An Operational System for Surveillance and Ecological Forecasting of West Nile Virus Outbreaks

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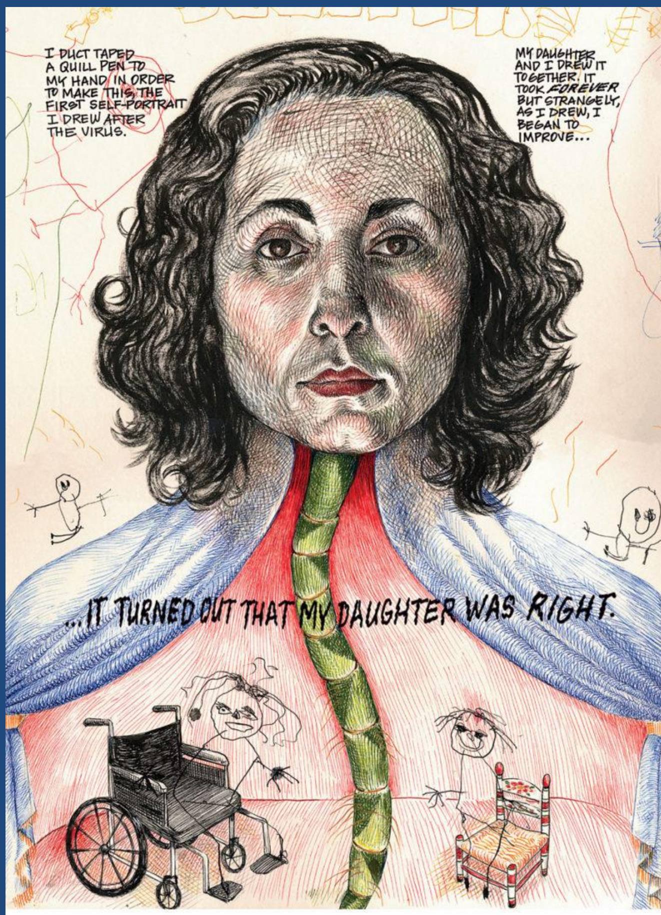
- Why did we do it?
- Where did we do it?
- How did we do it?
- Did it work?
- What did we learn?
- Why does it matter?

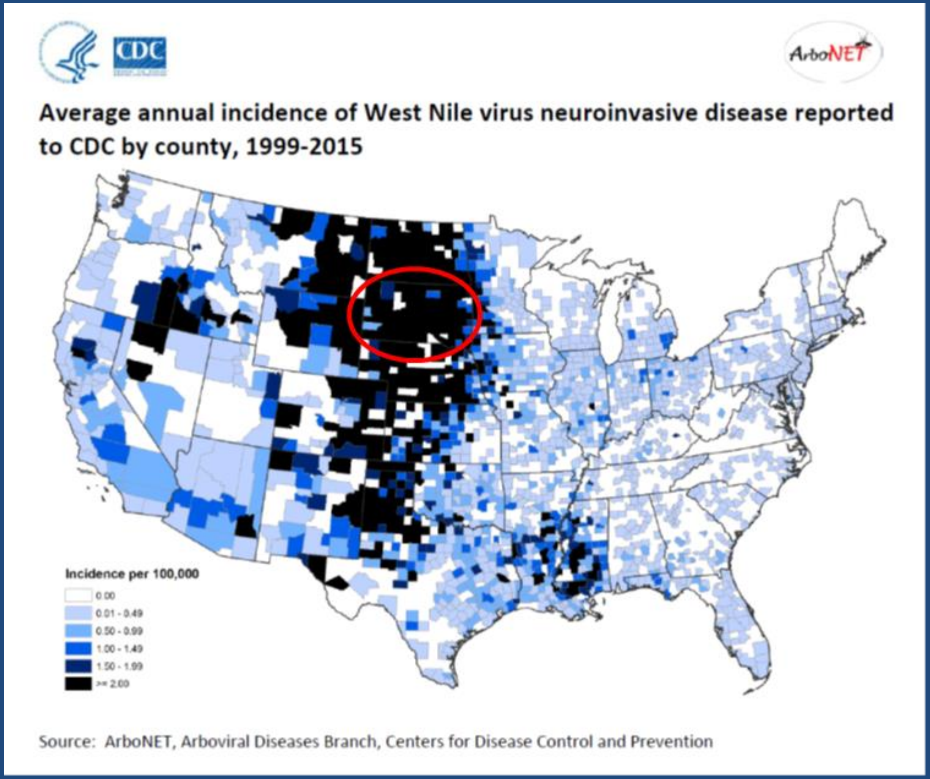
Why did we do it? West Nile virus is a terrible disease.



Emil Ferris, *Chicago Magazine*

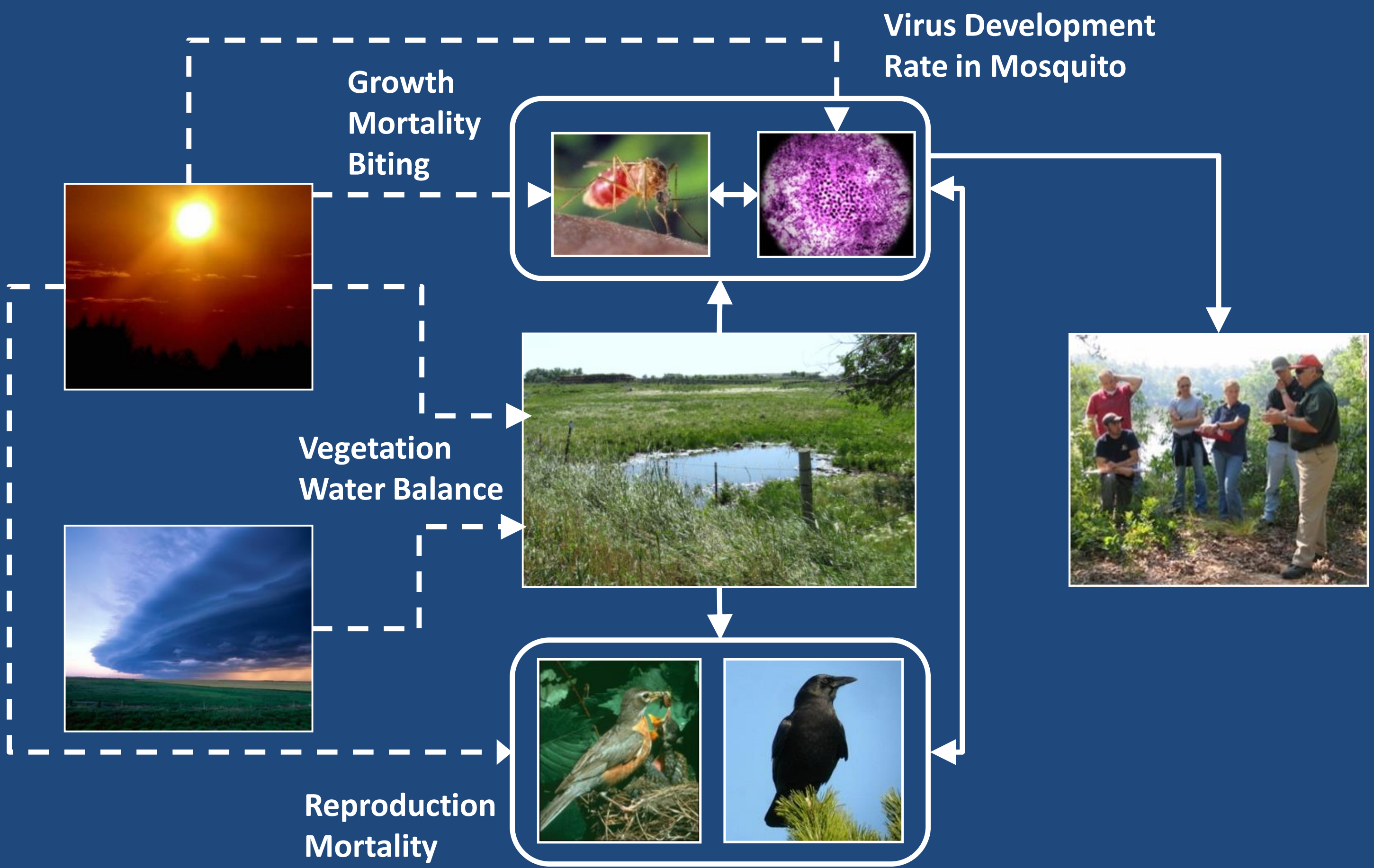
On her 40th birthday, Ferris was bitten by a mosquito and contracted West Nile virus. "At first I had sweats and chills, but then I was brought to the hospital — but I don't remember that last part. I had been out for weeks. Later the doctors told me I was paralyzed from the waist down. And that I had contracted meningitis and encephalitis. And that I lost my speech. And I had some brain damage. But the worst part was that my right hand was like this club — I had lost the use of my drawing hand."

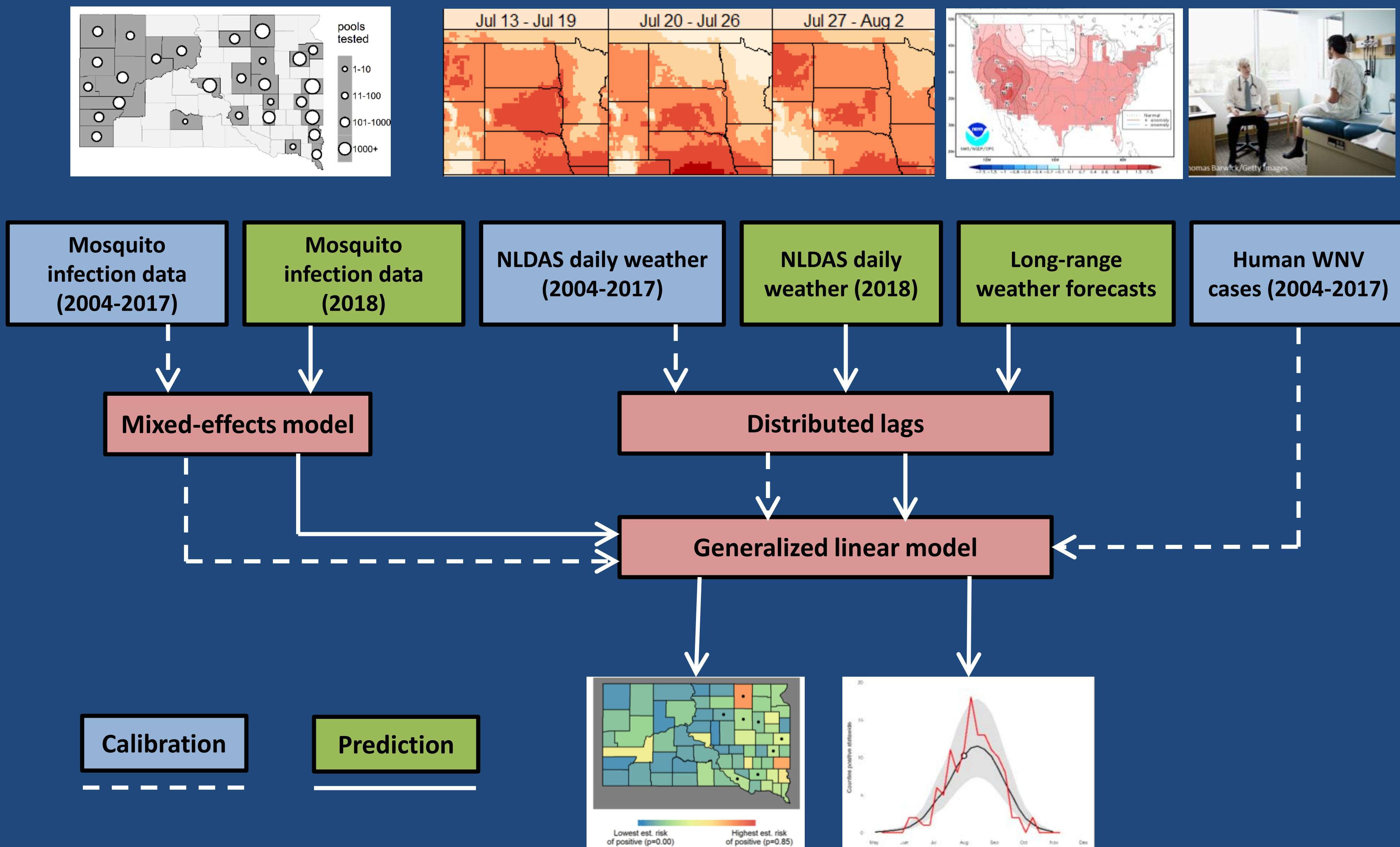
Where did we do it? South Dakota, of all places…



- 2,360 cases since 2002
  - 509 Neuroinvasive
  - 38 Deaths
  - 865,000 Population (2016)
- Highest annual incidence of all WNV disease (19.4/100,000)
- Highest annual incidence of WNV neuroinvasive disease in the United States (4.1/100,000)

How did we do it? Developed models of WNV transmission based on WNV risk factors.



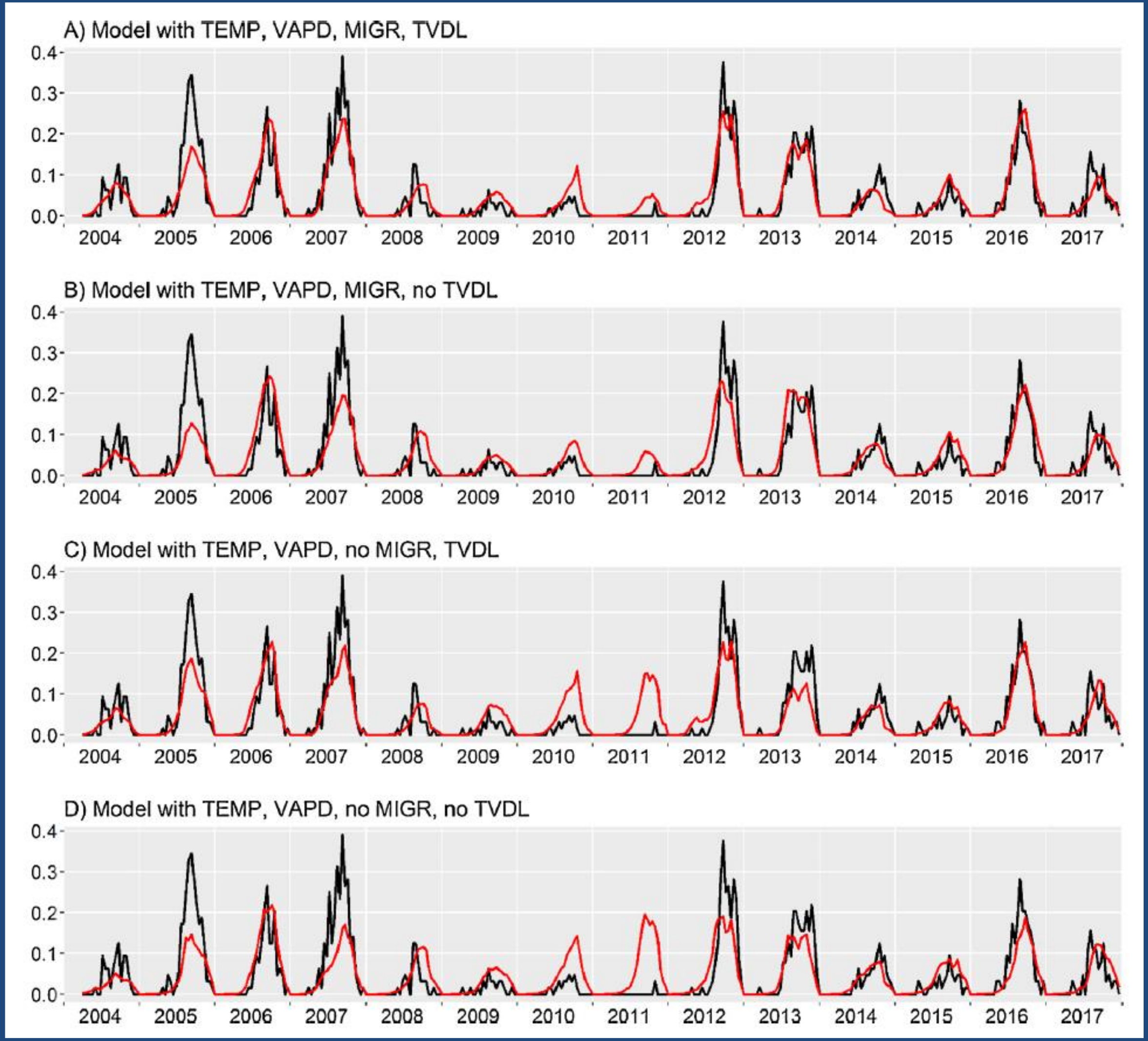

pools
tested
1-10
11-100
101-1000
1000+
Jul 13 - Jul 19
Jul 20 - Jul 26
Jul 27 - Aug 2
Mosquito infection data (2004-2017)
Mosquito infection data (2018)
NLDAS daily weather (2004-2017)
NLDAS daily weather (2018)
Long-range weather forecasts
Human WNV cases (2004-2017)
Mixed-effects model
Distributed lags
Generalized linear model
Calibration
Prediction
Lowest est. risk of positive (p=0.00)
Highest est. risk of positive (p=0.85)

How did we do it? Developed a weekly model of county-level WNV case occurrence.

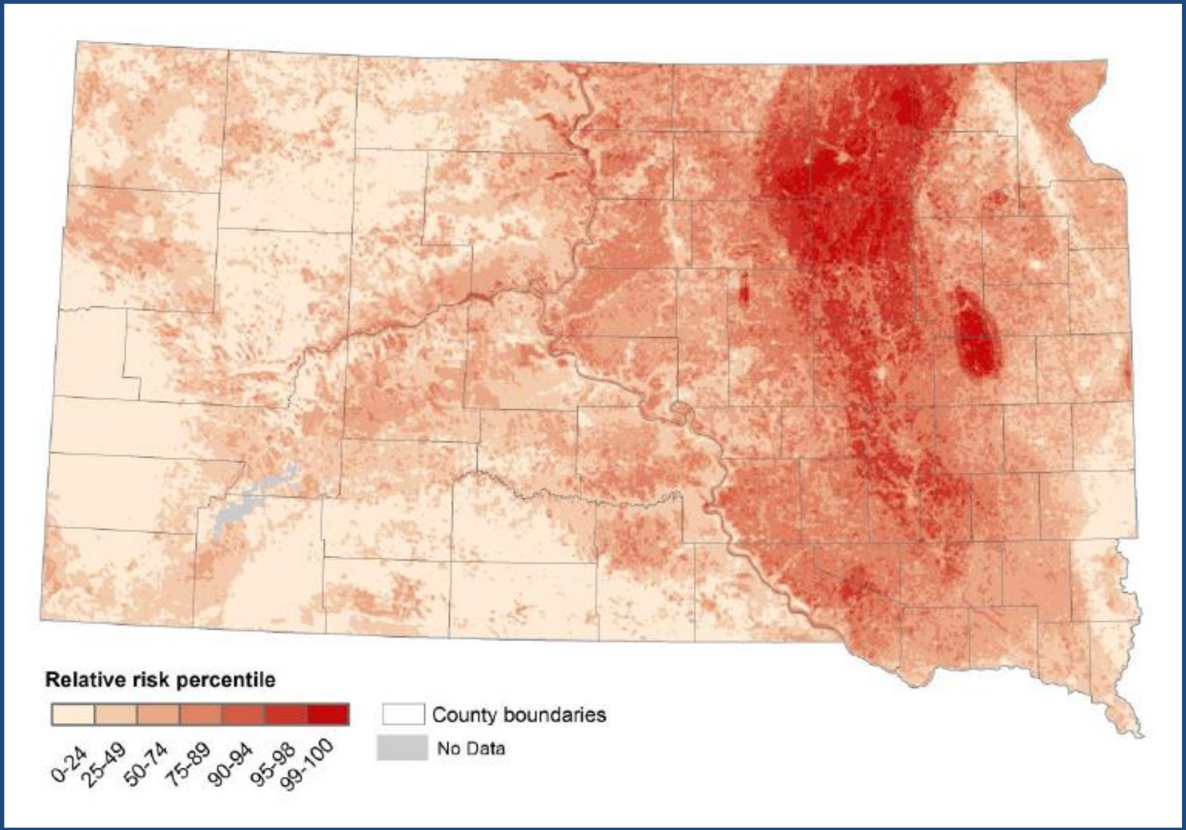
The best model included:

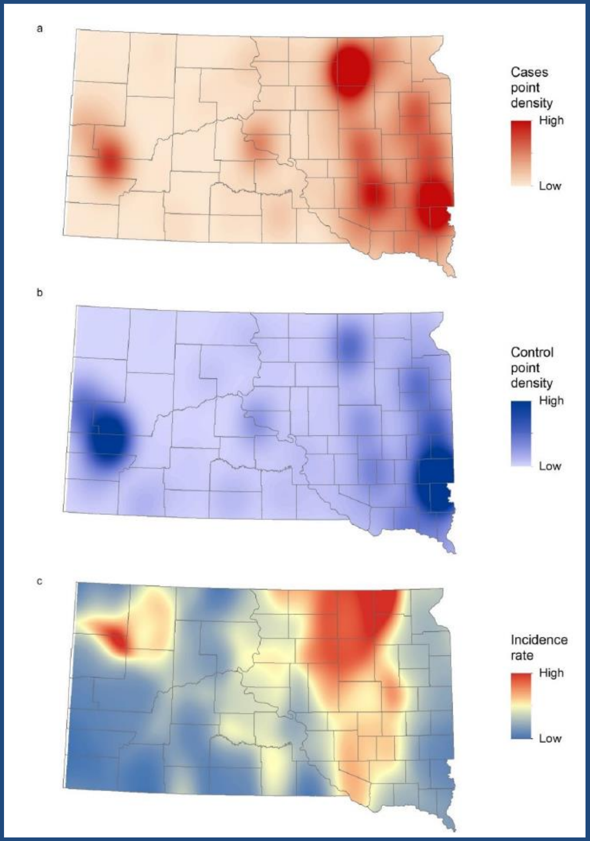
- Temperature
- Vapor pressure deficit
- Mosquito infection growth rate
- Time-varying distributed lags

Davis et al. (2018) *Acta Tropica* 185: 242-250



How did we do it? Developed a detailed risk map using geocoded human case data.





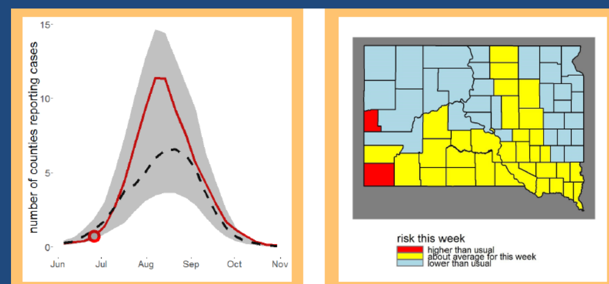
Main Predictors: Topography, MODIS NDWI (SD), Humidity (Mean & SD), Precipitation (Mean & SD), Land Cover, Soils (Ponding Freq)

Hess et al. (In Review) *GeoHealth*

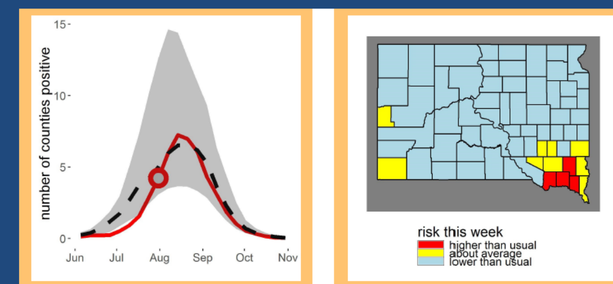
How did we do it? Seasonal WNV predictions were updated on a weekly basis in 2016, 2017, and 2018.

- Early season predictions driven by meteorological data and climate forecasts
- Late season predictions constrained by infection rates from mosquito surveillance

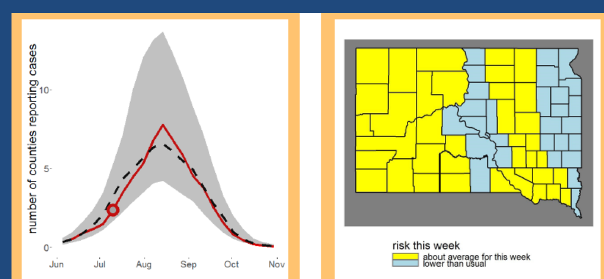
June 26



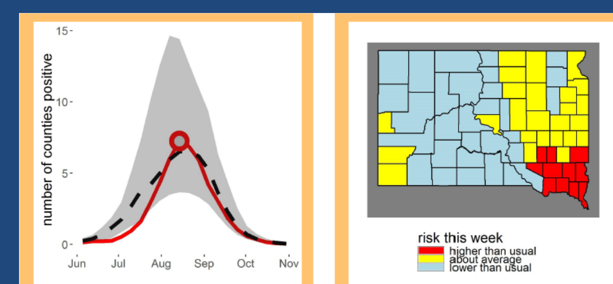
July 24



July 10

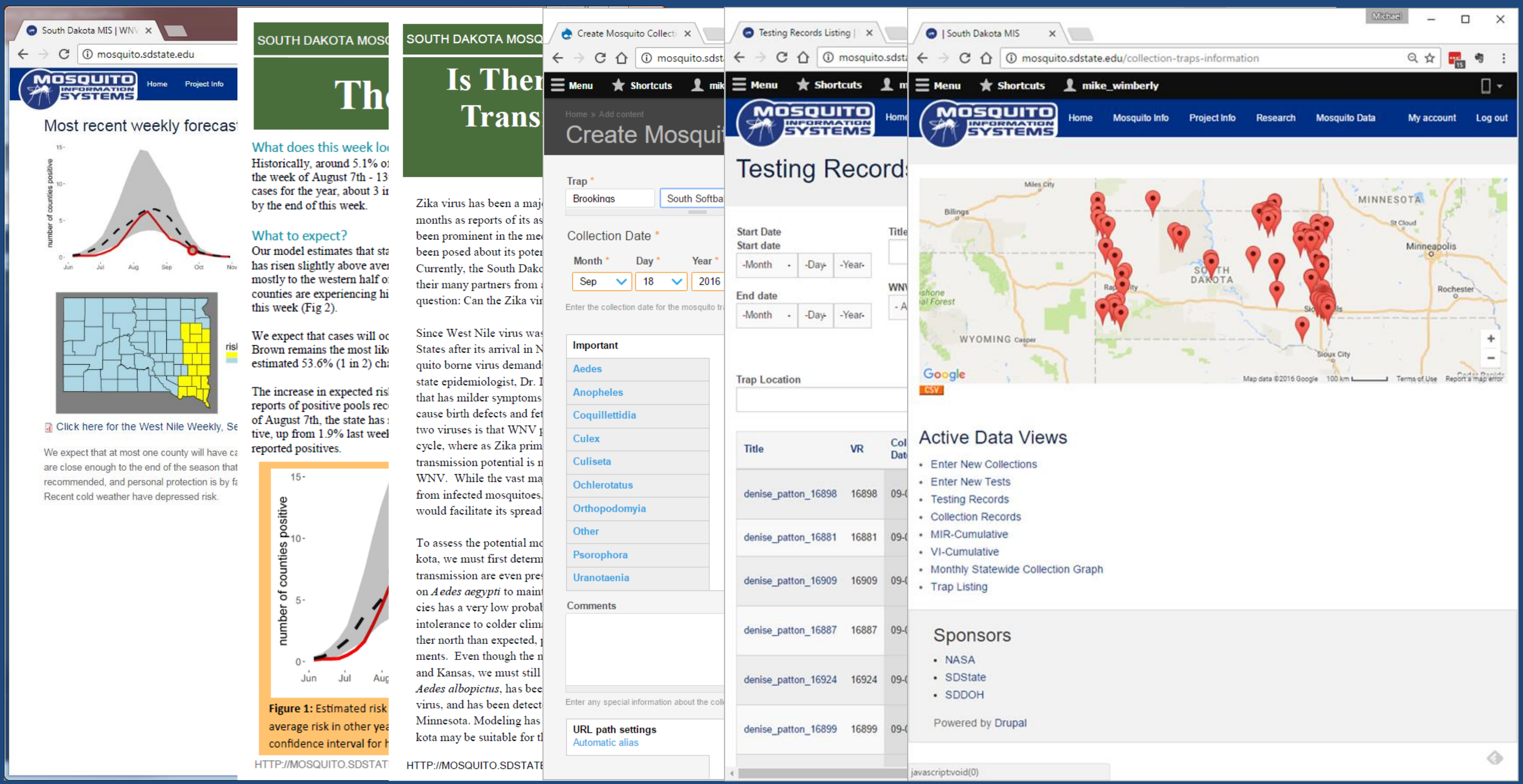


August 7



2017 West Nile virus predictions

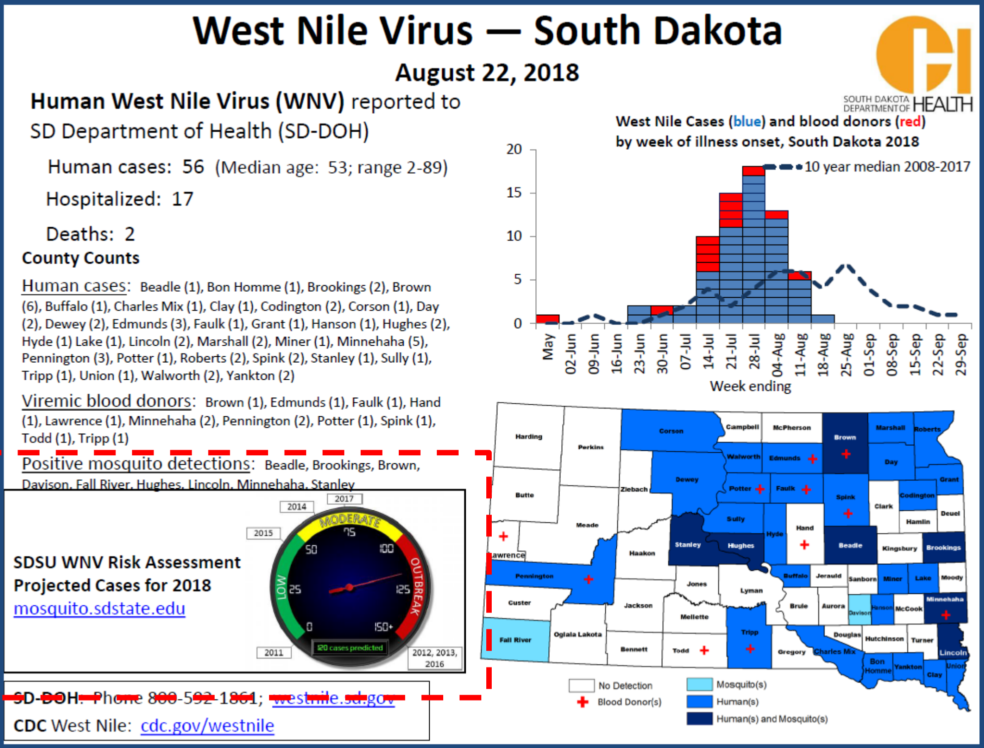
How did we do it? Website for collecting mosquito surveillance data and disseminating forecasts.



http://mosquito.sdstate.edu

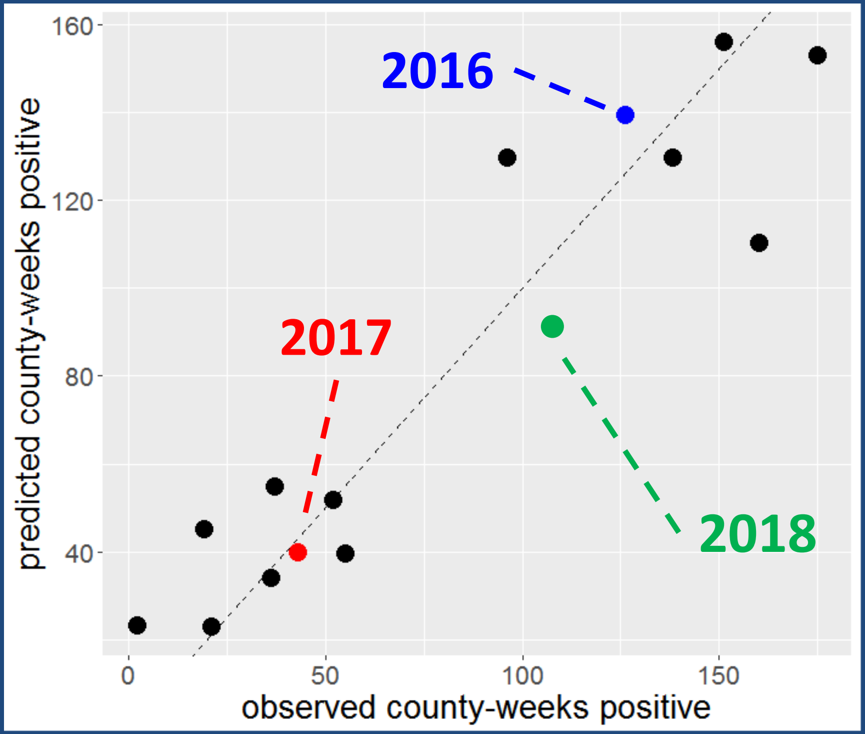
How did we do it? Partnered with SDDOH to transfer tools for forecasting

- Google Earth Engine script for accessing and processing NASA environmental data
- R script to automate model fitting and predictions
- Vignettes based on artificial data
- Tools made publicly available via Github
- Training provided to SDDOH epidemiologist Eric Grimm
- Final project ARL: 9 (Sustained Use in Decision-Making Context)



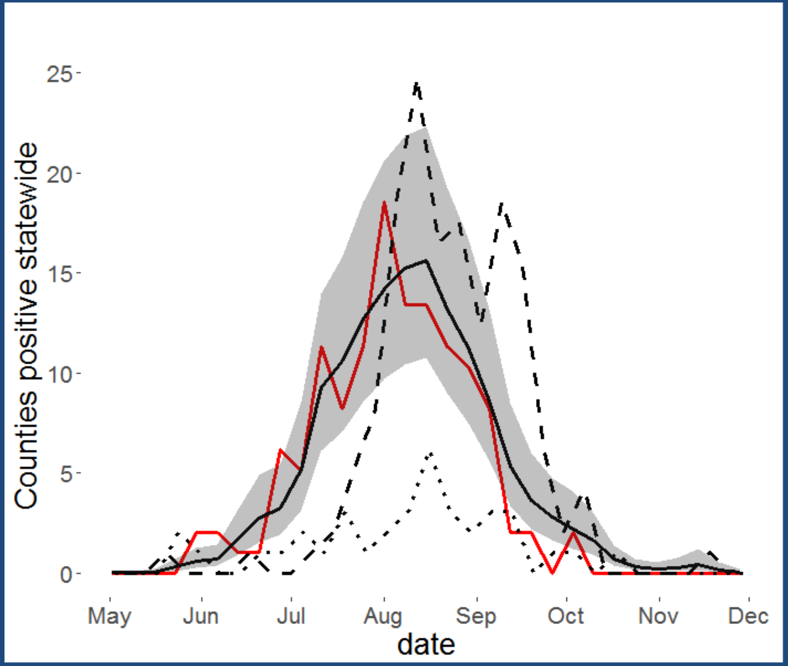
Did it work? Yes, we accurately predicted year-to-year variability in total WNV occurrence.

- **2016**
  - 139 positive county-weeks predicted on July 15th
  - 123 observed county-weeks
- **2017**
  - 40 predicted positive county-weeks
  - 43 observed county-weeks
- **2017**
  - 92 predicted positive county-weeks
  - 50 observed county-weeks so far
  - We expect to see at least 75 observed county weeks by the time all 2018 cases are reported.

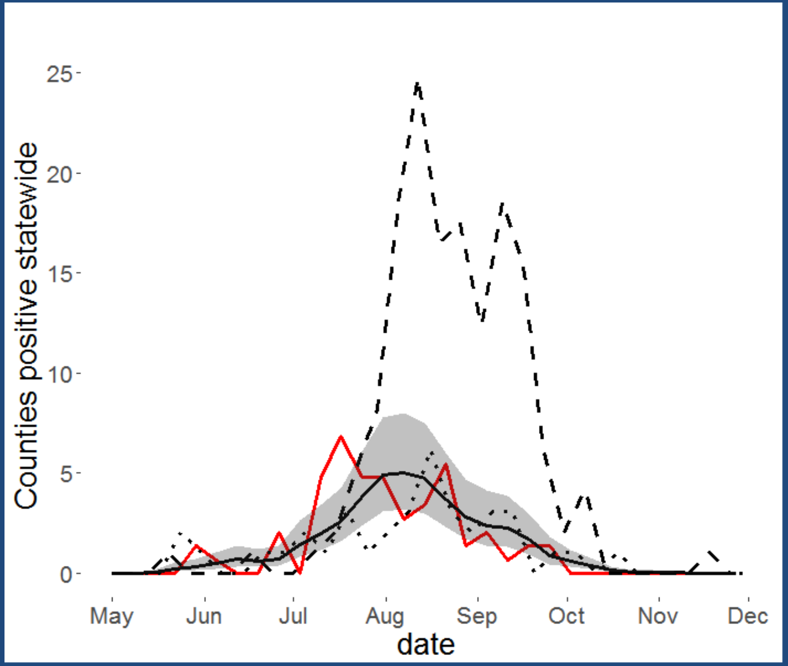


Did it work? Yes, predictions accuracy captured the seasonal trends in WNV occurrence.

2016



2017

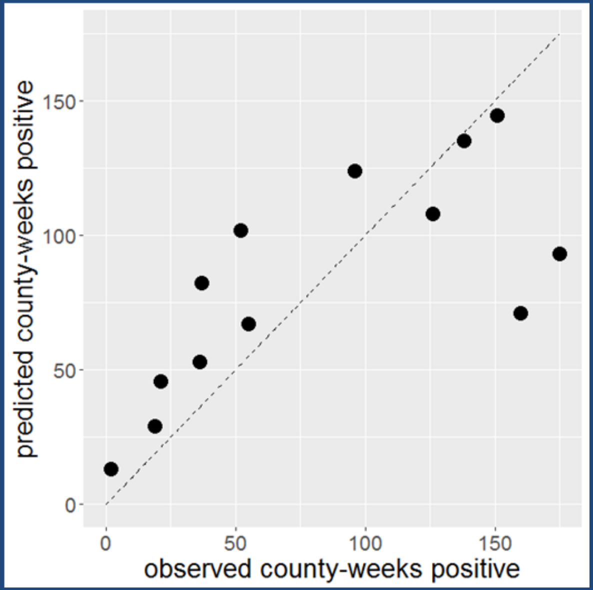


Black line/Gray Shading: Seasonal predictions made on July 15th with 95% prediction intervals.
Red line: Observed cases in 2016 or 2017.
Dashed line: Observed cases in 2012. Dotted line: observed cases in 2015.

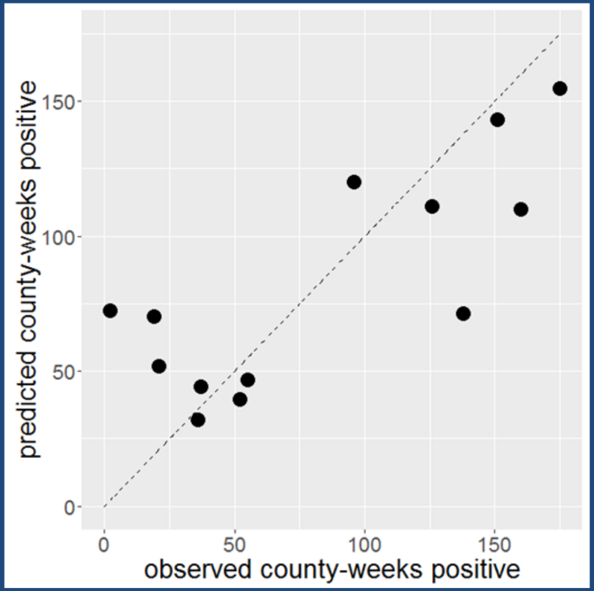
Davis et al. (2017) *PLoS Outbreaks: Curents*

What did we learn? Multiple sources of data are needed to make accurate predictions.

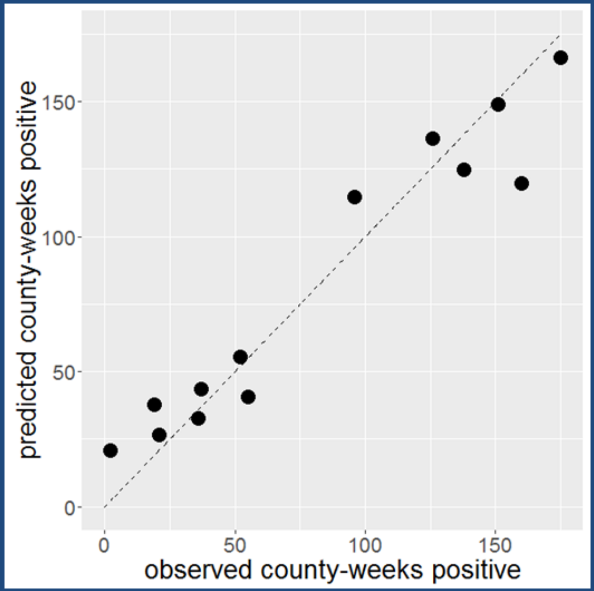
Mosquito infection data only



Meteorological data only



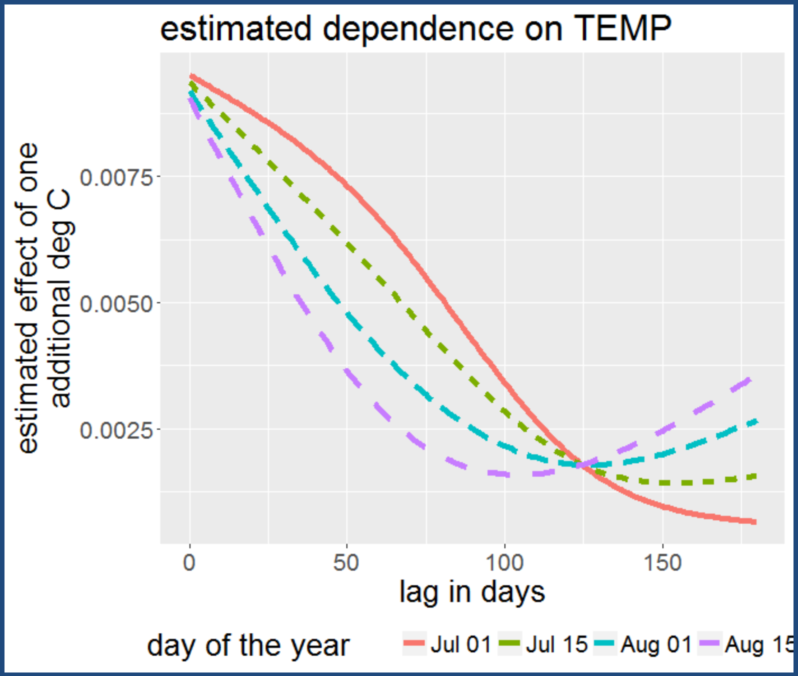
Combined mosquito infection and meteorological data

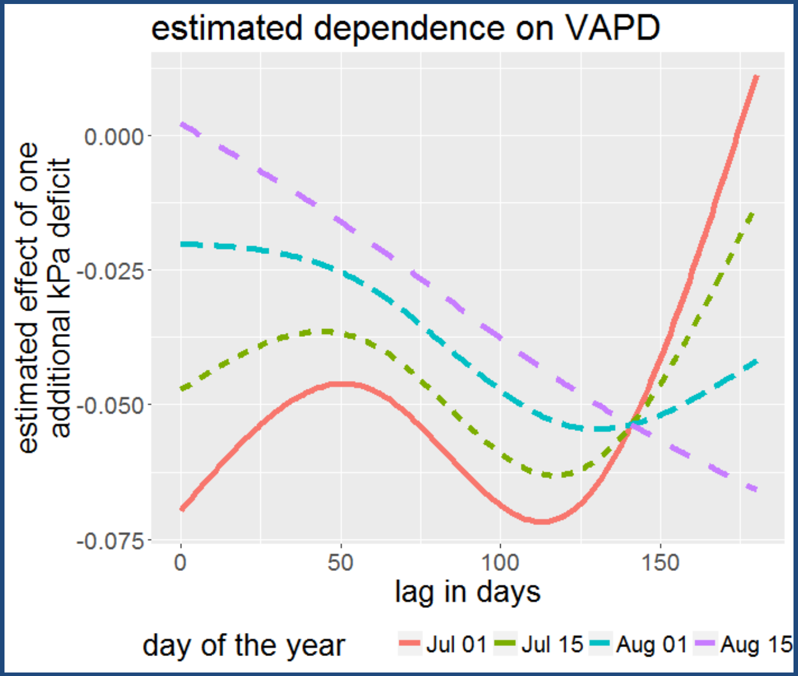


Annual predictions made on July 15th of each year.

What did we learn? Meteorological effects change throughout the WNV transmission season

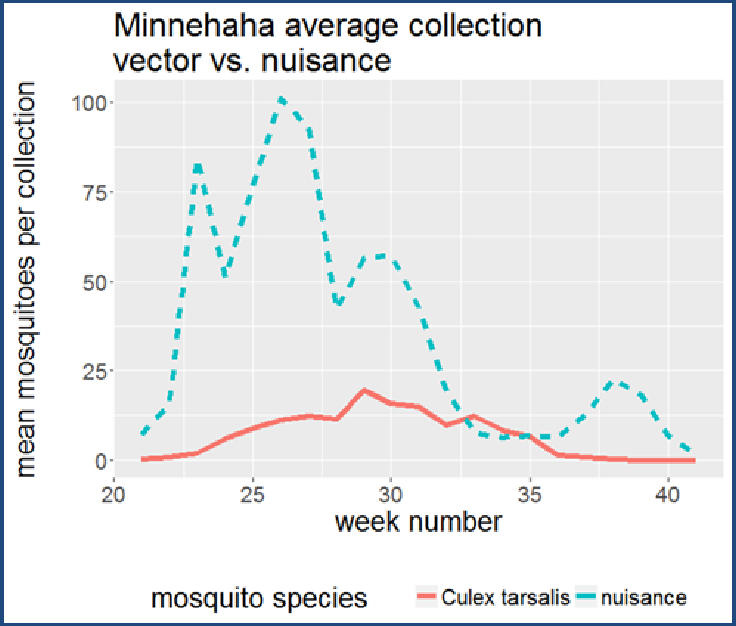
- Temperature effects are strongest at the shortest lags, with longer-term effects (30-90 days lags) decreasing over the transmission season.
- Effects of vapor pressure deficit are strongest in June and decrease over the transmission season.





Why does it matter?

- We confront the problem of mosquito-borne disease with limited resources and a large box of useful, but imperfect tools.
- For WNV, human cases are a lagging indicator of risk.
- People respond to the abundance of mosquitoes, which is not a good predictor of WNV risk.
- Prediction of WNV risk is necessary to target the right tools in the right places at the right times.



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  - Mark Hoven, Aberdeen
  - 100's of other statewide contributors to mosquito surveillance and control
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  - NASA Applied Sciences Program

Project Website

http://mosquito.sdstate.edu

Project Video

http://tinyurl.com/nasawnv

Or Google "Mosquito Meets MODIS"

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