City of Chicago **Analysis** of the West Nile Virus

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The main goal here for our analytics effort is to put systems in place that

reduce people's exposure to mosquitoes that carry WNV

. . . .

-Gene Leynes, Data Scientist, DoIT Chicago

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Guiding Questions

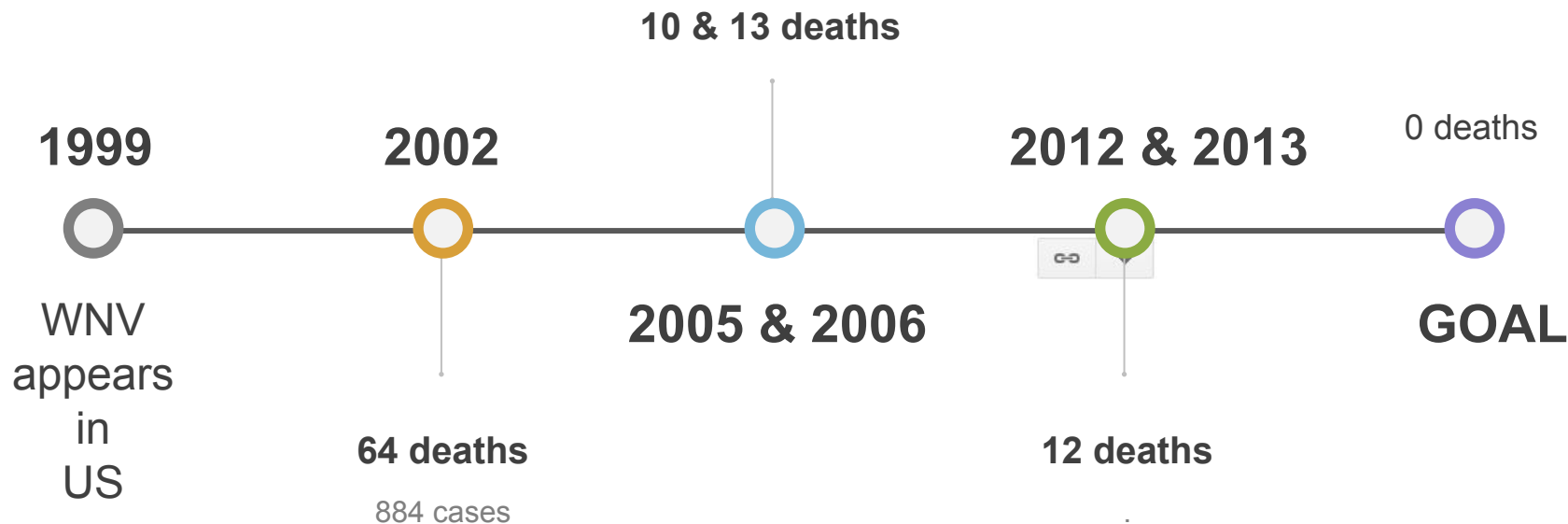How do we reduce incidences on West Nile Virus in the City of Chicago?

Where and how does WNV appear?

What are the costs and benefits of vector control for WNV?

How do we best use prevention methods like pesticide?

A History of West Nile Virus In Chicago

10 & 13 deaths

1999
WNV appears in US

2002
64 deaths
884 cases

2005 & 2006

2012 & 2013
12 deaths

0 deaths
GOAL

West Nile Is For the Birds. . . .

ABOUT WNV

West Nile virus (WNV) is transmitted through the bite of an infected mosquito

WNV has the potential to cause prolonged disability or death in people who are infected.

WNV was first detected in Chicago in 2001.

In 2002, Chicago suffered its first, and most severe, WNV epidemic: 884 human cases were reported, including 64 fatalities.

WNV activity is expected to continue in Chicago for the foreseeable future

Because they carry WNV far and wide

PROTECTING CHICAGOANS TODAY and TOMORROW

Surveillance for Human Infection

Mosquito Surveillance

Adult Mosquito Control

Larval Mosquito Control

Dead bird Surveillance

Educating the General Public and Health Care Providers

Surveillance Against WNV

WHY WE NEED SURVEILLANCE

Most people infected with the virus will not get sick; some (around 20 percent) may experience flu-like symptoms.

Less than 1 percent of people bitten by an infected mosquito will become severely ill with WNND.

Still, the number of WNV cases in an area could rise in any given year.

The state of Texas had an unexpected outbreak in 2012: after only 27 cases statewide in 2011, the state was hit with 1,868 the following year.

BEATING WEST NILE

Since 1999, nearly 2,000 US residents have died from WNV complications..

That number would likely be higher if not for surveillance measures.
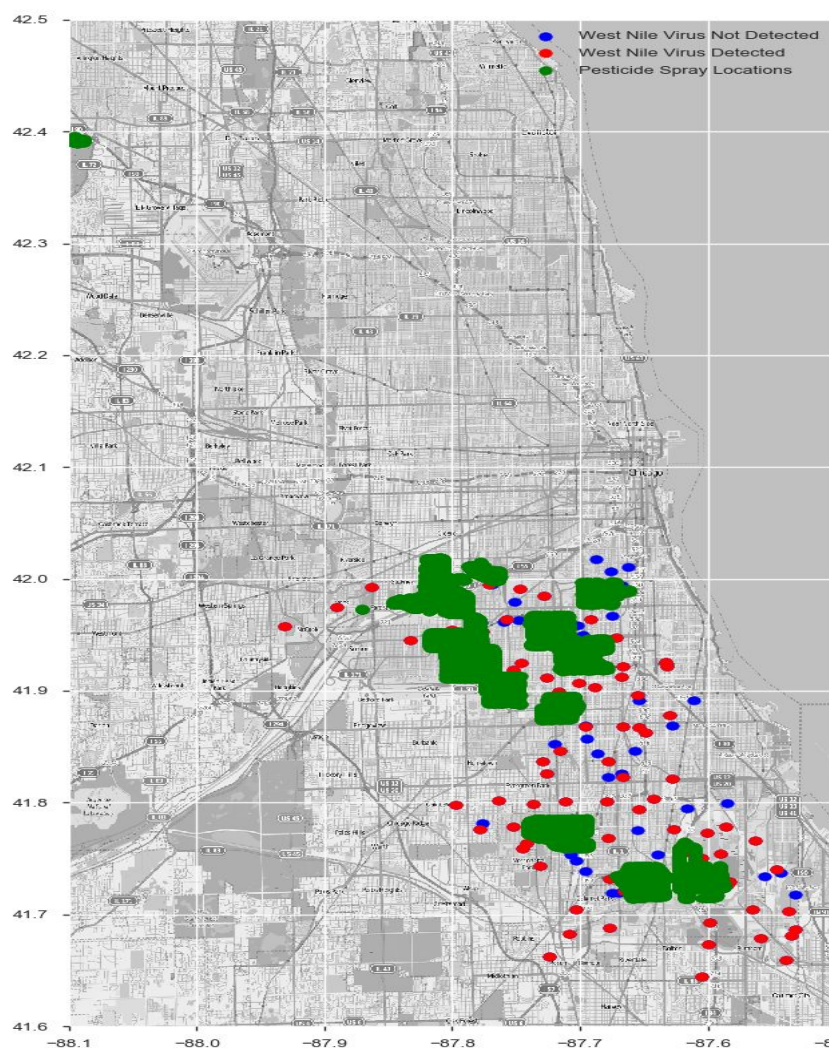
This surveillance allows local governments to take action (mainly in the form of mosquito spraying) to prevent the spread of WNV.

About the WNV Vectors

Culex Pipiens and Culex Pipiens/Restuans, Culex Restuans Species are detected to have the West Nile Virus
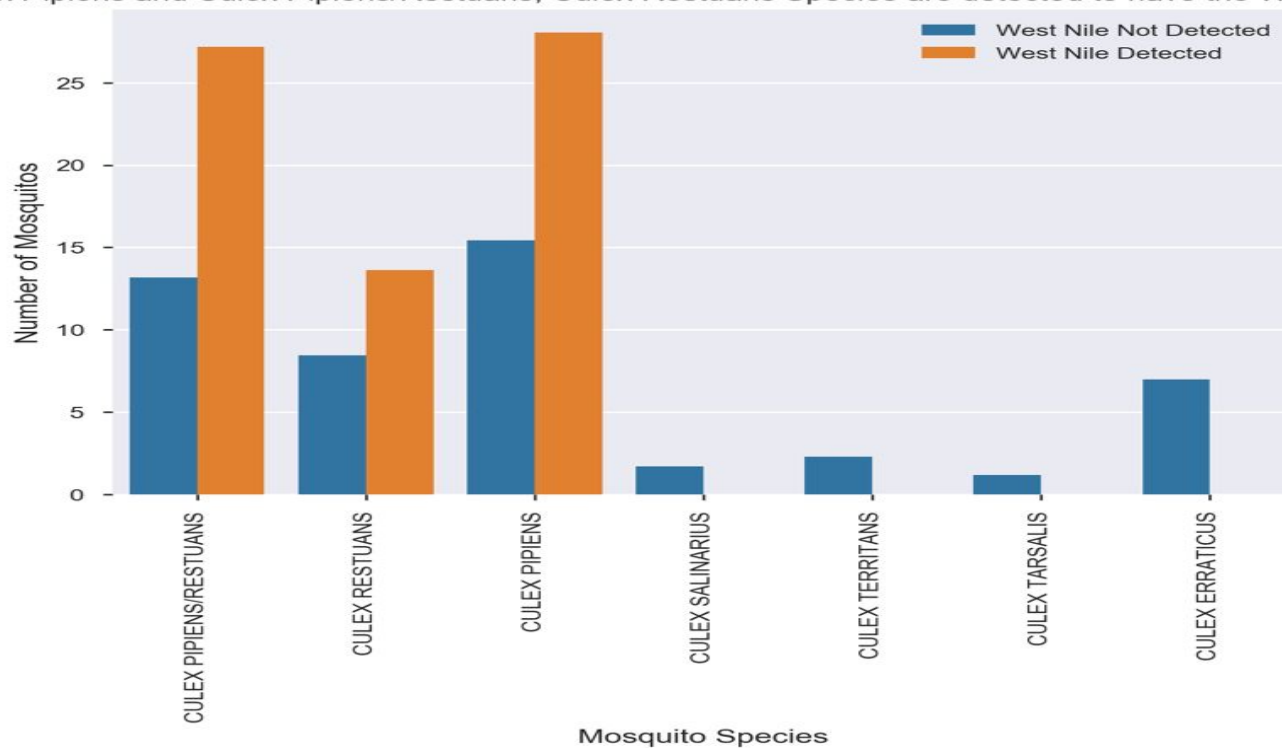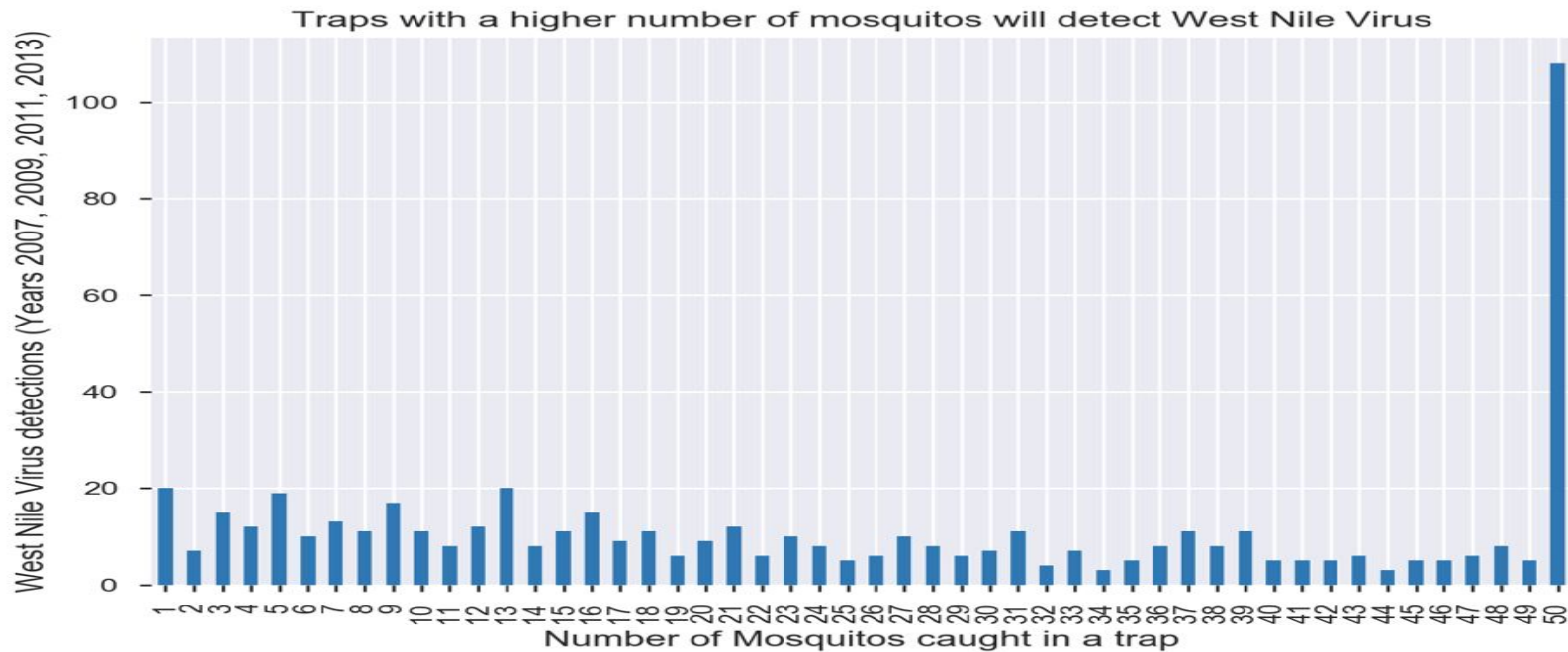
Red dots represent WNV presence

Blue dots represent no WNV present
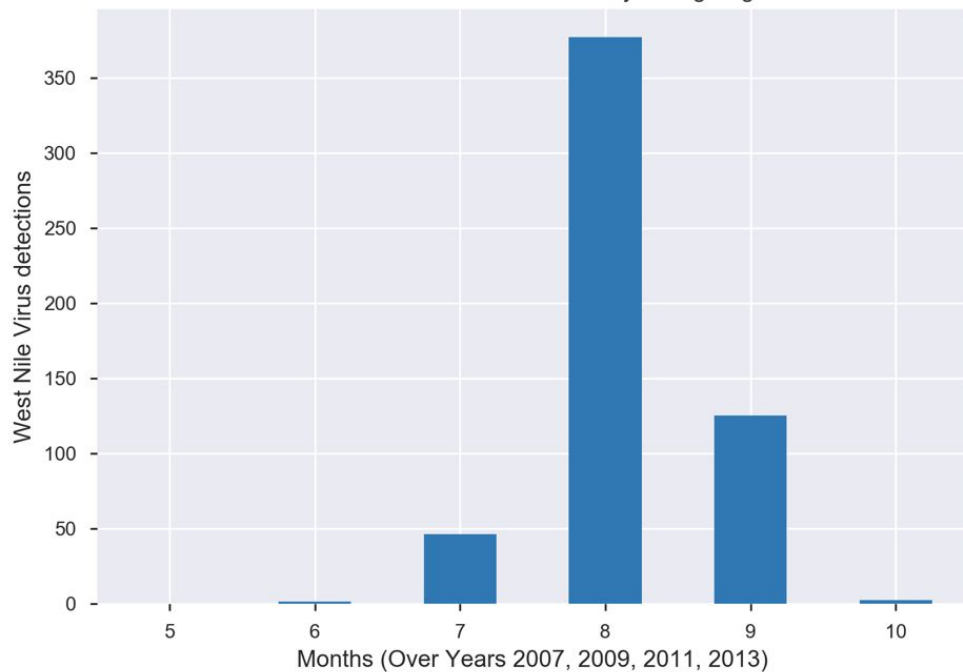
Green blobs represent spray areas
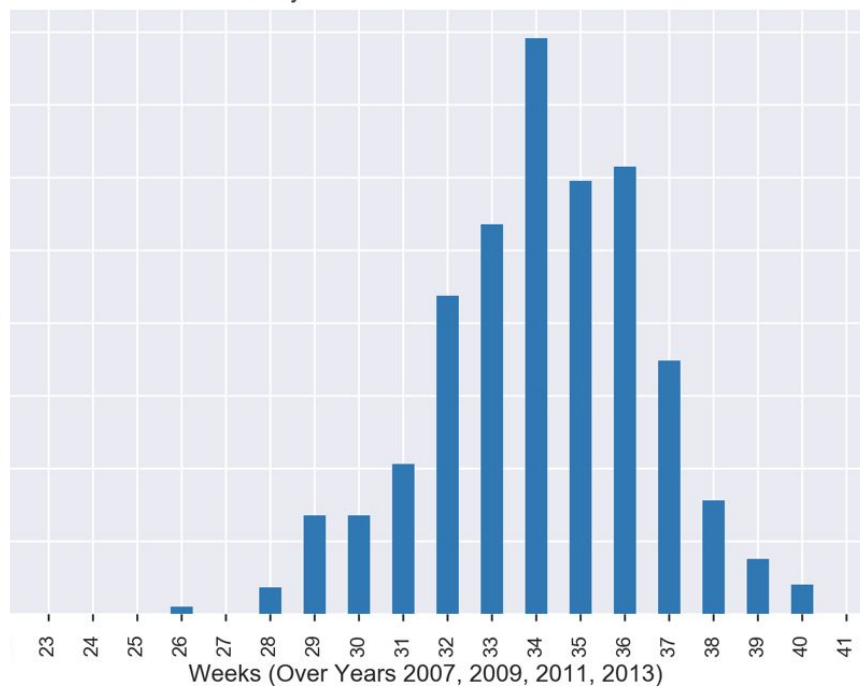
The Locations with the Most Mosquitoes Mean More WNV

Traps with a higher number of mosquitos will detect West Nile Virus

Summer is the Season of Infection

West Nile Virus is detected mostly during August
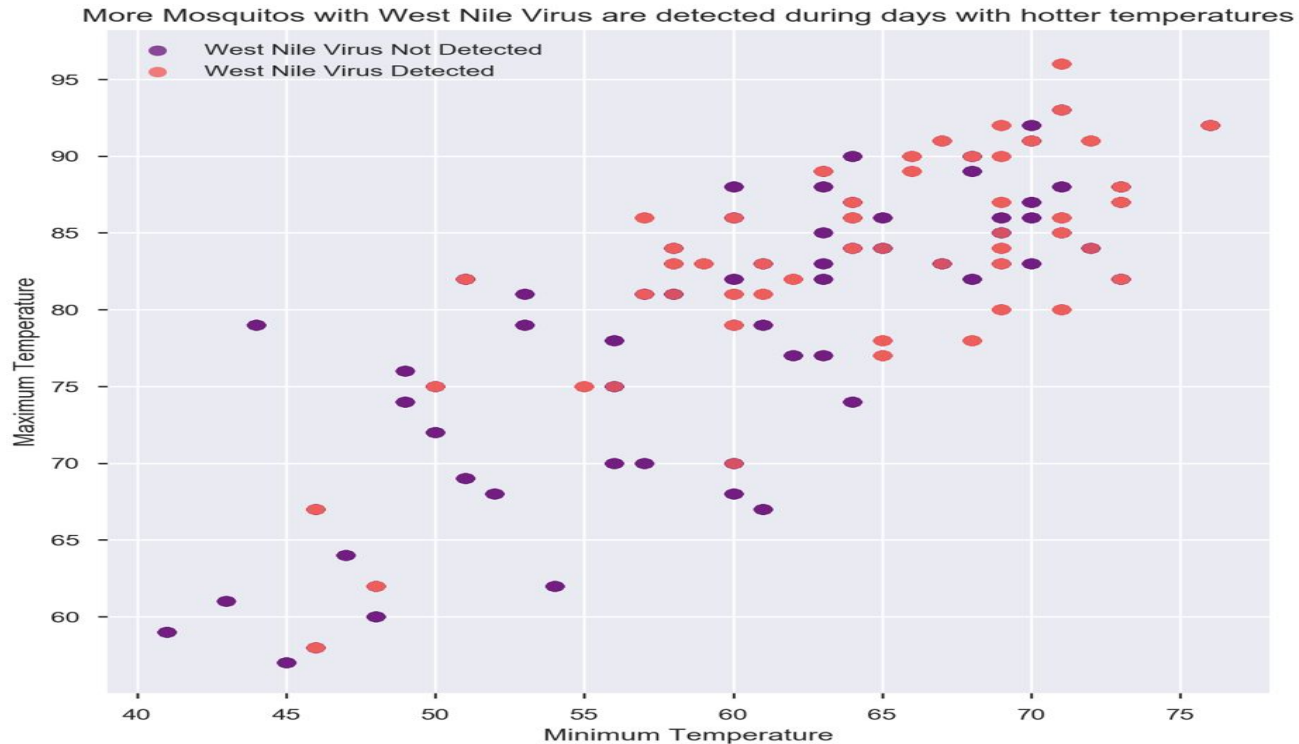
Week by Week West Nile Virus Detected

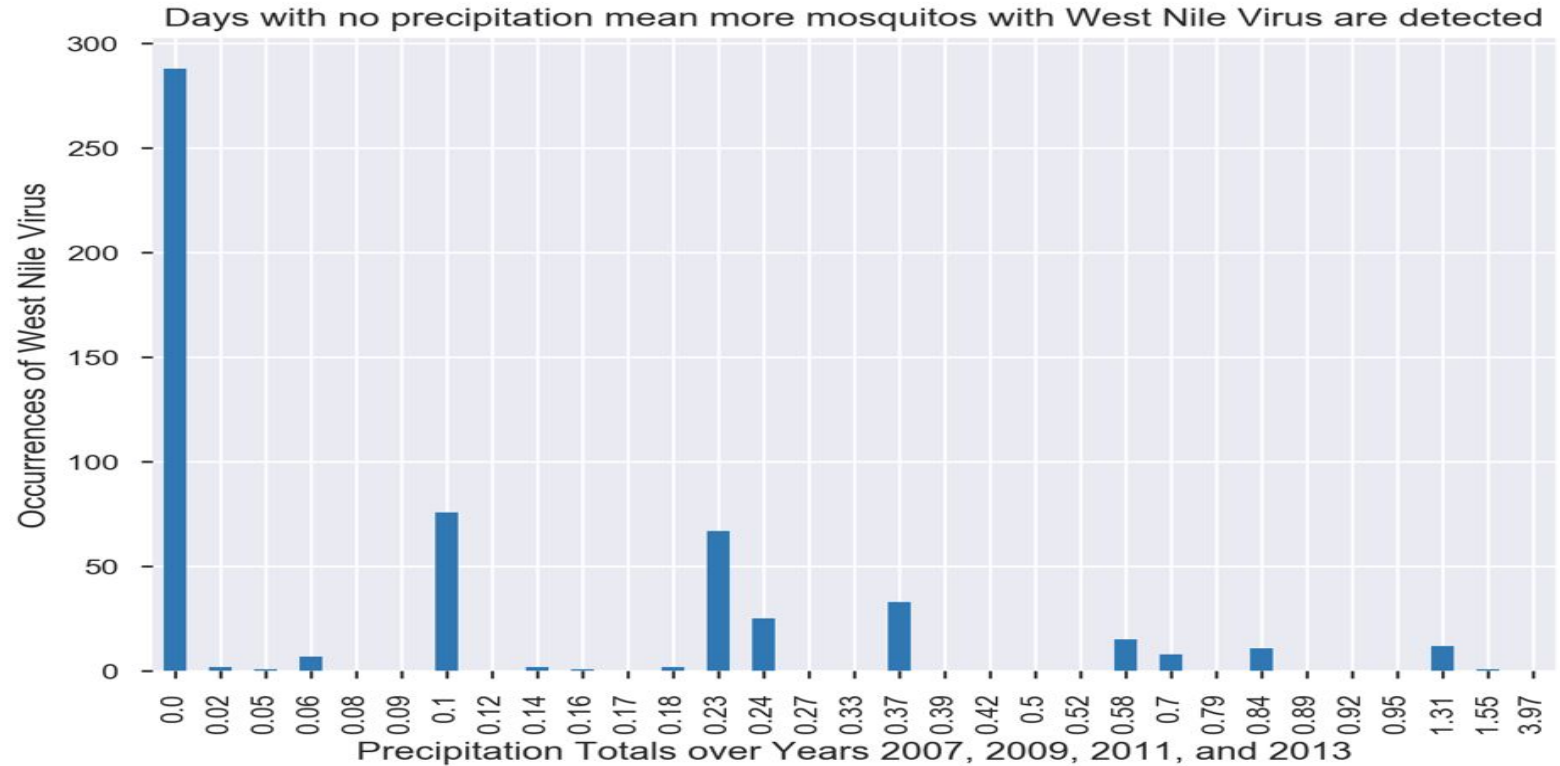# Hotter Weather = More WNV

More Mosquitos with West Nile Virus are detected during days with hotter temperatures

Drier Weather = More WNV

Days with no precipitation mean more mosquitos with West Nile Virus are detected
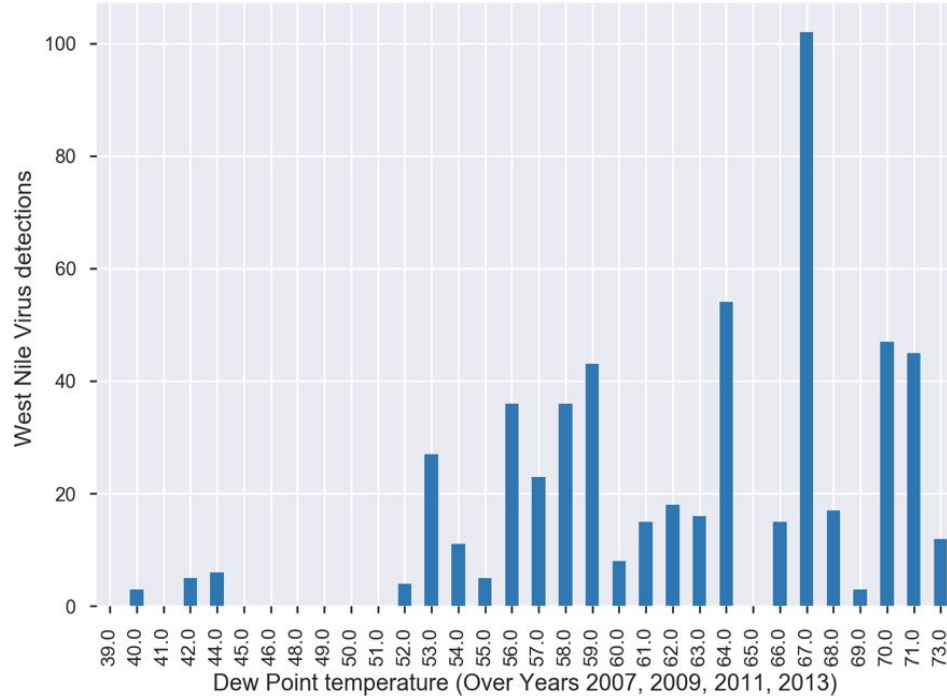
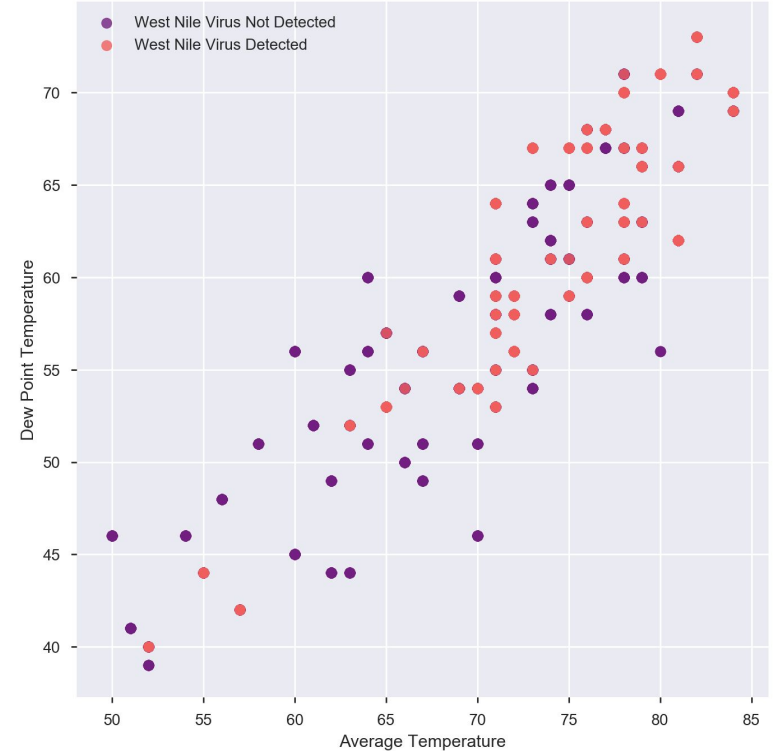# More Humidity = More WNV

West Nile Virus is detected more frequently during days with a higher dew point temperature

More mosquitos with West Nile Virus are detected on days with a higher relative humidity

Dew Point Temperature between 50 and 70 degrees is a likely range for West Nile Virus detection

📌
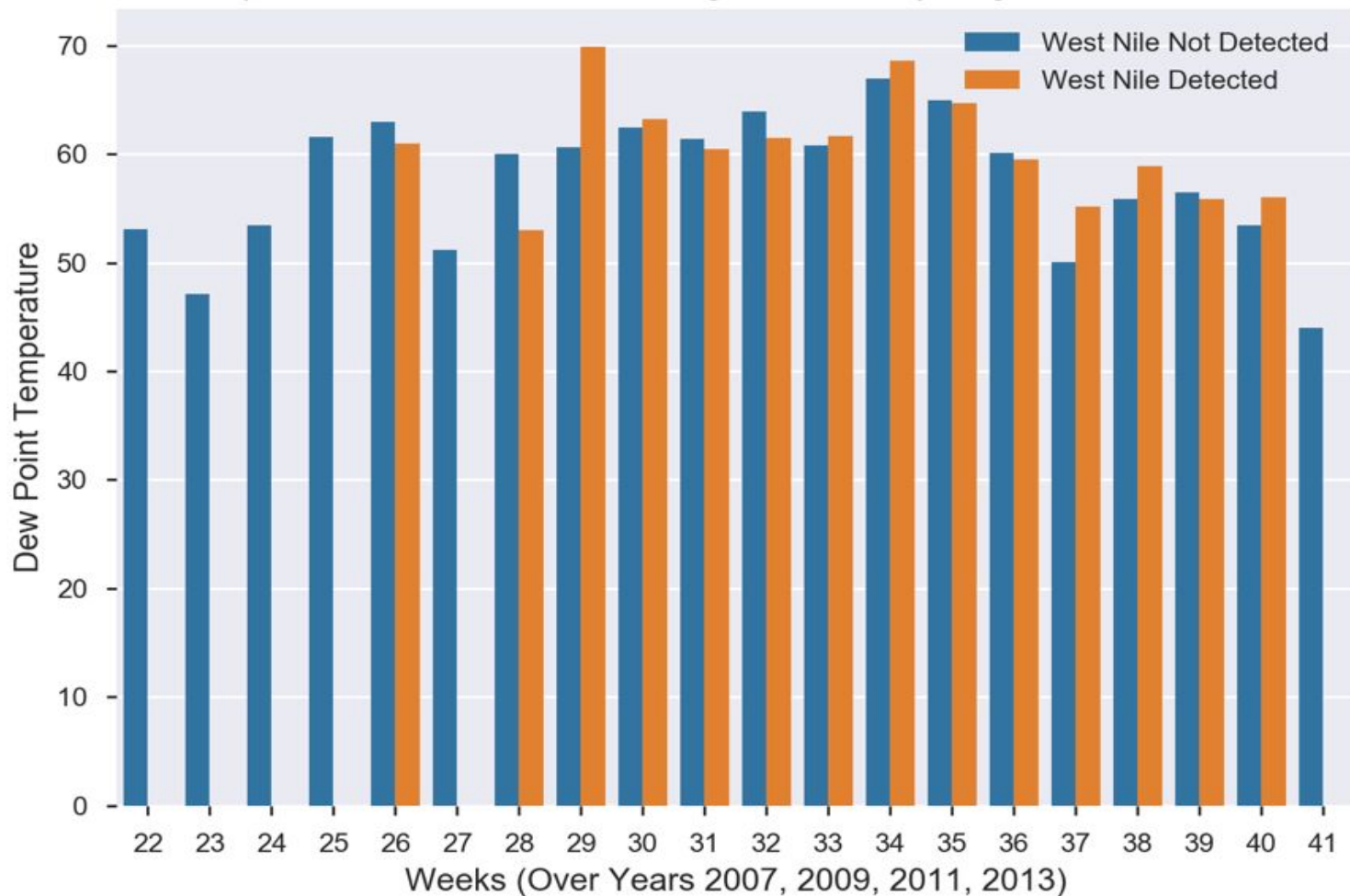
THE MODEL OF ALL MODELS

1 "Given this week's results, can we predict if there will be WNV at a given trap location next week? Building an algorithm that can detect at-risk sites earlier means that we can spray sooner, reducing public exposure to the virus."

Gene Leynes, Data Scientist, Chicago's Dept. of Innovation Technology

Our Model is Simple. . . .

Weather
Geography
Time of Year

Predict and
Prevent an
Outbreak
of WNV

WNV
Surveillance
Reports

How we built our ==algorithm/model==

- The model was trained on data mosquito data from the city of Chicago from 2007, 2009, 2011, and 2013. It was tested against data from 2008, 2010, 2012, and 2014

- The key output from our WNV algorithm is a score indicating the risk that a specific site could test positive for WNV in that particular week

- A variety of models, were tested, and features were only kept in the models if they improved the predictive ability

- For each trap, the model predicted the probability that West Nile would be present.

Results
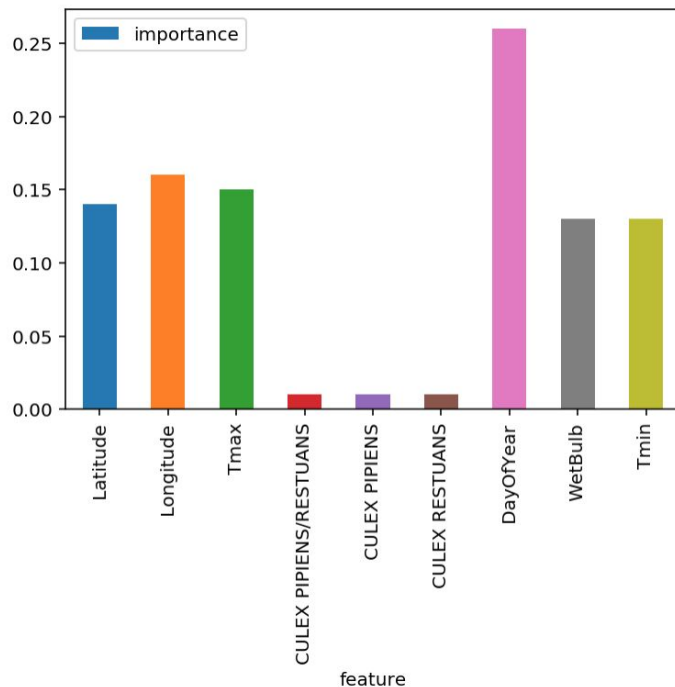
The most "predictive" feature is the **day of the year**

The weather for a particular time period is best used for predicting presence of WNV

The ROC AUC score was 0.72 (we aim for perfection at 1.0)

Model improvements:

- The test data did not include spraying and the number of mosquitos data

- More detailed handling of weather patterns (like the the number of days without precipitation)

- The model also tells us where WNV will show up
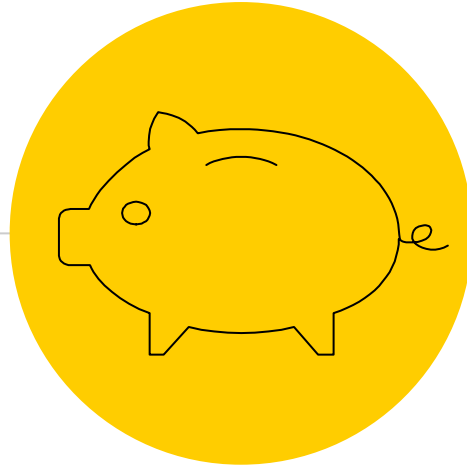
Cost Benefit Analysis

What are the real costs and benefits of vector control?

The Real Costs of Inaccuracy

No West Nile When There Really Is
- Unnecessary Spraying
- Quarantined population; Productivity and Tourism Loss

West Nile When There Really Isn't
- Negative Economic Impacts of WNV Outbreak
- Increased Chance of Human Epidemic

The confusion matrix.
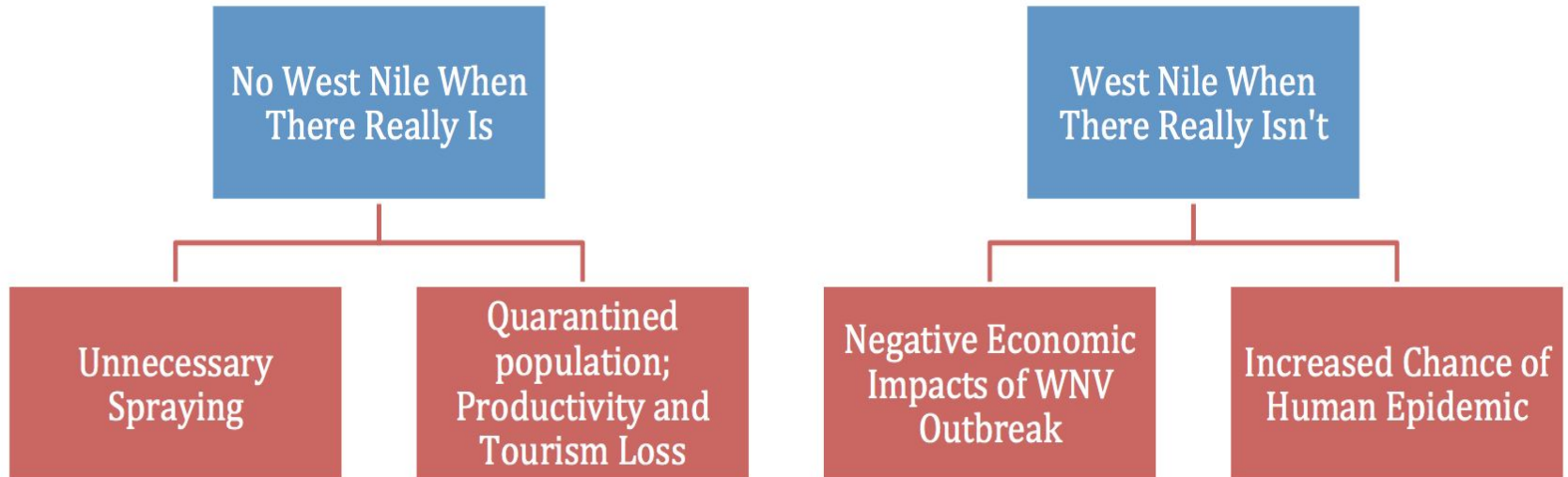
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The Human Cost

The Curious Case of Jeff Walls and Why We Can't Think of the City as a Vacuum

This is Jeff Walls. He contracted WNV in July or August 2017

- He doesn't remember if it was July or August

- He doesn't know where he contracted WNV – could've been in Chicago or in the suburbs

- He developed West Nile neuroinvasive disease needs long term care to from encephalitis
(donate to jeff at www.gofundme.com/jeffwallsr2r)

2 The Human Benefit

Not contracting WNV and suffering.

Since humans are gregarious, we must think of a regional approach to WNV vector control

The Cost - Benefit Analysis

Spraying

- $1.1 million to spray the city

- Spraying reduces WNV by an estimated 67%

- In 2017, an estimated 180-ish cases were prevented by spraying

Not Spraying

- $1.9 million in estimated damages
- Each WNND infection costs $25,117 in hospitalization + ____ in lost productivity
- This has also resulted in increased economic burdens due to initial acute health care needs of infected individuals and subsequent long-term costs associates with infection, estimated at approximately $56 million per year between 1999 and 2012 (Barrett, 2014)
- Losses in tourism and entertainment cannot be calculated
- The resurgence of WNV activity in 2012 (2,873 WNND cases and 286 deaths) suggests that a targeted prophylactic or therapeutic vaccine program, possibly to include senior citizens who represent the major population group who get WNND, would probably be cost-effective.

Reducing Costs: How to incorporate our model ==seamlessly==

- Fortunately, the city has had a long-running tool to help make the program easy to implement: ==WindyGrid==.

- WindyGrid is a computer application designed for city personnel that makes Chicago's big data easily and strategically accessible in one place.

- As a geographic information system, the application presents a unified view of city operations across a map of Chicago, giving key personnel access to all of the city's spatial data.

- This includes both historic and real-time data, with featured information including 911 and 311 service calls, transit and mobile asset locations, building information, and even public geospatially-enabled tweets.

- DoIT has since added WNV prediction data into WindyGrid. With all city employees able to access WindyGrid, CDPH's field staff has an already-running tool to use in its spraying and monitoring processes, making the transition to algorithm-optimized operations seamless..

$2,000,000
Mosquito abatement budget

*City of Chicago and Cook County

2,704,958 Chicagoans
Less than $1 per person; $2.50 per used tire disposed

100%
Total success!

Team C # ++

Any questions. . . ?

Raj Chakabarty
Zaheer Rangwala

Sian Lewis
Joshua Sung

Notes

For West Nile Neuroinvasice Disease, we calculated costs using similar methods as and specific data from Zohrabian et al. (*10*).

- ◉ Costs of inpatient and outpatient care,
- ◉ lost productivity, and miscellaneous expenses were summed to estimate the total cost of an individual WNND case.

- ◉ Costs for West Nile Fever, including average price for a physician visit,
- ◉ CDC-approved diagnostic testing, and
- ◉ productivity loss during symptomatic WNV disease, were summed to estimate the total cost of an individual WNF case.

Many WNF cases are not reported because they are not recognized as WNF; symptoms can resemble a cold or mild influenza-like illness, for which medical care is not sought, or is underdiagnosed because the additional cost of testing would not provide alternative direction to effective palliative medical care (*7*,*9*)

Zohrabian et al. (*10*) estimated the economic impact of the WNV disease outbreak in 2002 in Louisiana, which resulted in 24 deaths. They included costs of inpatient and outpatient medical care, productivity loss, the state's public health department, and vector control. Total epidemic costs were ≈$20.14 million for the 329 cases, including $9.2 million for mosquito control and public health agency costs.

Among patients in the study, the average age at initial diagnosis was 55 years, and one-fourth of patients were over 65 years of age. Hospitalized patients were absent from work or school for a median 42 days due to their illness