Analyzing Inhibitors of CO2 Detectors in Mosquitoes

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Introduction

Our project aimed to look at how CO2 concentration might affect mosquito populations. This is an important question to tackle because CO2 levels are rising across the Earth due to climate change. Using this information along with existing data on mosquito populations across Georgia, we sought to increase awareness and accessibility for vector-borne disease prevention. We accomplished this by looking at potential compounds to use in a prototype diffuser we designed in CAD.

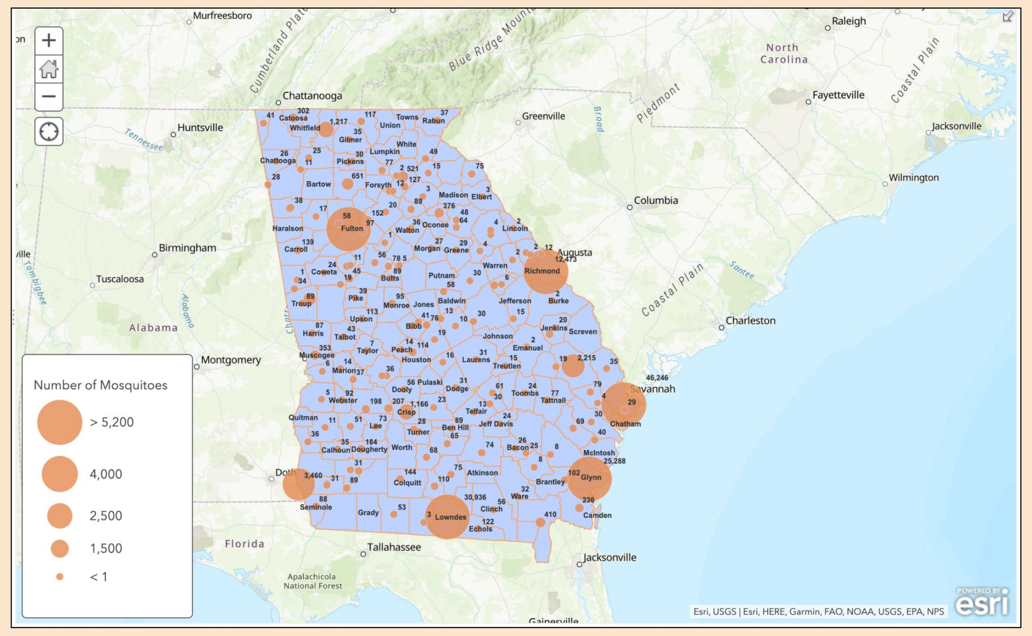
Research Questions

- How might mosquitoes be affected by changes of carbon dioxide concentration in the Earth's atmosphere?
- Which chemical compounds are most adapted for the inhibition of a mosquito's cpA nerves from functioning and detecting the carbon dioxide that humans exhale?

Hypothesis

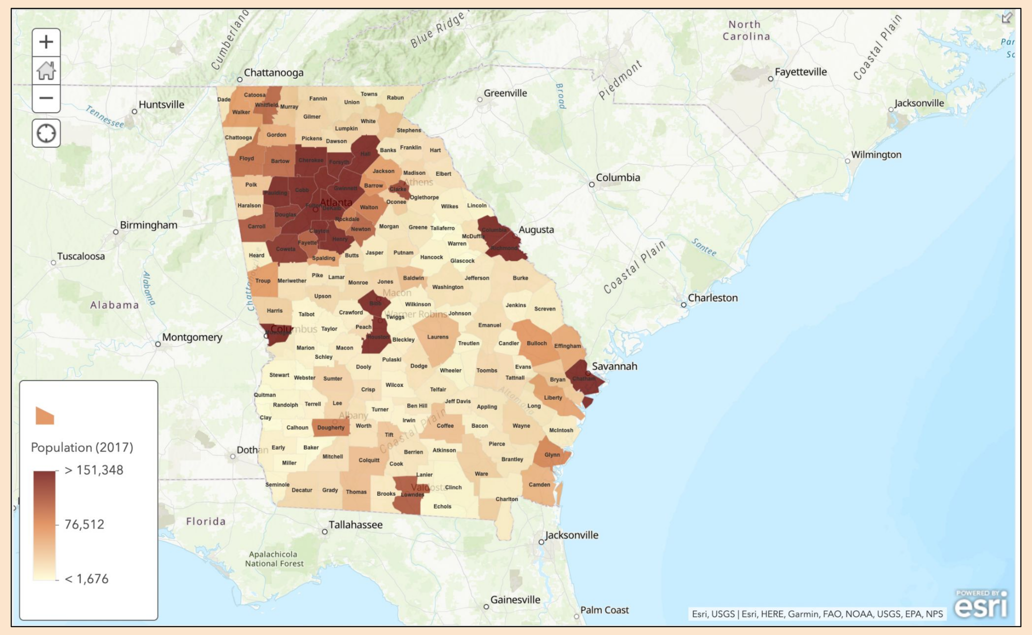
If atmospheric concentration of CO2 in an area is higher on average, there will be a greater density of mosquitoes present in that area.

Research



Mosquito Density Map

This map was created using ArcGIS and by inserting data published by the Georgia Department of Public Health in 2017. The number of mosquitoes per county include all species which were found in the numerous types of traps that were set.



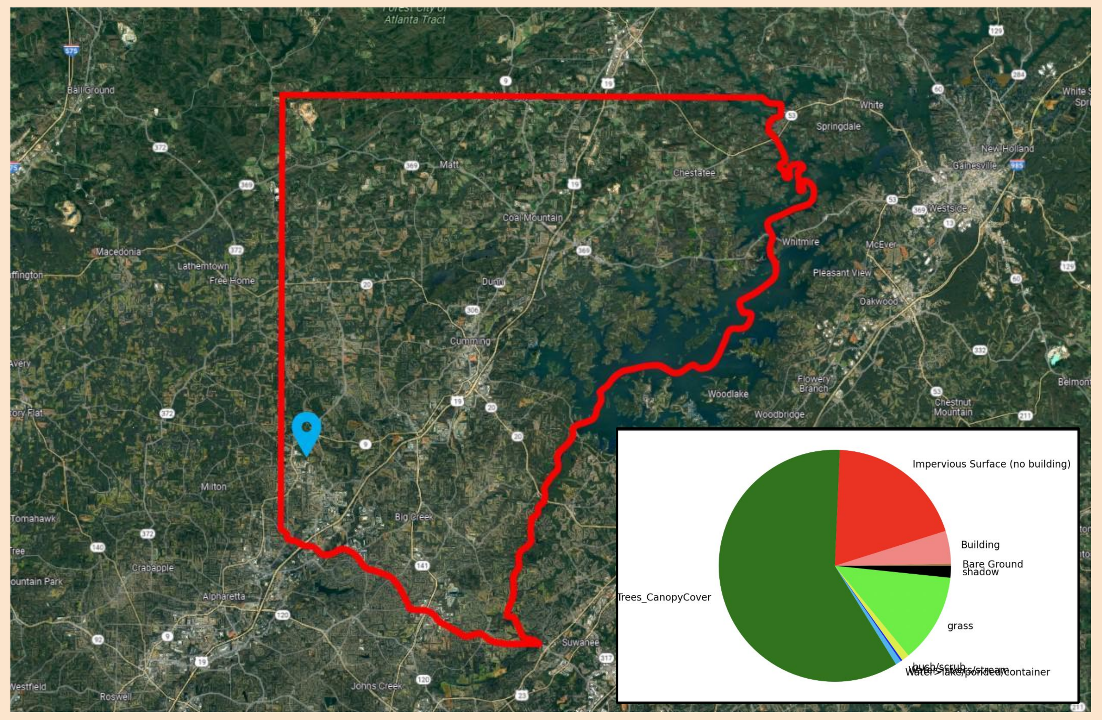
Human Density Map

This map was created using an already existing layer in ArcGIS which had human population density per county in 2017.

Georgia is the state with the highest mosquito abundance throughout the US. This could be due to its geographical location, or perhaps due to the land cover seen throughout the state. Temperature ranges also have been seen to have an affect on the amount of mosquitoes in an area, with higher temperatures correlating with larger amount of mosquitoes, specifically the *Culex nigripalpus* and *Culex quinquefasciatus.*

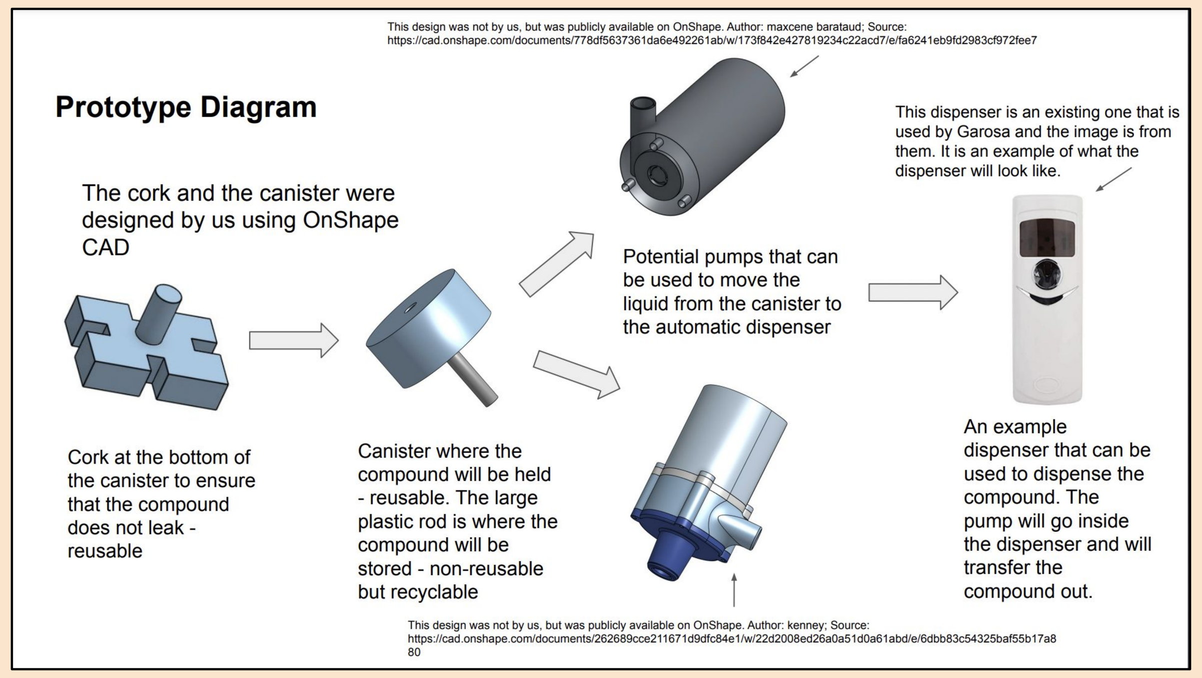
These two maps allowed us to determine which counties would have the highest need for our product. These would be the counties with the highest human and mosquito population density. The three counties which fit this criteria the most are **Chatham** county, **Fulton** county and **Richmond** county.

AOI Data



To better understand the land cover in our area of study (Georgia), any AOI points in Georgia were looked at. This point was located in Forsyth county, which is a county with an abundance of *Culex* and *Aedes albopictus* mosquitoes, which are some of the most harmful species of mosquitoes.

Prototype



To create the prototype, we looked at different means of aerosol production. This included looking at industrial solutions to germ prevention because it was the closest to what we were trying to do. Following this, we looked at how we could most effectively automate the spray of the compound. The existing devices were looked at and then a plan of a prototype was decided based on what we saw and read in the literature. We used OnShape to create the prototype and Google Slides was used to create the diagram. The prototype adopts an easily re-usable design to allow the user to easily change the tube in which the compound is stored. Additionally, everything on the design is either reusable or recyclable making the prototype more environmentally friendly. On top of that, the design will be cheap and portable for the user. The chosen compound that is recommended will be stored in one of the recyclable tubes and will be placed into the canister, screwed in by the cork at the bottom. It is important that it is also where there is a high risk of the spread of vector-borne diseases or for prevention measures. It is important that a dispenser is placed in an area in which there is a large amount of people. This way it will be more efficient and all people are being protected from vector-borne disease carriers. The easy use of our design and re-usability will allow anybody to use the dispenser to protect themselves especially if they are in an area of high risk for vector-borne diseases.

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"I am a STEM Professional": Without the help of Dr. Andrew Clark, with whom we attended office hours, we wouldn't have been able to compile and create layered maps using ArcGIS. Those maps enhanced our study on human populations and mosquito populations within the state of Georgia. With the combination of other sources of data including demographics and socioeconomic backgrounds, we were able to formulate a comprehensive public health initiative for the prevention of vector-borne diseases in different counties in the state of Georgia. Our project benefited greatly from Dr. Clark's collaboration and guidance.

"I am an Engineer": Using the ArcGIS maps we created, we were able to better understand mosquito densities across the populated counties in the state of Georgia. This narrowed our results to identify specific compounds that are usable in different regions using our prototype diffuser designed in OnShape CAD. Our design presents a practical solution for vector-borne disease prevention, as the design is affordable, safe, and accessible across a wide variety of citizens.

"I Make an Impact": Issues of affordability, accessibility, and high mosquito population helped drive our project initiative. After our research was completed, we were able to suggest specific recommendations for different public health situations. Ethyl pyruvate was found to be effective in most situations, but a mix of 2,3 Butanedione, 1-Butanal, 1-Hexanol, and 1-Pentanal could be used in areas where Culex quinquefasciatus mosquitoes are found in abundance. Wilkes county, Gwinnett county, and Clinch county would benefit greatly from the latter compound because Culex quinquefasciatus has an abundant population in those counties.

Conclusion

- Ethyl pyruvate and the combination of 2,3 Butanedione, 1-Butanal, 1-Hexanol, and 1-Pentanal seemed to be the most convenient compounds to use for our prototype in the state of Georgia. Maximal coverage cannot be guaranteed, so there is no complete protection against vector-borne diseases.
- Target audiences are counties with higher mosquito populations (Chatham, Glynn, Lowndes, Richmond and Fulton).
- Limitations include there only being one AOI observation in Georgia and mosquitoes having other olfactory neurons which can detect smells other than CO2, which is why maximum protection against mosquitoes can't be guaranteed.
- No direct link found between levels of CO2 concentration in the atmosphere and mosquito populations in those areas.

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