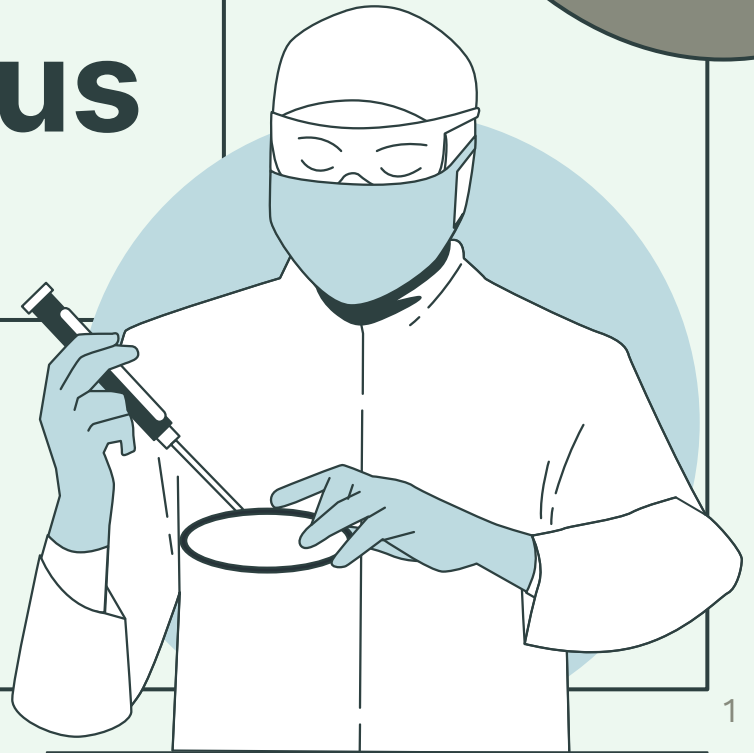
West Nile Virus Prediction

Group 5:
Hongaik, Darren, Yu Kiat, Sean, Munyee

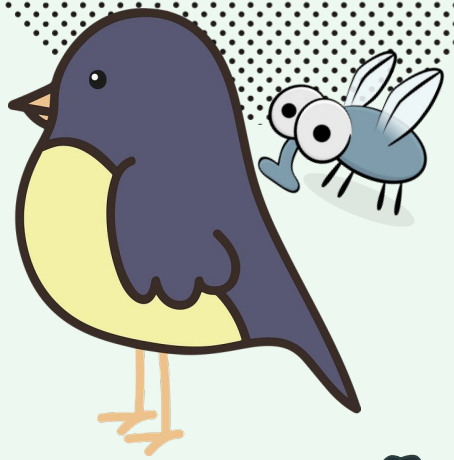


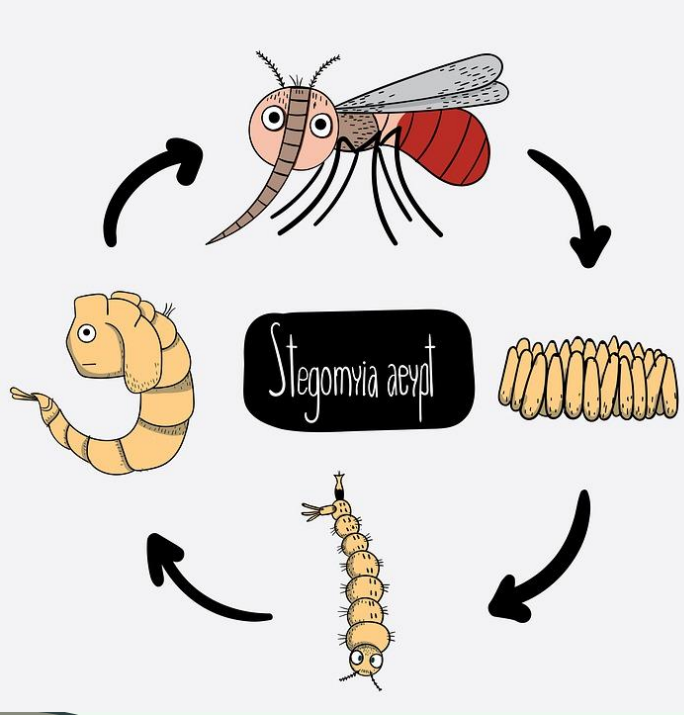
CONTENTS

INTRODUCTION

West Nile Virus (WNV) is a member of the flavivirus genus. It can cause neurological disease and death. Most commonly found in Africa, Europe, the Middle East, North America and West Asia. WNV is maintained in nature in a cycle involving transmission between birds and mosquitoes.

[source]





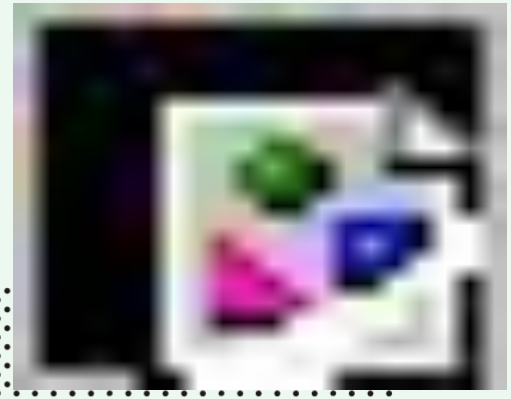
INTRODUCTION

- The mosquito life cycle for a female can last anywhere from 42 - 56 days.
- For the male mosquito, the average lifespan is only about 10 days
- The life cycle usually takes 2–4 weeks to complete, but it can be completed in less than one week during the heat of summer.
- Culex species are most active at dusk and dawn during the mosquito season (in Indiana, this is usually from May to October

INTRODUCTION

- Out of total cases in Illinois, 66% of WNV cases were from Chicago region.
- Chicago = largest number of people

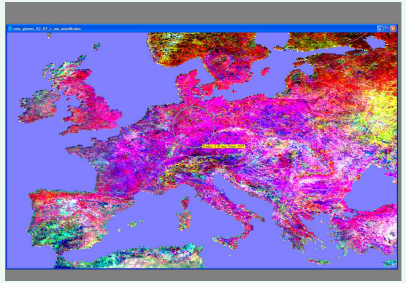
Data



- WNV Surveillance Reports recorded between 2007 and 2014.
- The test results include the number of mosquitos, the mosquitos species, and whether or not West Nile virus is present in the cohort.
- Addresses of the traps are provided as well.

Data

- Spray data
  - GIS data between 2011-2013



- Weather data
  - National Oceanic and Atmospheric Administration (NOAA)

Problem Statement

WNV Prediction

The motivation of this analysis is to select the best model and make predictions of WNV presence.

Best time to Spray

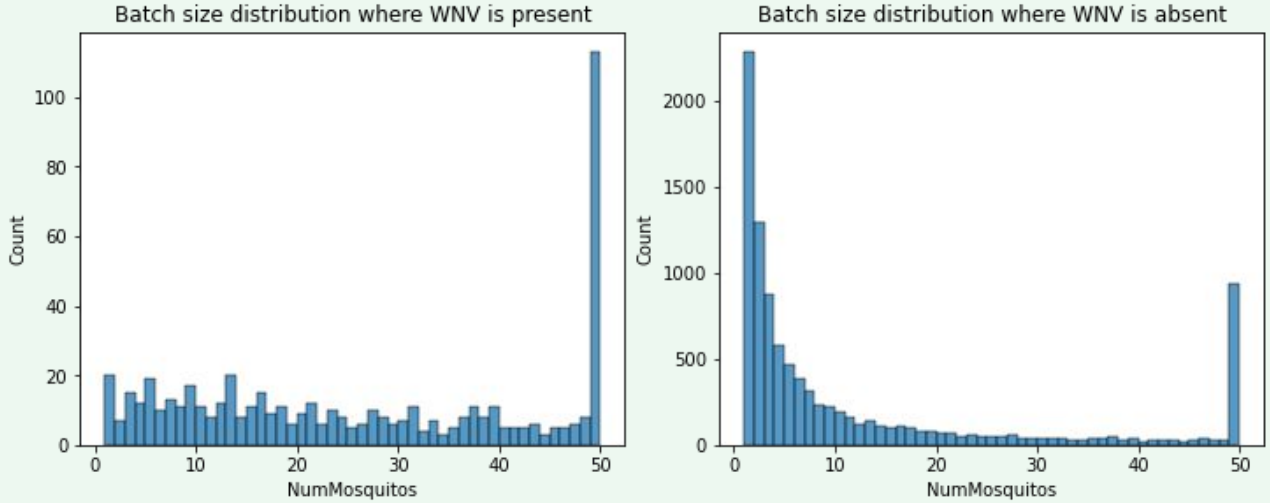
The model will also serve as a insight of the best time and location to spray.

CBA

Provide summary of the expected cost of spraying vs health medical costs incurred if not mitigated.

EDA

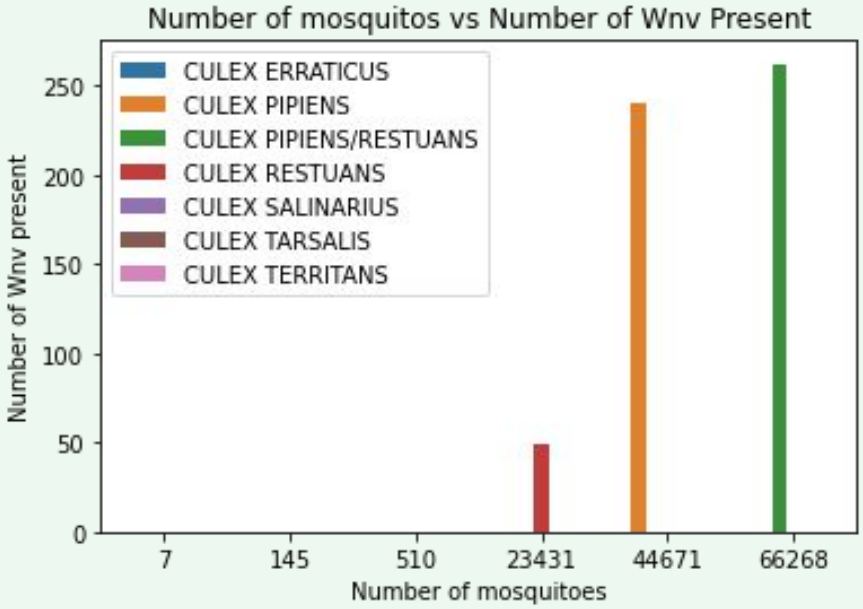
WNV count vs no. of mosquitoes



Batch size distribution shows most WNV presence are at 50 number of mosquito batch size while most WNV absent are at lower batch sizes around 1-2 batchsize.

However, in the test set the batch size was not provided.

WNV correlation with Species



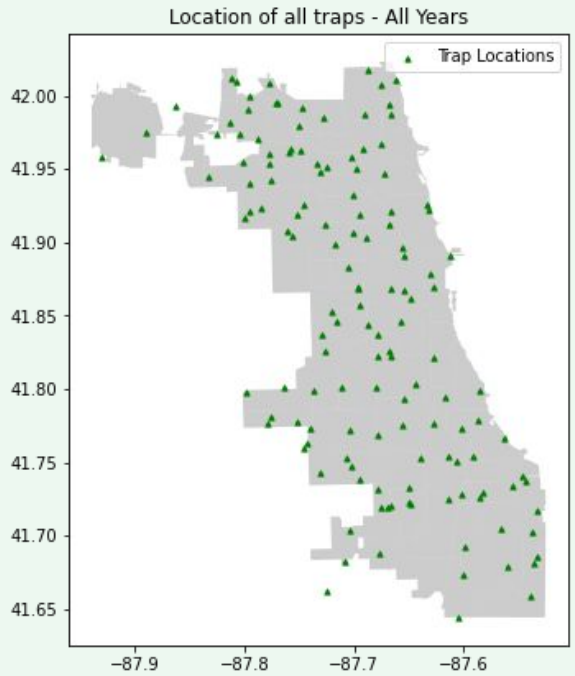
- Only **Pipiens** and **Restuans** subspecies have been detected with the virus.
- Even though the other species do not show any WNV cases but it doesn't mean that they are not capable of carrying the WNV. From the barplot, we can see that there are **low number of other species** found near the traps. This might not be the most important feature because of this.

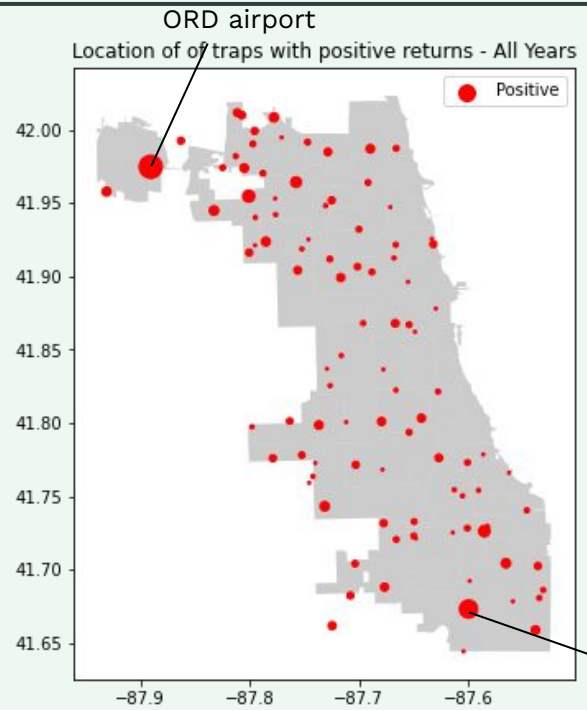
Number of mosquito species tested:

Species	
CULEX ERRATICUS	7
CULEX PIPIENS	44671
CULEX PIPIENS/RESTUANS	66268
CULEX RESTUANS	23431
CULEX SALINARIUS	145
CULEX TARSALIS	7
CULEX TERRITANS	510

Name: NumMosquitos, dtype: int64

Trap Location and Results

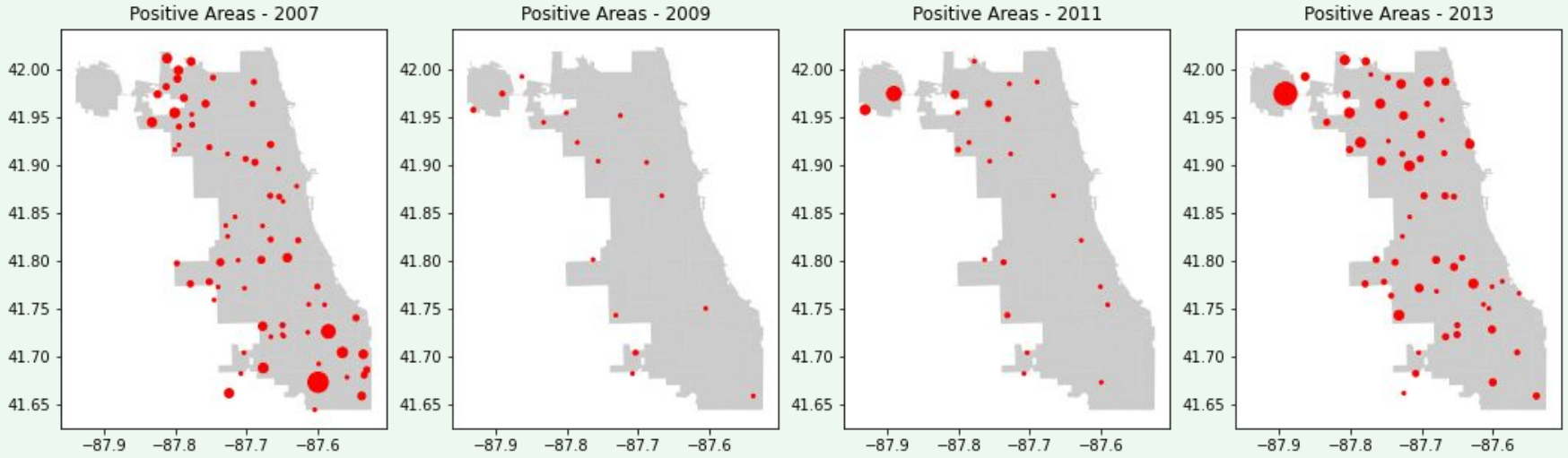




Almost all traps return positive and highest number of traps are mainly located at the **ORD airport and near a water reclamation plant** at South Doty Avenue.

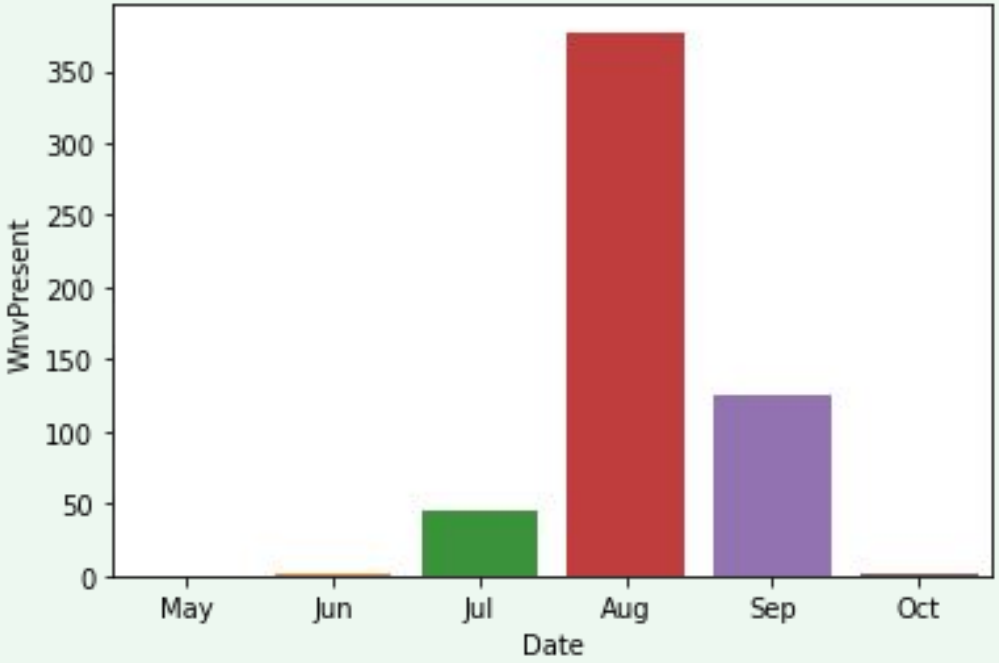
Highly attributed to transmission from flight passengers and conducive breeding grounds at large bodies of water located in the reclamation plants.

Trap results across time



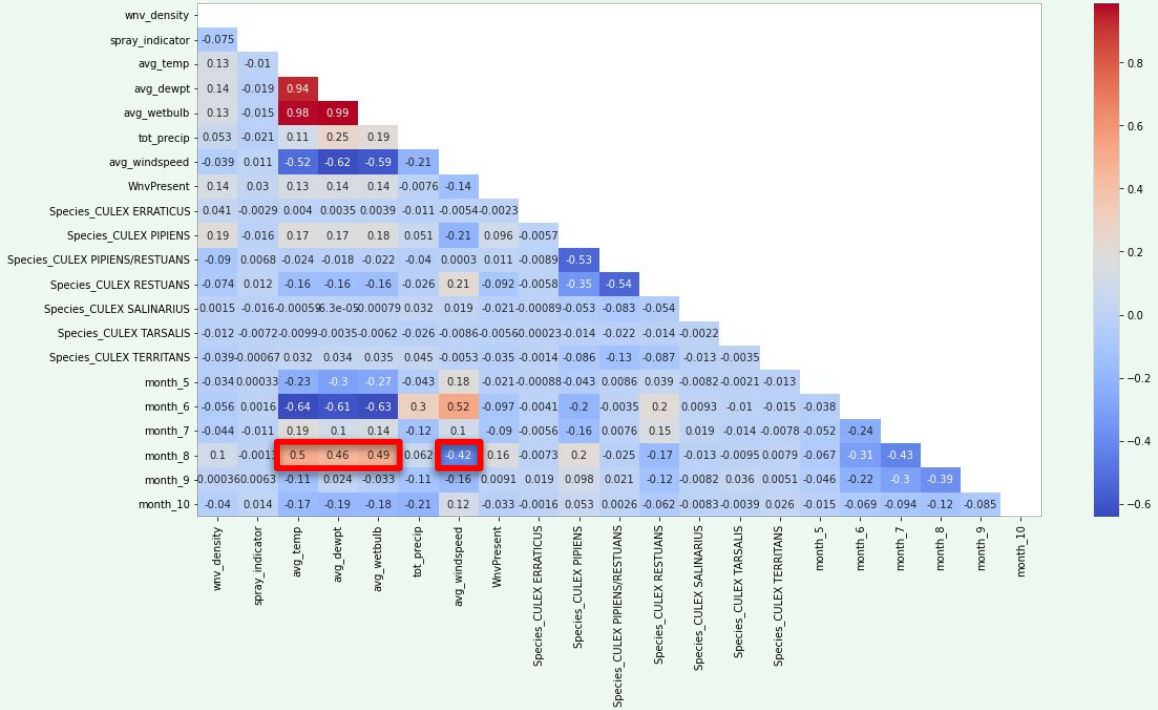
There was a spike in WNV trap positive results in 2007 and 2013 but overall the lowest in 2009. This could be due to efforts to curb WNV in 2008.

WNV vs month plot



Highest occurrence of WNV in Aug while lowest in june and oct.

Heatmap correlation



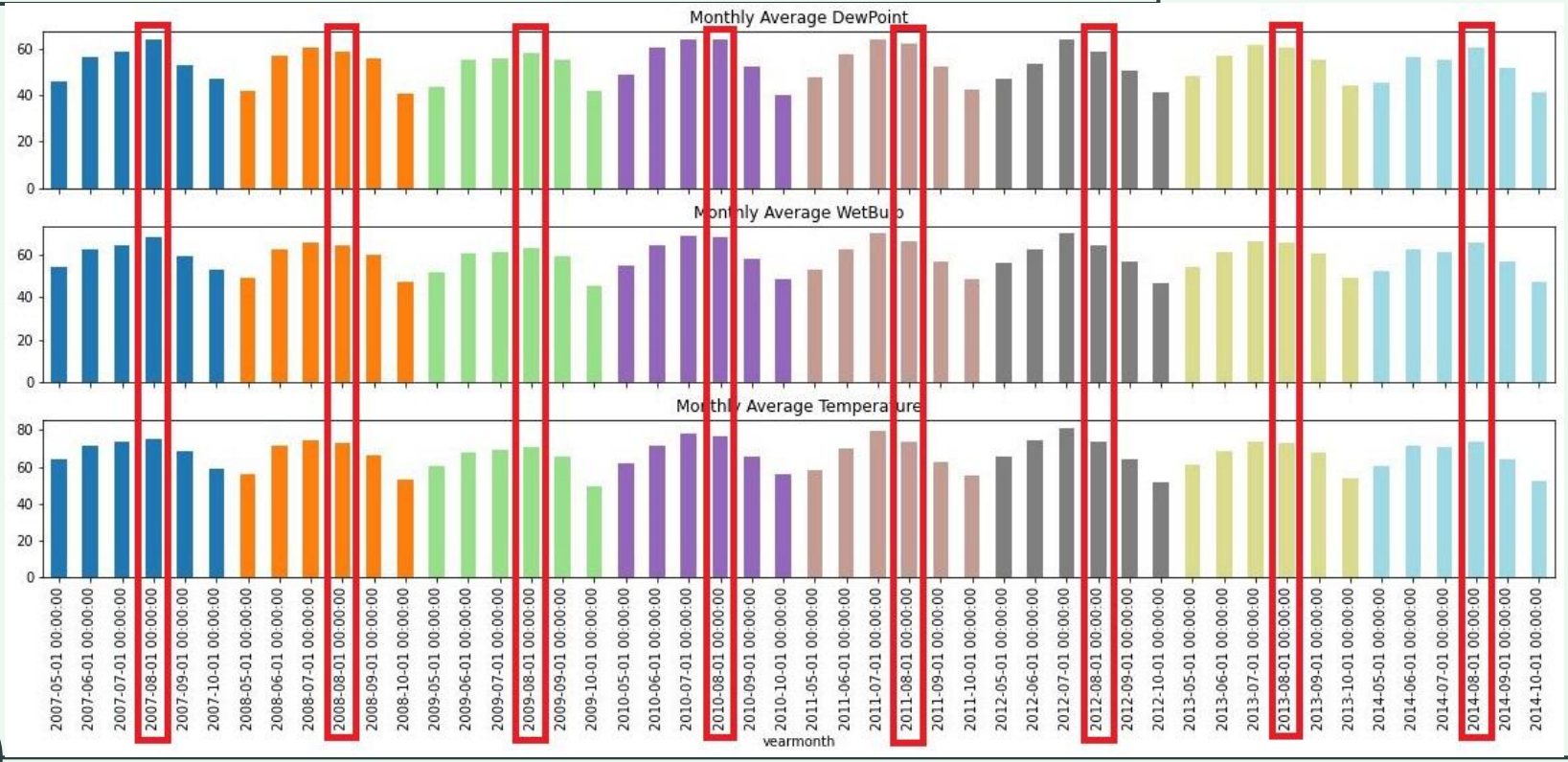
Some positive correlated features:

- avg temp and avg dewpoint/avg wetbulb
- Avg dewpoint and avg wetbulb
- Month 8 to all the weather features.

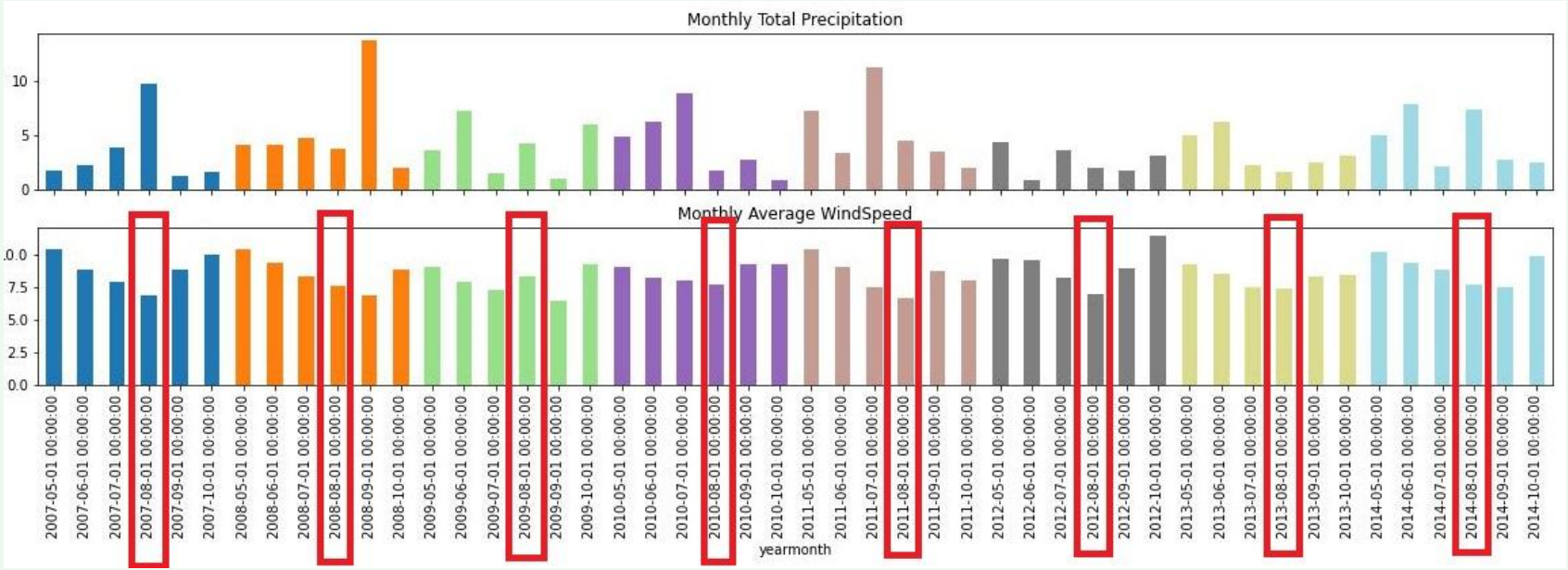
Some negative correlated features:

- Month 6 to all the avg weather components

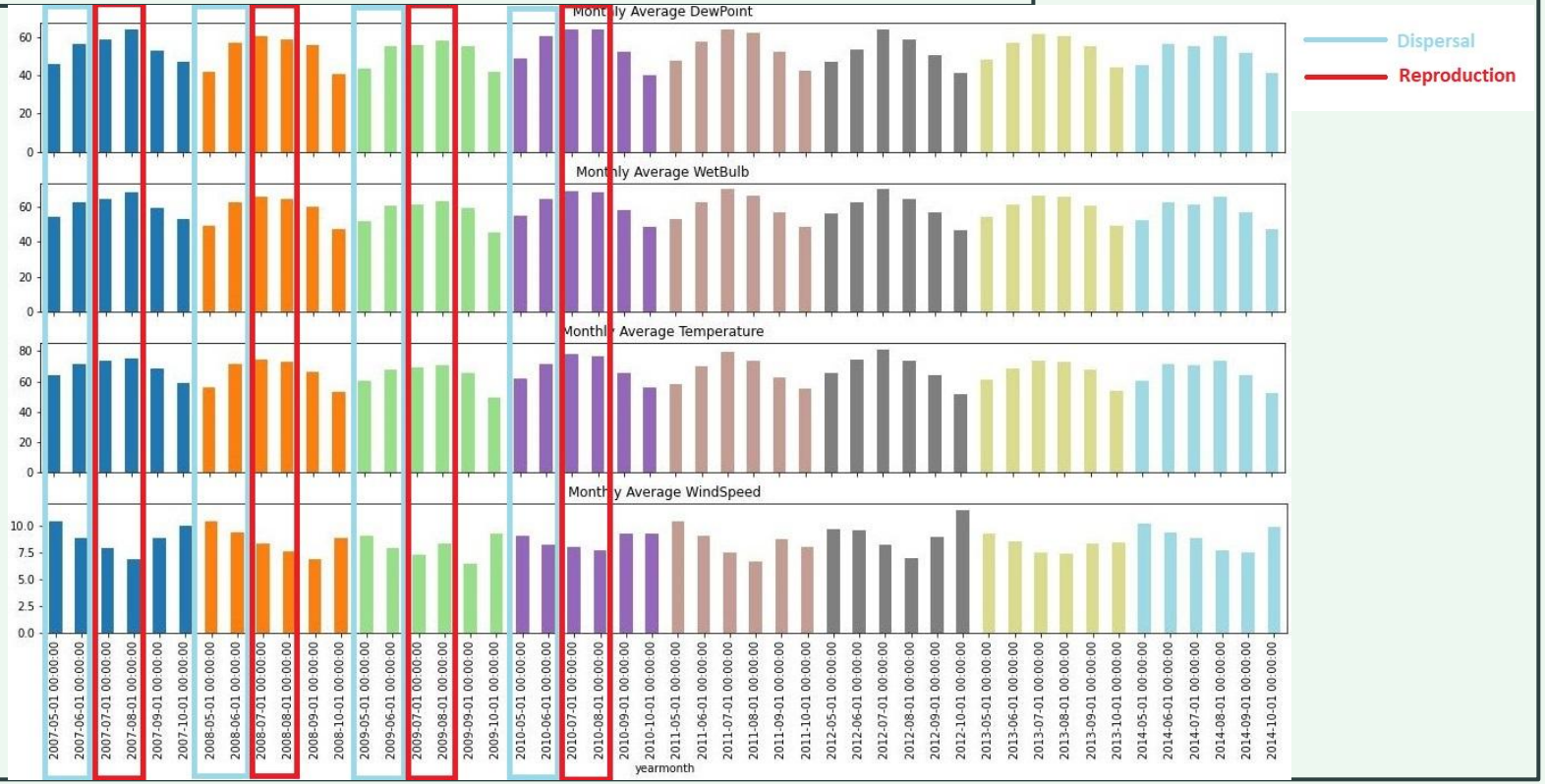
WNV vs month plot



WNV vs month plot



WNV vs month plot



Feature Engineering

Feature Engineering

1) Averaging monthly weather data

Temp	Avg()	**avg_temp**
Dewpt		**avg_dewpt**
Wetbulb		**avg_wetbulb**
Precip		**tot_precip**
Windspeed		**avg_windspeed**

2) Calculating the density of WNV cases

- Calculate the number of cases in the same address

3) Spray_indicator

- Checks whether spray is done within 50m of trap

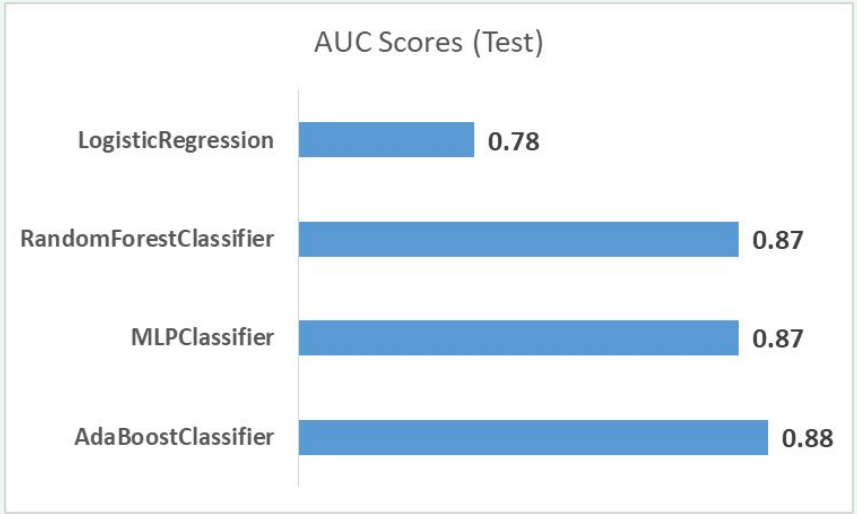
Feature Engineering

	Species	month	wnv_density	spray_indicator	avg_temp	avg_dewpt	avg_wetbulb	tot_precip	avg_windspeed	WnvPresent
0	CULEX PIPIENS/RESTUANS	5	8	0	63.4375	44.375	53.410714	1.52	10.2875	0
1	CULEX RESTUANS	5	8	0	63.4375	44.375	53.410714	1.52	10.2875	0
2	CULEX RESTUANS	5	0	0	63.4375	44.375	53.410714	1.52	10.2875	0
3	CULEX PIPIENS/RESTUANS	5	4	1	63.4375	44.375	53.410714	1.52	10.2875	0
4	CULEX RESTUANS	5	4	1	63.4375	44.375	53.410714	1.52	10.2875	0

Modelling

Modelling

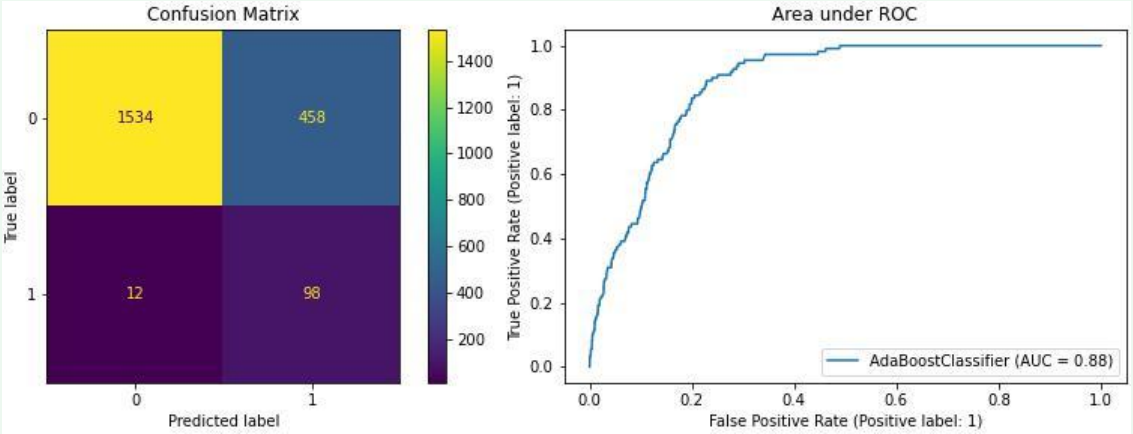
Create predictors from given variables → Train-test split with stratification → Train models



- Best model - AdaBoost
- None of the models could pick up positive cases

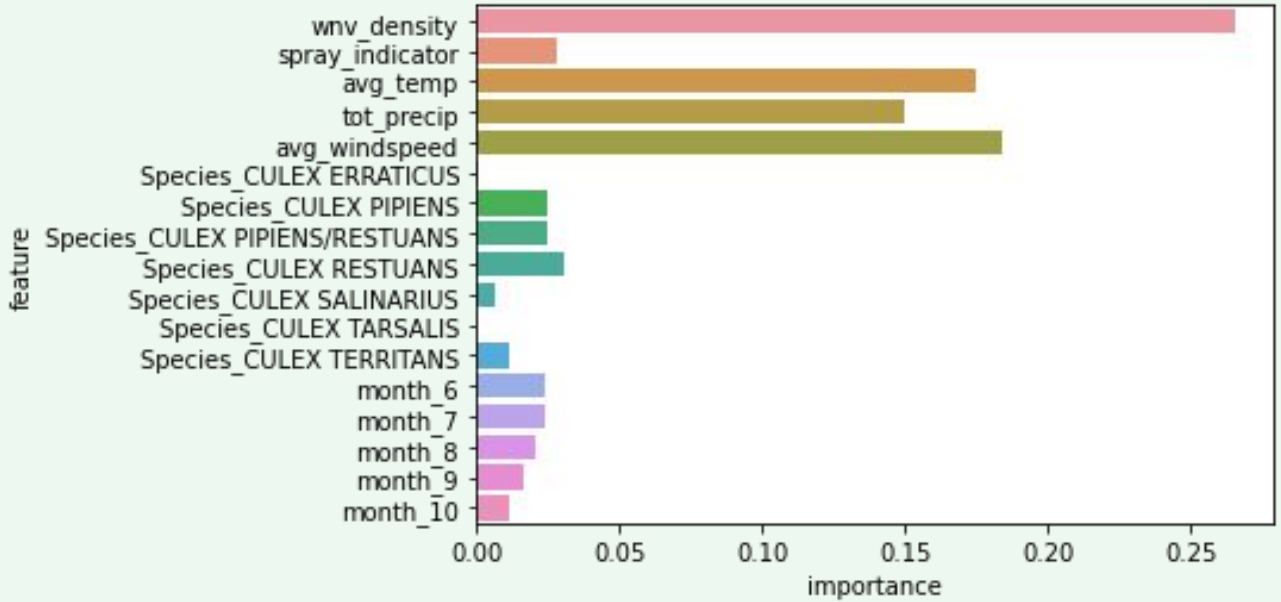
Tuning the best model

- Tuned AdaBoost with RandomForest as base estimator



- Although AUC did not improve, the model is now able to pick up positive cases
- SMOTE did not help; hyperparameters did

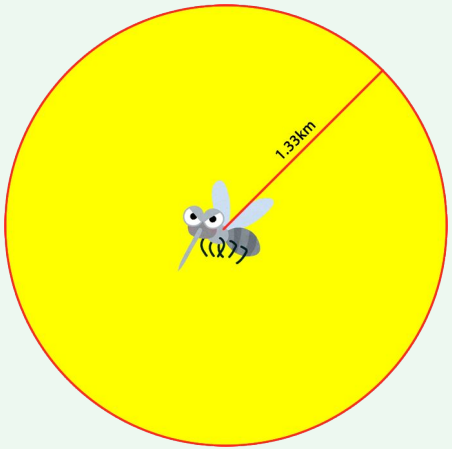
Top Predictors



Cost Benefit Analysis

Calculating spray costs

	Price (gallon)	Pounds AI/gallon	Price per Pound	Application Rate/Acre	Cost/Acre
275 gal Zenivex® E20	$282.00*	1.48	$190.54	.0035	$0.67



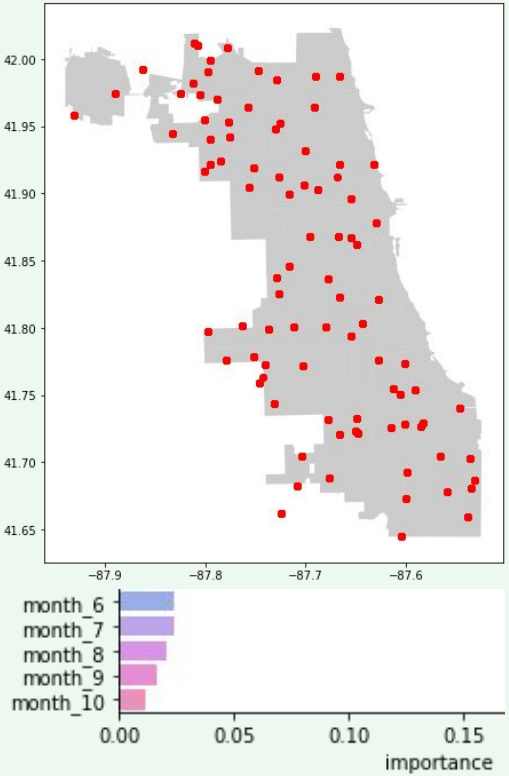
Radius of 1.33km ≅ 1373 acres

- Chicago Department of Public Health uses Zenivex[1]
  - Zenivex costs $0.67 per acre
- Culex mosquitoes travel up to 1.33km on average[2]
  - Area of 1373 acres
- Costs 1373 * $0.67 = $919.91 to spray the area covered by the mosquitoes

[1] https://www.chicago.gov/city/en/depts/cdph/provdrs/healthy_communities/news/2020/august/city-to-spray-insecticide-thursday-to-kill-mosquitoes0.html

[2] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278816/

Calculating spray costs



Targeted spraying using the model

- Spray only at locations that model predicted to have WNV
  - Across 2008, 2010, 2012 and 2014, 92 locations ever detected with WNV
- Spray only during peak periods
  - Jun to Oct
  - Each spray lasts ~30 days[1]

$919.91 * 92 traps * 5 months =

Annual cost: $423,158.60

[1] https://www.callnorthwest.com/2019/05/how-long-does-a-mosquito-treatment-last/

Benefits of spraying

- Lower number of mosquitoes in city
  - Reduce occurrence of other diseases, like Zika, Malaria etc
- Lower amount of medical fees paid due to contracting mosquito-borne diseases

Costs of not spraying

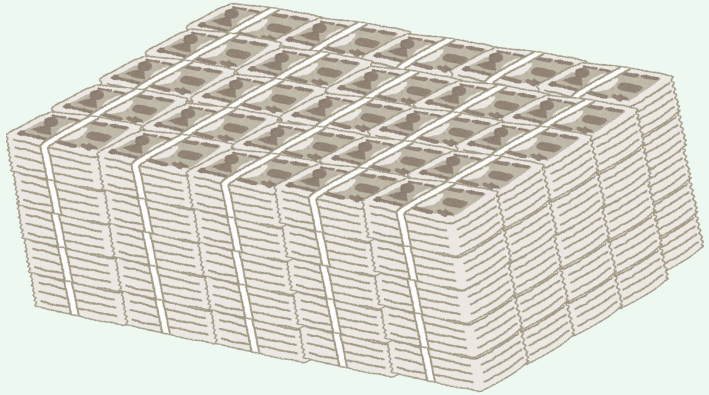
- If infected with WNV, may develop serious symptoms
  - Could result in hospitalisation and treatment; and
  - Lost productivity due to missing work
- Estimated annual cost of $60,000,000 in medical fees and lost productivity[1]

[1] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3945683/

Cost comparison

Spray

$423,158



No spray

≅$60,000,000

Conclusion

Conclusion

No. of mosquitoes

The probability of detecting WNV is correlated to the number of mosquitoes

Peak months

WNV-present mosquitoes more prevalent in Jun-Sep

Temperature and humidity

Peak months correlates with higher temperatures and humidity

WNV density

Frequency which a trap tests positive is strongest indicator of WNV

Limitations

Time lag

Data across years was aggregated but transmissions may not be uniform across years

Comprehensiveness

There could be areas not under surveillance

Might have missed other hotspots

Limited data

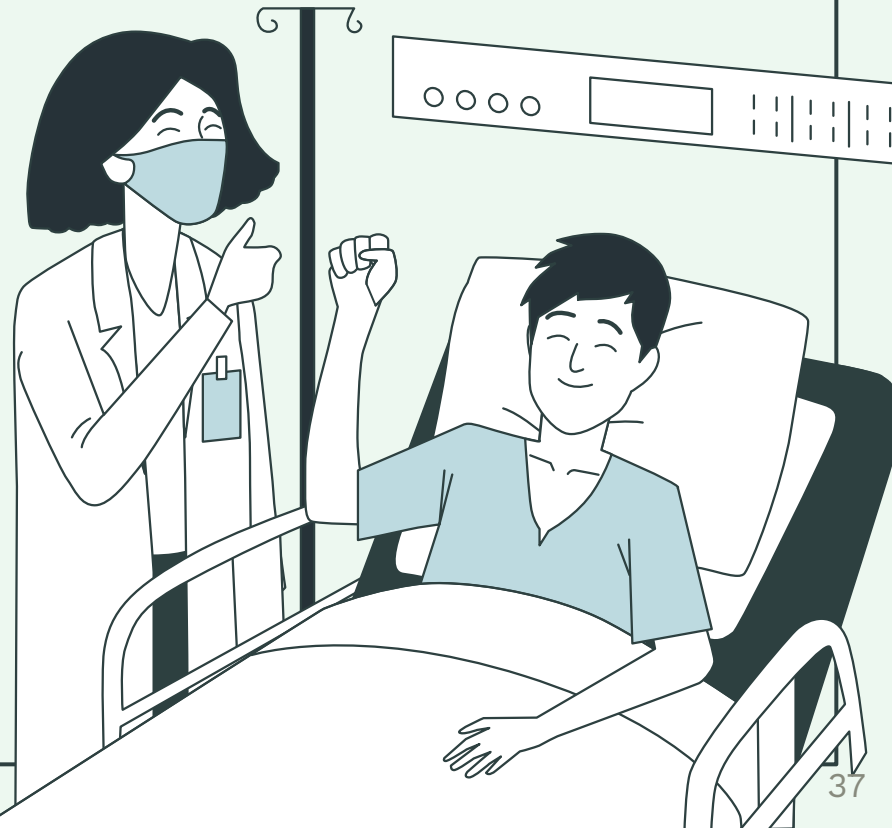
Training data was limited for certain months and locations

Recommendations

RECOMMENDATIONS

- Spray at every location that the model predicted WNV positive
- Spray monthly from Jun to Oct, where WNV is at its peak
- Spray frequency can be increased in areas predicted to be hotspots
- Monitor weather all year round for high temperatures and humidity and conduct sprays accordingly
    - Weather may change over time (climate change) and WNV peak periods may shift

THANKS



References

- West Nile virus
  https://www.who.int/news-room/fact-sheets/detail/west-nile-virus
- City to Spray Insecticide Thursday to Kill Mosquitoes
  https://www.chicago.gov/city/en/depts/cdph/provdrs/healthy_communities/news/2020/august/city-to-spray-insecticide-thursday-to-kill-mosquitoes0.html
- Dispersal of Culex Mosquitoes
  https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3278816/
- How long does a mosquito treatment last
  https://www.callnorthwest.com/2019/05/how-long-does-a-mosquito-treatment-last/
- Initial and Long-Term Costs of Patients Hospitalized with West Nile Virus Disease
  https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3945683/