Predicting West Nile Virus and associated costs

By Joseph Klein, Jingfei Cai, Andy Gonzalez, and Rich Enikeieff

Agenda

Problem Statement

West Nile Virus, control methods, and costs

Building the Model

Key Takeaways

Problem Statement

We aim to predict the presence of West Nile Virus infected mosquitoes in traps positioned across Chicago's Cook county using weather data provided by the National Oceanic and Atmospheric Administration (NOAA) and fumigation efforts data from the City of Chicago. Using the predictions of our model, we will estimate a cost-benefit analysis that juxtaposes spraying locations based on predictions and the added cost as consequence of West Nile Virus if left untreated.

Building the model

Feature selection:

Location of the traps: Raw data include trap number, block number, and street name; street address, longitude, and latitude were derived from the combination of street name/block number; dummy variables of the street address were used in the model.

Species of the mosquitoes: Mosquito species was coded as dummy variables.

Temperature: Average temperature for the entry date.

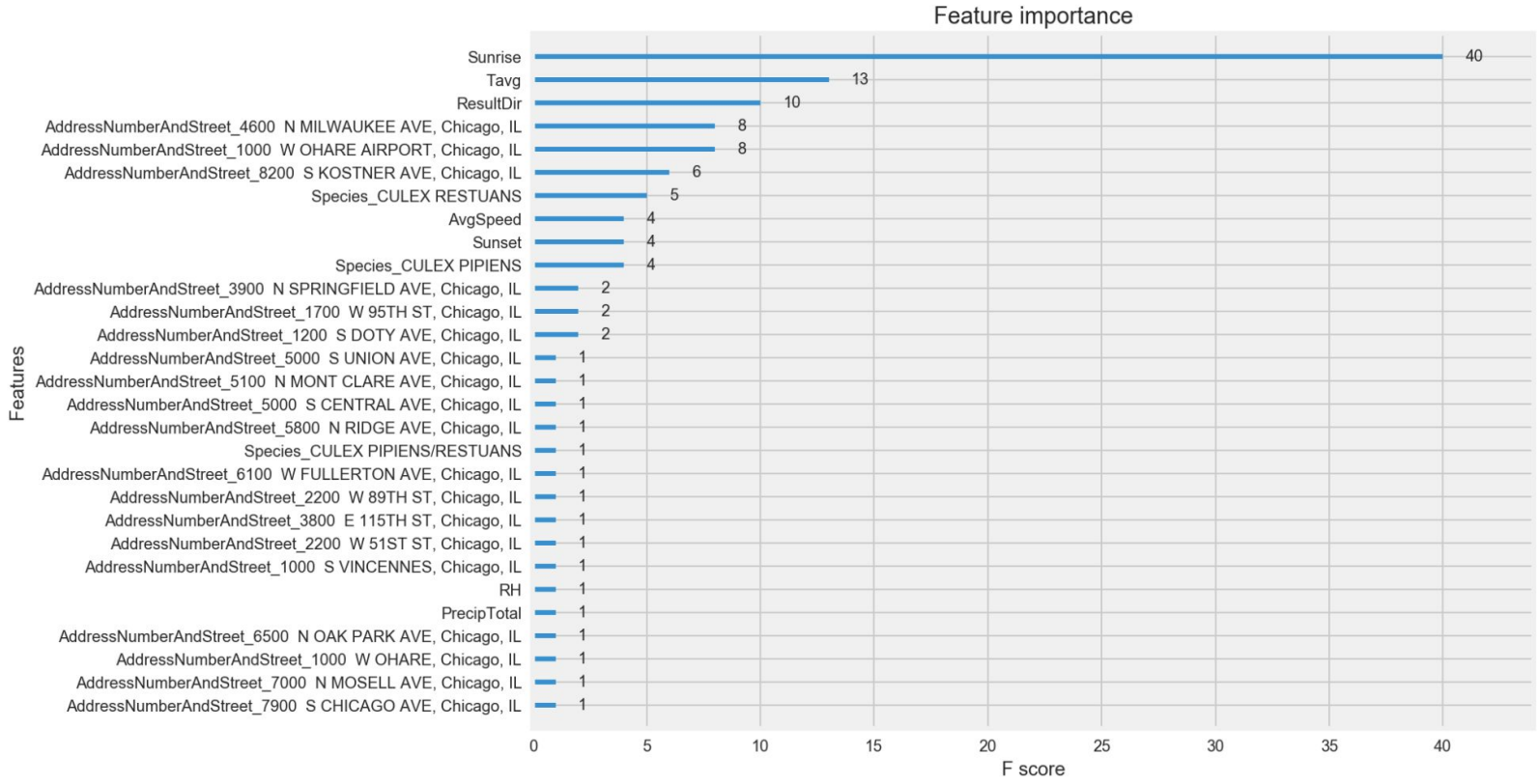
Sunrise/Sunset: Raw data is calculated sunrise/sunset time; converted to number of hours passed since midnight.

Rain: Total precipitation for the entry date.

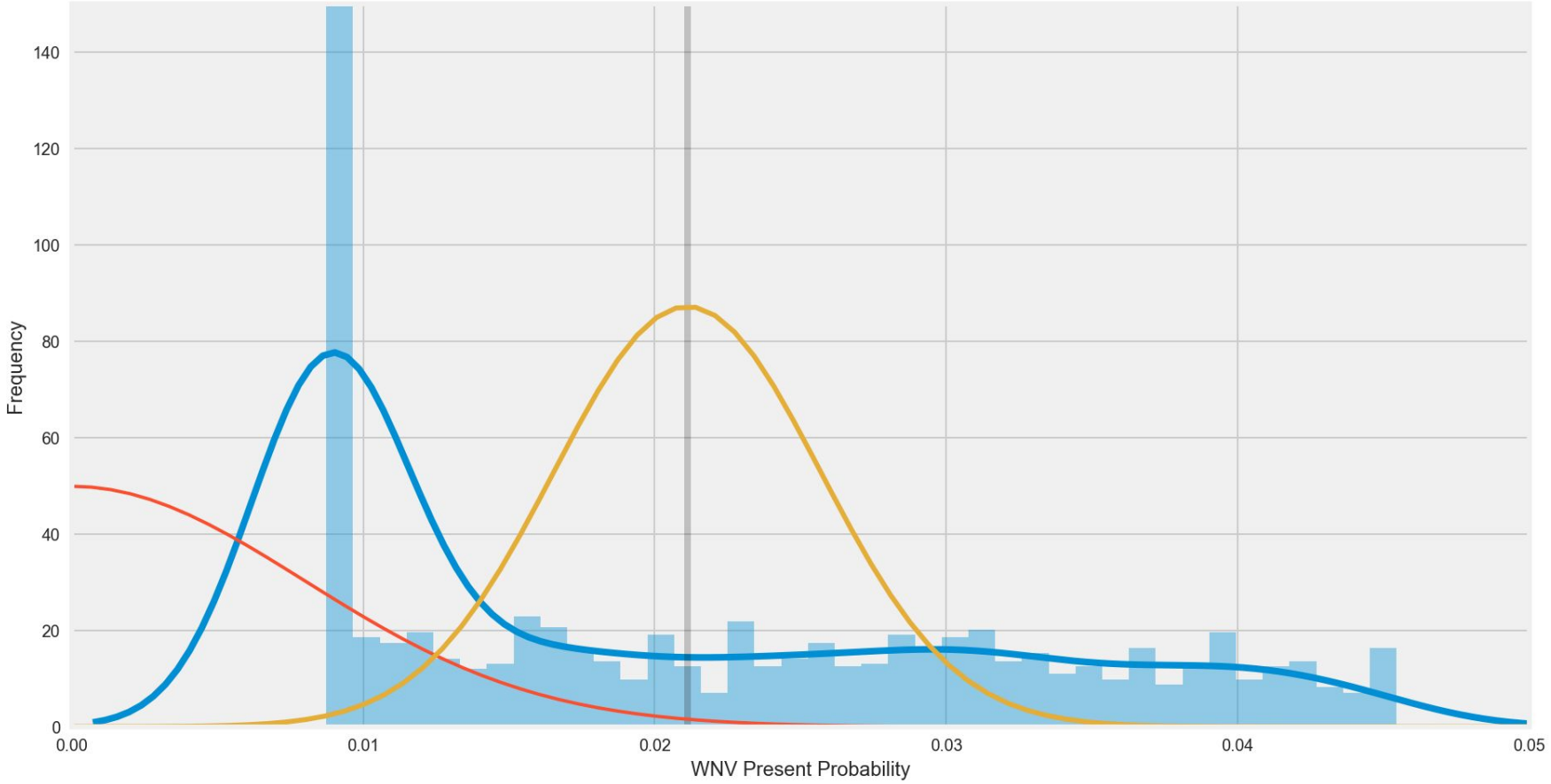
Wind: Average wind speed and direction for the entry date.

Humidity: Relative humidity (approximated based on average temperature and dew point) for the entry date.

Building the model



Prediction Results



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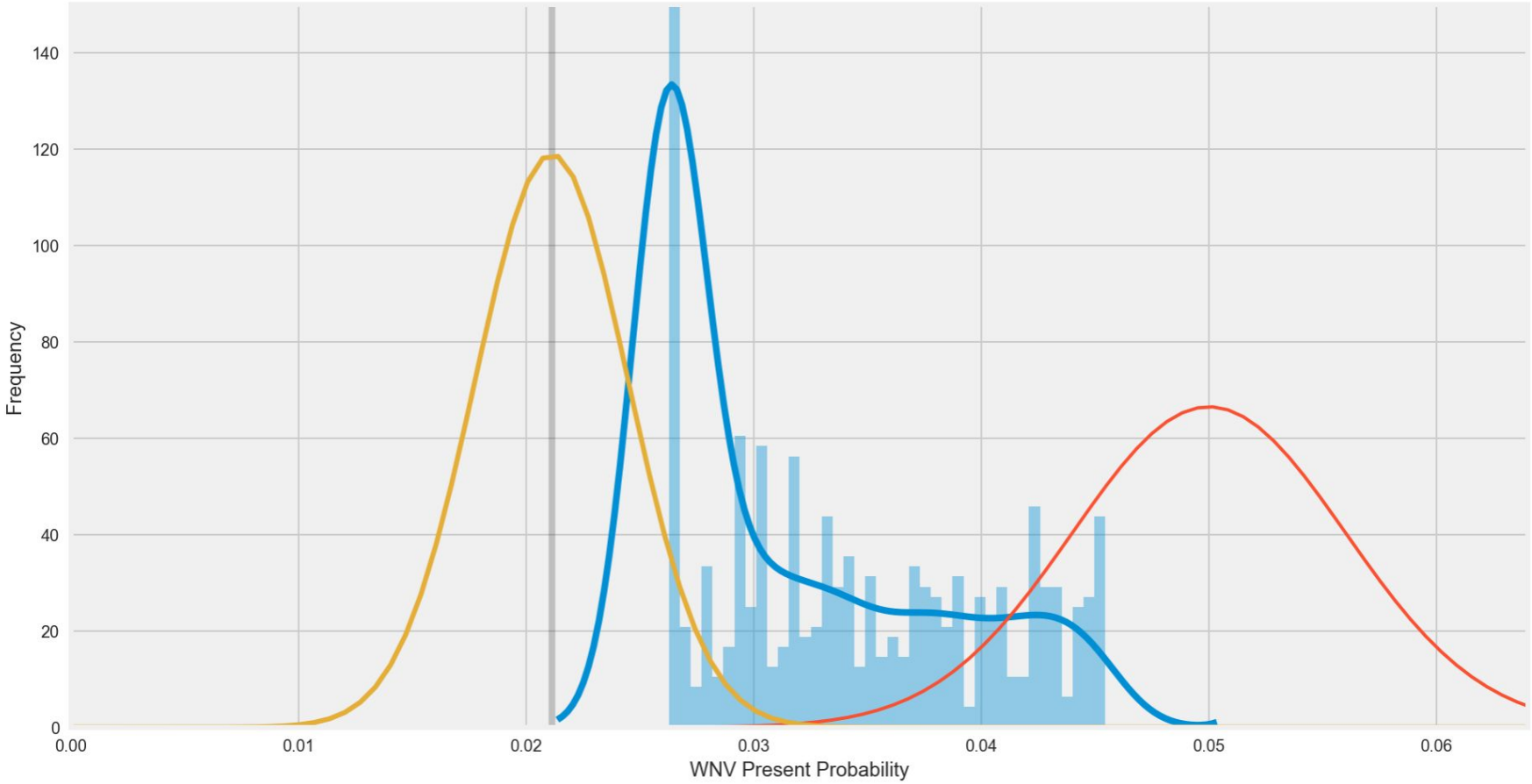
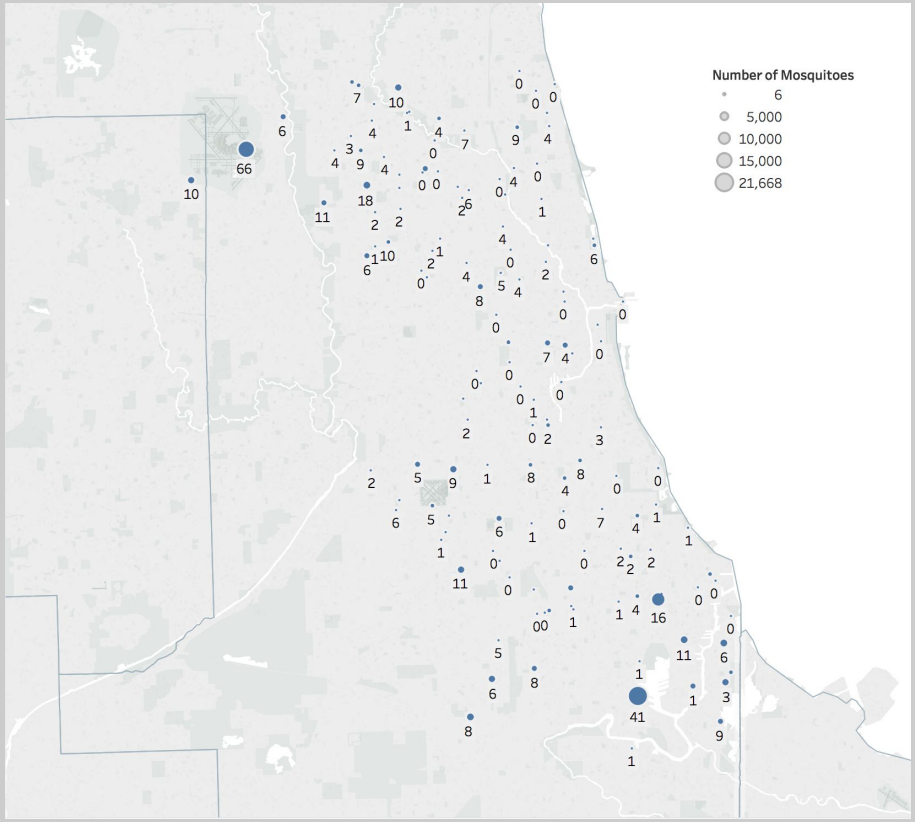
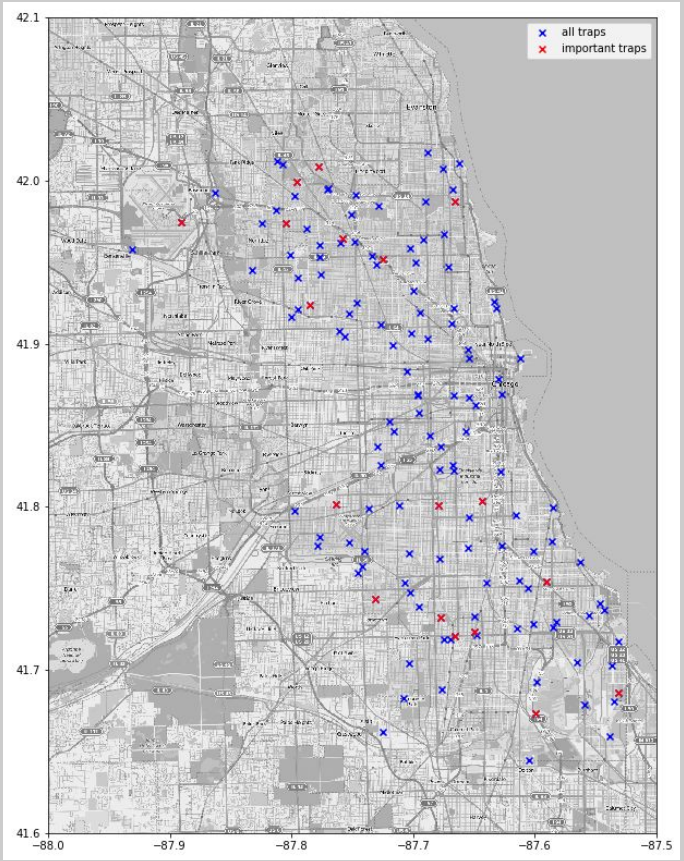


Traps vs. Counts of WNV-positive



Important Traps Indicated by Model



Symptoms of WNV:

Fever accompanied by malaise, headache, myalgia, rash, lymphadenopathy, eye pain, anorexia and vomiting lasting for 3 to 6 days, to severe meningo-encephalitis, severe muscle weakness, flaccid paralysis, and finally death.

Chances of infection:

- 80% of infected individuals do not exhibit symptoms
- 20% exhibit febrile symptoms
- Less than 1% of the infected population will have life threatening symptoms
- 1/100,000 infection rate

Local Population affected by WNV:

- Population hits: 296 infections 2008-2013
- 16 deaths
- Median age ≥ 55
- Upper quartile ≥ 65
- 55:45 male/female split

Current Preventive Measures:

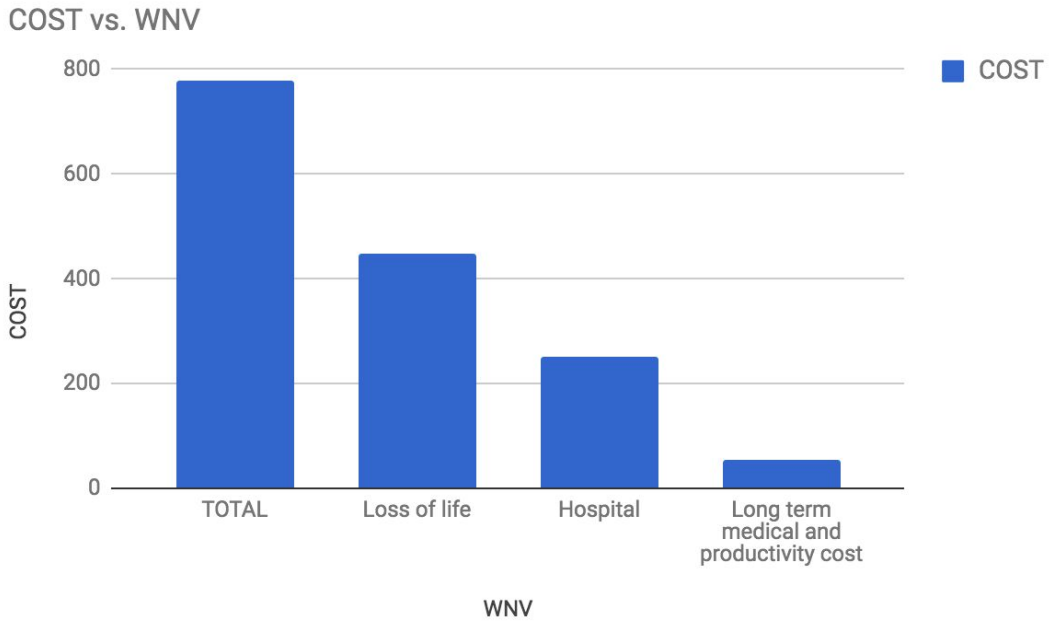
Larvicide - Altosid® XR-Briquets (Methoprene)

- Duration: 1-28 days depending on sunlight levels
- Cost: $1.5 - 1.6 per acre
- Effect: Slight irritation to skin if touched or throat if breathed

Adulticide - Zenivex (Etofenprox)

- Duration: 1.7 days in water, 4.4 in soil
- Cost: $.67 per acre (commercial cost)
- Effect: Harmful if swallowed, and causes irritation to eyes

Cost assessment:



Cost assessment:

Cost per year 57~ mil

Cost breakdown:

- 779 mil total:
  - 447 mil loss due to loss of life (productivity hit)
  - 252 mil due to hospitalization during illness
  - 54 mil long term medical and loss of productivity costs

Fiscal cost for the city:

- 5,200,000 for mosquito abatements
  - Salaries
  - Vehicles
  - Pesticides, Larvicides
  - Testing equipment
  - traps
- 500,000 vector control programs
  - Aerial pesticide control
  - Salaries

Pesticide Environmental Cost:

- Spray pesticides used for adult mosquito control do not pose significant acute toxicity risk to invertebrates in receiving systems.
- In California, 15% of the post-application water samples were significantly toxic for aquatic life.
- Etofenprox is highly toxic to bees, and other benign insects
- Toxic to pets and children for the hours following the spray

Recommendations:

- Citizen education:
  - Clean up sitting water i.e (outside drainage, excess puddles from rain, dog bowls, etc)
  - Limit outside exposure during prime mosquito hours
  - Use insect repellant
- Aerial spraying
  - Most efficient method for spraying large areas
- Vehicular spraying
  - Able to get niche areas that aerial sprays are unable to get to
- Larvicide
  - Preventing mosquitoes from entering maturity thus limiting possible exposure to WNV

Cost conclusions:

Currently, due to the sporadic and scarce nature of WNV. It is not recommended to aggressively pursue the entire eradication of WNV over other diseases due to funding limitations, and the futility of wiping out mosquitoes. As of 2015, there have been 20,265 hospitalizations for WNND, and 1,783 deaths (9%). 1266.6 cases per year and 111 deaths per year while tragic this is is not as pertinent as other diseases. Aerial spraying is currently the most effective city wide measure in reducing mosquito populations as proven by Dallas in 2012.

Key Takeaways

- Weather, mosquito species, and trap test history were the best predictors of West Nile Virus incidence.
- Even with a model correctly predicting 76.3%, efforts to minimize the impact of the disease must include citizen education: Spraying will only reduce the disease vector partially.
- While overall contract size and scope for mosquito abatement programs has grown, the $5.2 million spent per year toward that goal is still dwarfed by the potential cost of more than $20 million.

Questions?

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Midwest regional models - http://mrcc.isws.illinois.edu/research/westnile/index.jsp

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