West Nile Virus Abatement Strategy

Prepared for the Centers for Disease Control

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GENERAL ASSEMBLY

Agenda

- Define the problem
- Background information
- Historical observations
- Exploratory Data Analysis (EDA)
- Predictive model discussion
- Cost Benefit Analysis
- Final thoughts

Define the Problem

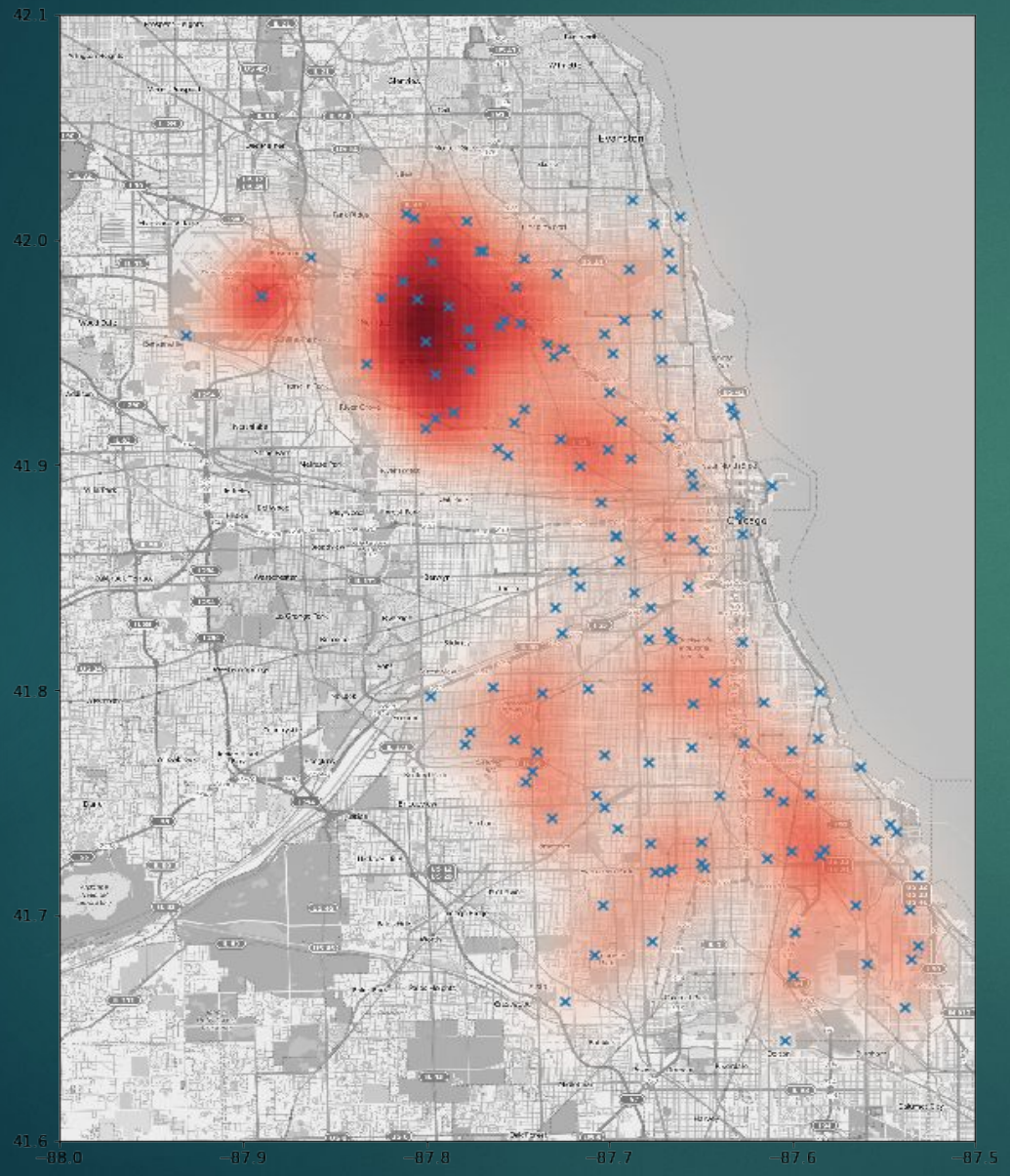
- "West Nile virus is most commonly spread to humans through infected mosquitos. Around 20% of people who become infected with the virus develop symptoms ranging from a persistent fever, to serious neurological illnesses that can result in death."

- Between 2007 and 2017 there were 993 recorded cases of West Nile Virus in the state of Illinois. Of those 993 cases, 64 resulted in death. This equates to a 6.45% mortality rate for WNV in the state of Illinois.

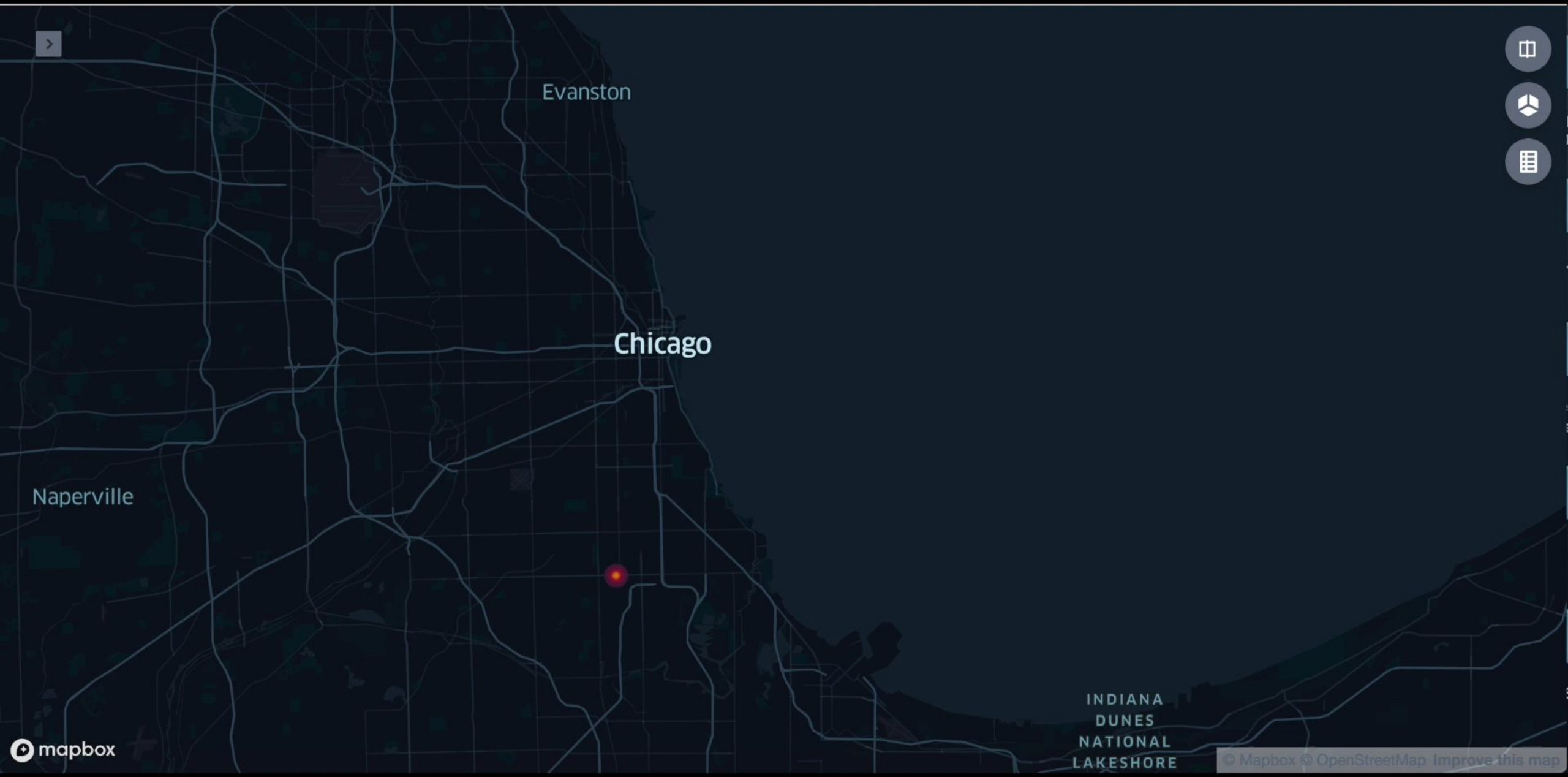
Background Information

- Weather has a gigantic effect on the mosquito population
- Typically, spring rainfall leads to mosquito breeding
- Mosquitos become active once temperatures are consistently above 50 degrees, but activity tends to jump when temperatures are above 78 degrees.
- In general mosquitos are most active at dusk and dawn
- Warmer weather leads to a greater chance of WNV infection. Research has shown that for mosquitoes carrying West Nile virus, the virus can be amplified in warmer weather. Warmer air incubates viruses faster in mosquitoes, which gives them more time to spread those viruses.

Historical Observations



West Nile Virus Density year over year
2007 – 2013


Evanston
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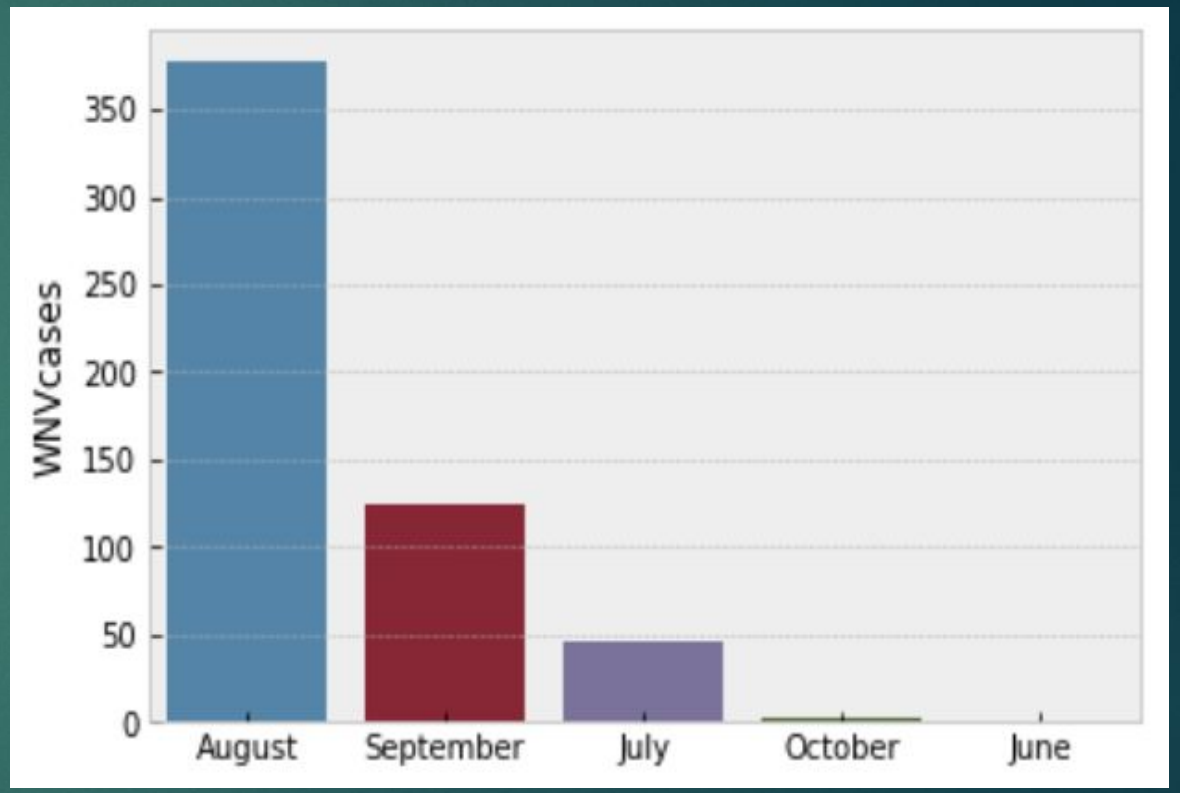
Exploratory Data Analysis (EDA)

- Weather data provided by National Oceanic and Atmospheric Administration (NOAA)
- Location, Trap, WNV and mosquito data provided by City of Chicago
- Spray data provided by City of Chicago
- Upon observation of weather data, decided this data set needed to be cleaned. Used ‘bfill’ and ‘ffill’ methods of the replace function to fill null values. Additionally, converted data types to numeric.

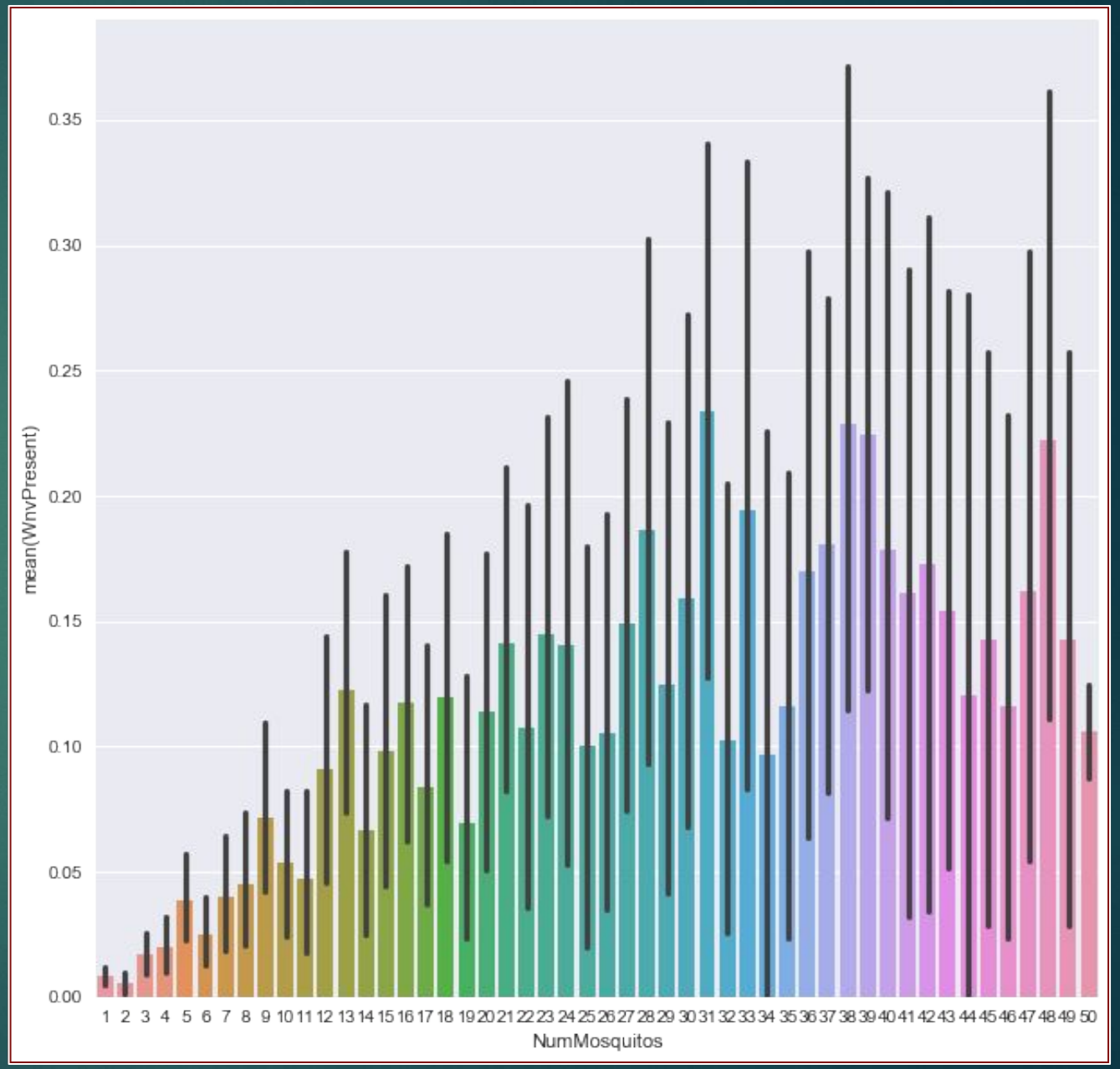
EDA (Cont.)

- Reviewing mosquito, WNV, location and trap data, recognized that many of the columns were not needed or redundant (Ex: Address, Address info, etc.)
- Majority of WNV cases found in mosquitos occur in August. The three highest months of prevalence are July, August and September.



EDA (Cont.)

- Investigated "Trap Power," which considers the traps that catch the most mosquitos and also have the highest prevalence of WNV. This helps determine the best locations to begin spraying.



Predictive Model Discussion

- Spatiotemporal model
- Only year we had complete weather and spray data was 2013
- We considered historical weather data over a 2 month span, as well as historical spray data over a month span.
- The spray data is distance weighted, meaning a spray event which occurs closer to a trap has a greater weight than a spray event further from a trap.
- The occurrence of WNV is rare in the dataset, thus out classes were imbalanced. To deal with this we used the SMOTE oversampler to balance the classes.

Predictive Model Discussion (Cont.)

- We trained a Random Forest model on a subset of the 2013 data, which was the most complete.
- The goal of the model was to accurately predict where and when WNV will occur.

Accuracy: 93% | Specificity: 94% | Precision: %61 | Sensitivity: %80

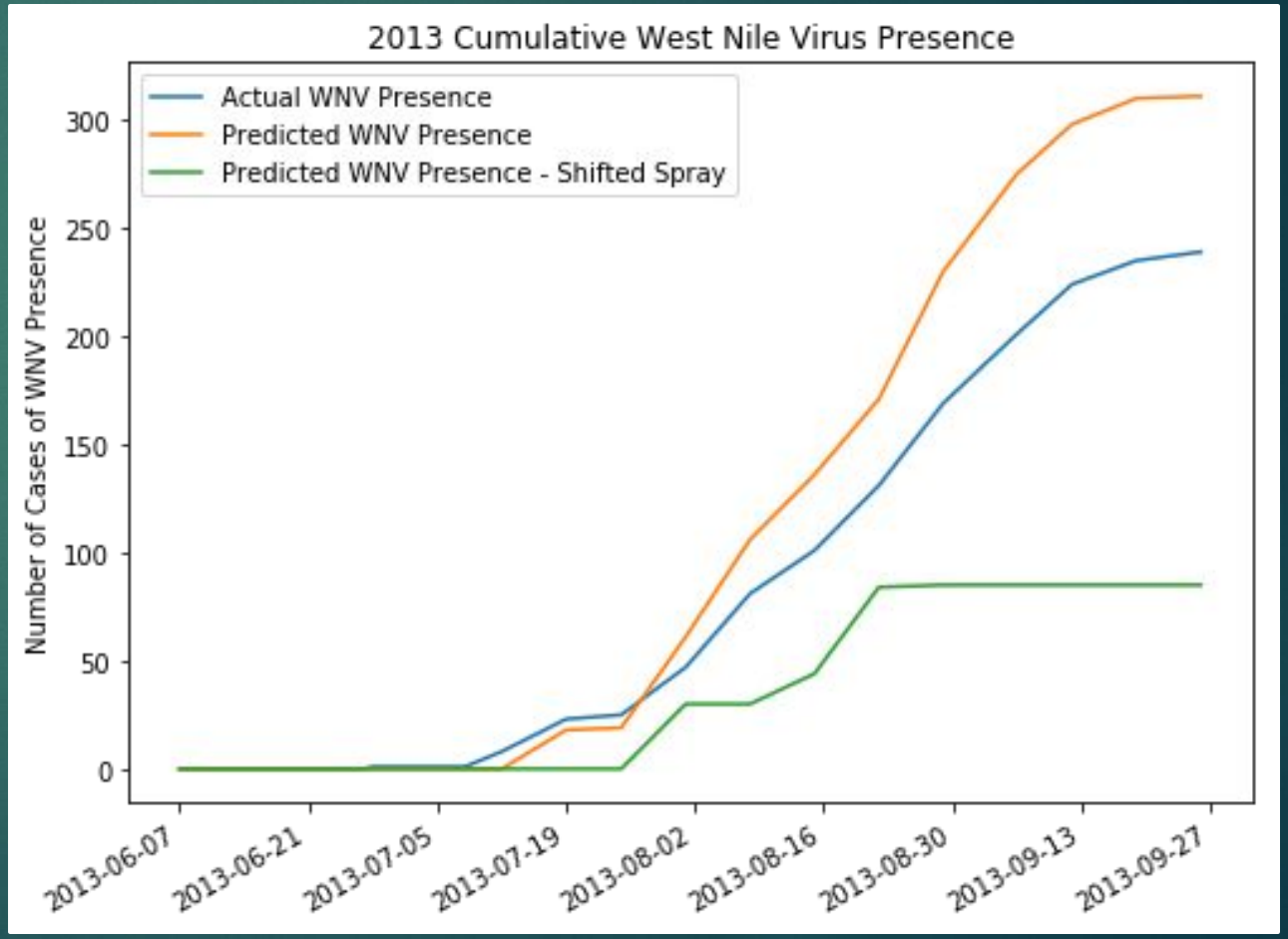
	No WNV Predicted	WNV Predicted	
No WNV Present	2033	120	2153
WNV Present	48	191	239
	2081	311	

Model Implications

- We are able to identify when and where WNV will be present.
- Through visualizations we were able to infer that spraying has thus far been reactionary to the presence of WNV.
- The city is spraying in the right places but not early enough.

Model Implications

We applied the model to shifted spray data to see what our model would predict if the city sprayed in the same locations but one week earlier.



Cost Benefit Analysis

What is Chicago spending on spraying?

- According to data from the Agency financial reports and census data, Cook County spends roughly 2.3 million on spraying for mosquitos.
- Cost per square mile to spray ~ $9,500
- Spraying costs are in line with other Illinois counties. In other words, efforts to reduce spraying costs are not worthwhile.

Cost Benefit Analysis

Is it worth it to continue spraying?

- In 2017 Chicago had ~67 cases of West Nile virus.
- According to a study done, about $3.4 million is spent on WNV medical care per year. While this number does include long-term care costs, it disregards things like lost wages, and productivity
- Moreover, 8 people died in Illinois from West Nile virus, so the number above is relatively conservative and would likely be a lot higher.
- The calculated total cost to spray at current levels is ~ $2.3M

Cost Benefit Analysis

When and where should the city spray?

- Per our discovery, target areas that have a high "trap power."
- Historically, Chicago has sprayed reactively to the presence of WNV. Using this model, we recommend that Chicago spray in areas with high "trap power" one week earlier than the model predicts.
- When this is achieved, our model predicts we can reduce the presence of WNV by ~ 72%.

Final Thoughts

- The presence of WNV can be reduced by taking a more proactive approach to mosquito abatement by spraying earlier.
- This study was done using 2013 data, we would be interested to run this exercise again with more complete spray data from other years.
- Thank you to the CDC and the City of Chicago

Sources

- Data Source:
- https://www.kaggle.com/c/predict-west-nile-virus/data
- Medical Costs Calculations: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3945683/
- General WNV Info: https://wwwn.cdc.gov/arbonet/Maps/ADB_Diseases_Map/index.html
- Background mosquito Info:
- https://blog.mosquito.buzz/how-weather-affects-mosquito-activity
- Static Heatmap Image Link: https://www.kaggle.com/vascovv/west-nile-heatmap/code