | identify | | | TRUE | | https://data.globe.gov/system/photos/20 | | | | 39.293 | -77.2304 | 0 |
| 150914 | | | | | | | | | | | | | | | | | | | | | |
| 169797 | | | | | | | | | | | | | | | | | | | | | |
| 169797 | | | | | | | | FALSE | | identify | | | FALSE | | https://data.globe.gov/system/photos/20 | | | | 39.2446 | -77.2013 | 0 |
| 198288 | | | | | | | | FALSE | | identify | | | FALSE | | https://data.globe.gov/system/photos/20 | | | | 39.2518 | -77.1992 | 0 |

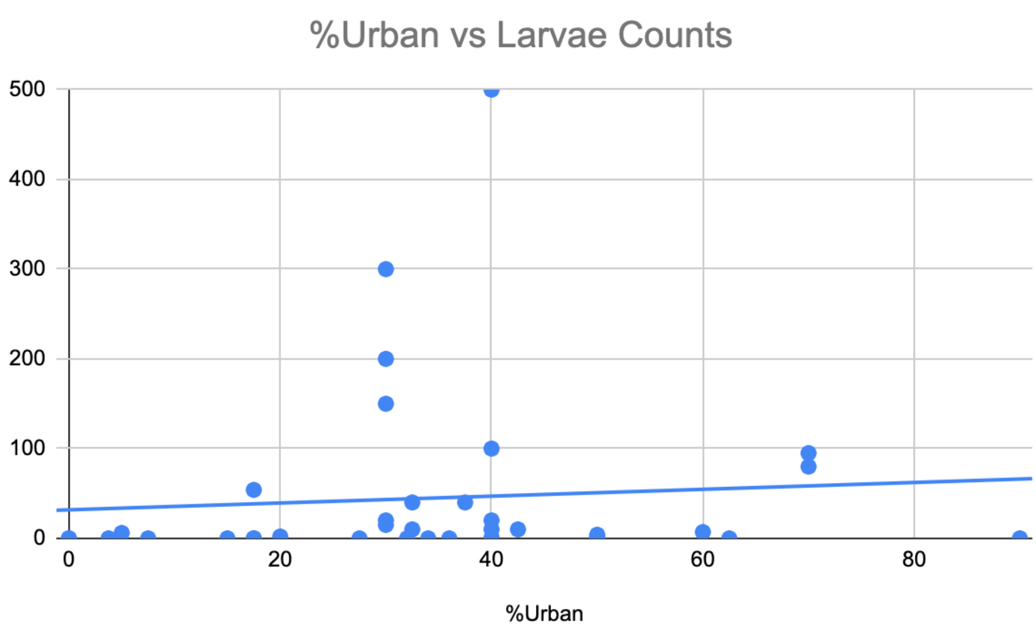
| Site Id | School Nai | Site Name | Protocol | Data Coun | Latitude | Longitude | Elevation | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 98946 | Arlington I | 18SUJ610 | land_cove | 6 | 39.0766 | -76.6069 | 15.5 | | Site | urban/residential | habitat counts |
| 147899 | College of | 17SQV101 | land_cove | 2 | 35.7643 | -78.676 | 79.6 | | 147899 | 2.50% | 2 |
| 36194 | El NiÃ±o Fi | 18SUJ104 | land_cove | 2 | 39.2534 | -77.1973 | 181.1 | | 144544 | 0% | 10 |
| 144543 | GPM Satel | 18SUH671 | land_cove | 2 | 38.7172 | -76.5287 | 1.1 | | 46273 | 100% | 35 |
| 171619 | GPM Satel | 18SUH671 | land_cove | 4 | 38.7181 | -76.5287 | 0.9 | | 35785 | 100% | 73 |
| 144544 | GPM Satel | 18SUH672 | land_cove | 10 | 38.7181 | -76.5276 | 2.4 | | 137256 | 40% | 7 |
| 150914 | GPM Satel | 18SUJ076 | land_cove | 2 | 39.2924 | -77.231 | 215.8 | | 51934 | 77.50% | 10 |
| 169797 | GPM Satel | 18SUJ100 | land_cove | 2 | 39.2443 | -77.2017 | 158.4 | | 137478 | 18.75% | 9 |
| 198288 | GPM Satel | 18SUJ102 | land_cove | 2 | 39.2516 | -77.1996 | 179.7 | | 215468 | 0.00% | 3 |
| 193178 | GPM Satel | 18SUJ102 | land_cove | 5 | 39.2525 | -77.1996 | 182.3 | | 137434 | 22.50% | 7 |
| 194112 | GPM Satel | 18SUJ104 | land_cove | 2 | 39.248 | -77.1972 | 179.4 | | 137438 | 12.35% | 9 |
| 46273 | GPM Satel | 18SUJ104 | land_cove | 35 | 39.2534 | -77.1973 | 181.1 | | 137295 | 0.00% | 3 |
| 165729 | GPM Satel | 18SUJ105 | land_cove | 6 | 39.2525 | -77.1962 | 179.9 | | 318563 | 13.76% | 3 |
| 35785 | GPM Satel | 18SUJ105 | land_cove | 73 | 39.2534 | -77.1962 | 178.8 | | 319221 | 18.00% | 11 |
| 159401 | GPM Satel | 18SUJ110 | land_cove | 9 | 39.1338 | -77.1867 | 136.7 | | 319222 | 16.07% | 9 |
| 154969 | GPM Satel | 18SUJ179 | land_cove | 3 | 39.1146 | -77.1063 | 123.8 | | 318802 | 2.50% | 3 |
| 246946 | Institute f | 17SLV590 | land_cove | 4 | 35.6316 | -82.5572 | 664.5 | | 241973 | 52.50% | 4 |
| 148205 | Institute f | 17SQV34( | land_cove | 2 | 35.8175 | -78.4099 | 93.7 | | 36326 | 32.50% | 7 |

A significant positive correlation was discovered between the urbanization in a location and proportion of mosquito larvae counts for the first scope of our data. Analysts created linear regression and a least-squares regression model to visualize a line of best fit and determine both the correlation coefficients and variance of the data. With more than 50 data points available to use, the citizen science data gathered was sufficient enough to answer the first and therefore second research question outlined by the team.

# Results




~ GLOBE Data in Virginia, Maryland, North Carolina, and Delaware
Correlation Coefficient (R): 0.55 - moderately strong, positive
Variance (R^2): 0.303




~ GLOBE Data in Kentucky, Tennessee, West Virginia, South Carolina, Missouri, Arkansas, Pennsylvania, Ohio, Illinois, Georgia, and Alabama
Correlation Coefficient (R): 0.077 - weak, positive correlation
Variance (R^2): 0.0059

# Discussion

In this study, the association between degree of urbanization and proportion of mosquito larvae varies greatly depending on the scope of the citizen science data gathered from GLOBE Observer, a citizen science application that allows volunteers to take observations of a range of Earth Science. For example, data was first filtered by the states of Virginia, Maryland, North Carolina, and Delaware and downloaded to Excel. Then the urban percentage of each site classification was averaged, and the number of larvae at each site was determined. After plotting in Excel, researchers saw that as there was a shift from rural settings to urban developments (% urban increases), there also tended to be an increase in mosquito larvae counts. Data was plotted and the team found a correlation coefficient of 0.55, meaning there was a moderate and positive association between the two variables, and an R^2 value of 0.303, which means about 30.2% of the variation in mosquito larvae could be explained by the degree of urbanization at a given site. When the scope of the data was expanded to include more states in the same climate zone (Kentucky, Tennessee, West Virginia, South Carolina, Missouri, Arkansas, Pennsylvania, Ohio, Illinois, Georgia, and Alabama), this data was plotted and a correlation coefficient of about only 0.077 was found, indicating a very weak, positive association between the two variables. The R^2 value was about 0.006, meaning about 0.6% of the variation in mosquito larvae could be explained by the degree of urbanization. Although only moderately strong, in the smaller region of the U.S. that was used in this study, there was an association between the degree of urbanization of an environment and the proportion of mosquito larvae.

One possible source of error in the research was the presence of lurking variables that may also impact mosquito breeding tendencies. The extreme variation in larvae counts that was observed could be for a variety of reasons, including surface temperature or soil moisture levels. As a result, it is possible that these variables affected the presence of larvae differently in the areas of interest, making the results of this study inconclusive. Another source of error could be the inconsistency of citizen science data itself. This type of data tends to be very subjective - human perception of the environment can vary from person to person, so one person's land cover classification of a location may vary greatly with someone else's. Therefore, the samples taken by citizens may not be representative of the entire population, leading to sampling bias and unreliable results. Additionally, with a limited sample size and shorter timeframe, it is more difficult to draw conclusions about the larger population of urban environments. This highlights the importance of carefully designing research projects, ensuring sufficient data collection, and allowing adequate time for analysis and interpretation.

Other studies that track mosquito population dynamics, breeding preferences, and disease outbreaks tend to use NASA data, as it is far more objective in nature. This data is derived directly from satellites orbiting earth, making it far more accurate than citizen science data alone. Therefore, since no satellite data was used in this study, the approach taken for this project was unique.

Researchers' hypothesis that a greater proportion of urbanization is associated with greater proportions of mosquito larvae was predicated on the assumption that the citizen science data collected would be consistent enough to determine a relationship between urbanization and mosquito population dynamics based on GLOBE Observer data. Since no such definitive relationship was found, the hypothesis does not align with the findings. The results of the study indicate that citizen science data alone is not sufficient for this research and that there are other variables that may have affected mosquito breeding, meaning the team did not prove their hypothesis to be true.

## Conclusion

It can be concluded that while citizen science may be a permissible data source for some projects, it is not consistent enough to prove certain relationships in research. To reach this conclusion, researchers used a comparison of graphical representations and linear regressions of the citizen science data. Since there was no consistency in the data, the correlation coefficients were very different, meaning that there was likely no association to be found in the study. Overall, it can be said that there is little to no association between urbanization and mosquito larvae using the GLOBE Observer data, which is vital in evaluating the efficacy of citizen science in research. This project demonstrates that using purely citizen science is not consistent enough to demonstrate any relationships between variables. Although there are many benefits to using citizen science, it alone should not be used as a primary data tool. This also highlights the importance of carefully considering the scope of citizen science data when studying the impact of urbanization on mosquito populations.

Several improvements could have been made to the data collection process. In an attempt to keep air temperature and climate as close to constant as possible, the scope of the data was limited to states in the eastern and southern portions of the U.S., with mild climates. However, there are a plethora of other variables such as soil moisture and surface temperature that could act as lurking variables and also affect mosquito breeding. Therefore, the data filtration process could have been more thorough to ensure a more definitive relationship.

In the future, team members could analyze the factors that caused the results in more detail, whether it was population density of people in the areas of interest or the soil moisture levels. Although no relationship between urbanization and mosquito larvae counts was found using GLOBE Observer data, it is equally important to identify the reasons why there was no association. The team could filter by additional protocols in GLOBE Observer to hold as many other variables constant as possible.

Working with project mentors gave the team the necessary support to plan an organized and realistic research project. Whether it was learning how to access GLOBE Observer Data or receiving feedback on the project outline - which included roles and responsibilities - the guidance of peer mentors and other mentors kept the team on track with deliverables and enabled members to produce a high quality project.

## Acknowledgments

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# GLOBE IVSS Badges


We are engineers because we used student-generated citizen science data as a tool to solve the problem of evaluating whether that data is consistent enough to create predictive models. We optimized the standard design of mosquito population dynamics models by using purely citizen science rather than NASA data. We discuss that by finding a strong association between mosquito population dynamics and urbanization, that we can better map mosquito disease risk by location.


We are data scientists because we utilized GLOBE Observer datasets, which contained SEES 2023 data, in our project. We explain that there are limitations to using purely citizen science for this type of research because of its subjective nature and inconsistency. As a result of our study, we found that making inferences based on our data was not possible. We used our findings to propose a solution to his problem: integrate citizen science with NASA/gov datasets to find relationships. Our citizen science data came from a variety of locations across the eastern/southern United States.


We are storytellers because of the way we display our data and the lack of conclusiveness of the citizen science data we gathered. To do so, we graphed our two sets of data as scatter plots and compared them through linear regression. One dataset had a much weaker association than the other, which was well demonstrated through our graphs.

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