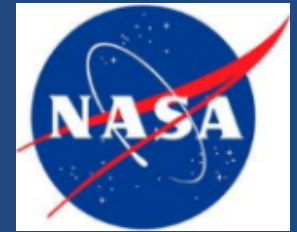


An Operational System for Surveillance and Ecological Forecasting of West Nile Virus Outbreaks



Michael C. Wimberly¹, Justin K. Davis¹, Geoffrey
Vincent², Andrea Hess¹, and Michael B. Hildreth²

1 Geospatial Sciences Center of Excellence, South Dakota State
University, Brookings SD 57007

2 Department of Biology and Microbiology, South Dakota State
University, Brookings SD 57007

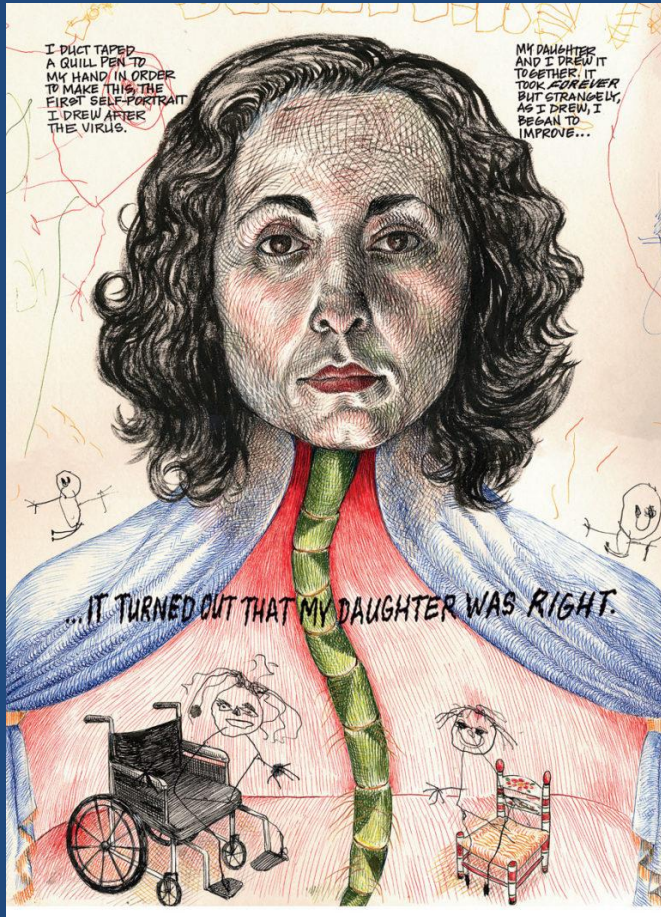
An Operational System for Surveillance and Ecological Forecasting of West Nile Virus Outbreaks

- 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?



https://www.medicinenet.com/image-collection/west_nile_virus_picture/picture.htm

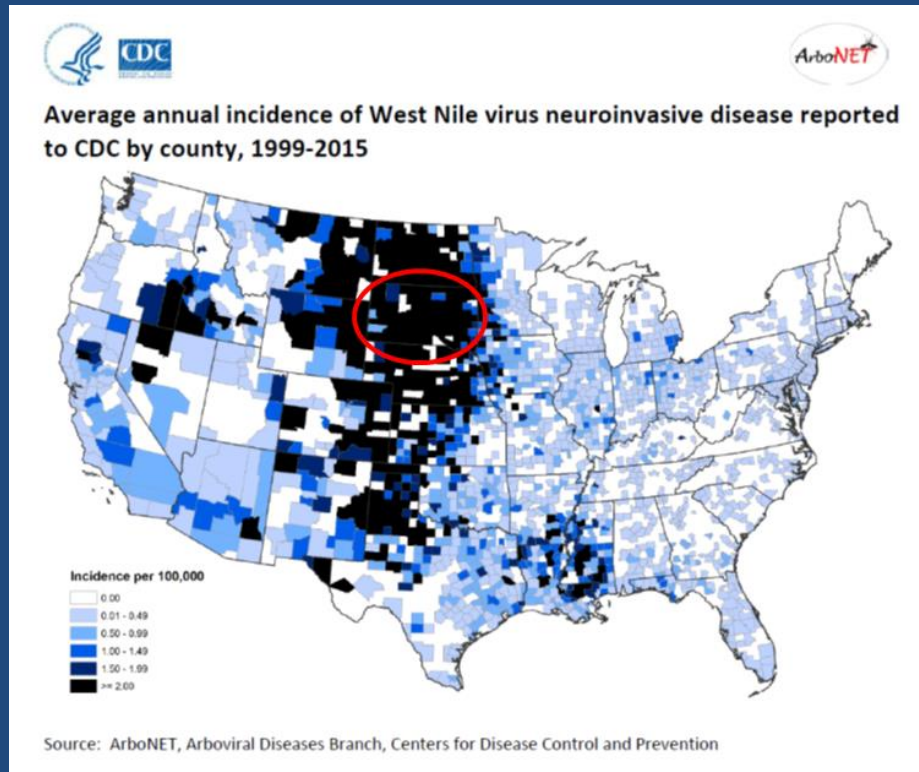
Why did we do it? West Nile virus is a terrible disease.



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."

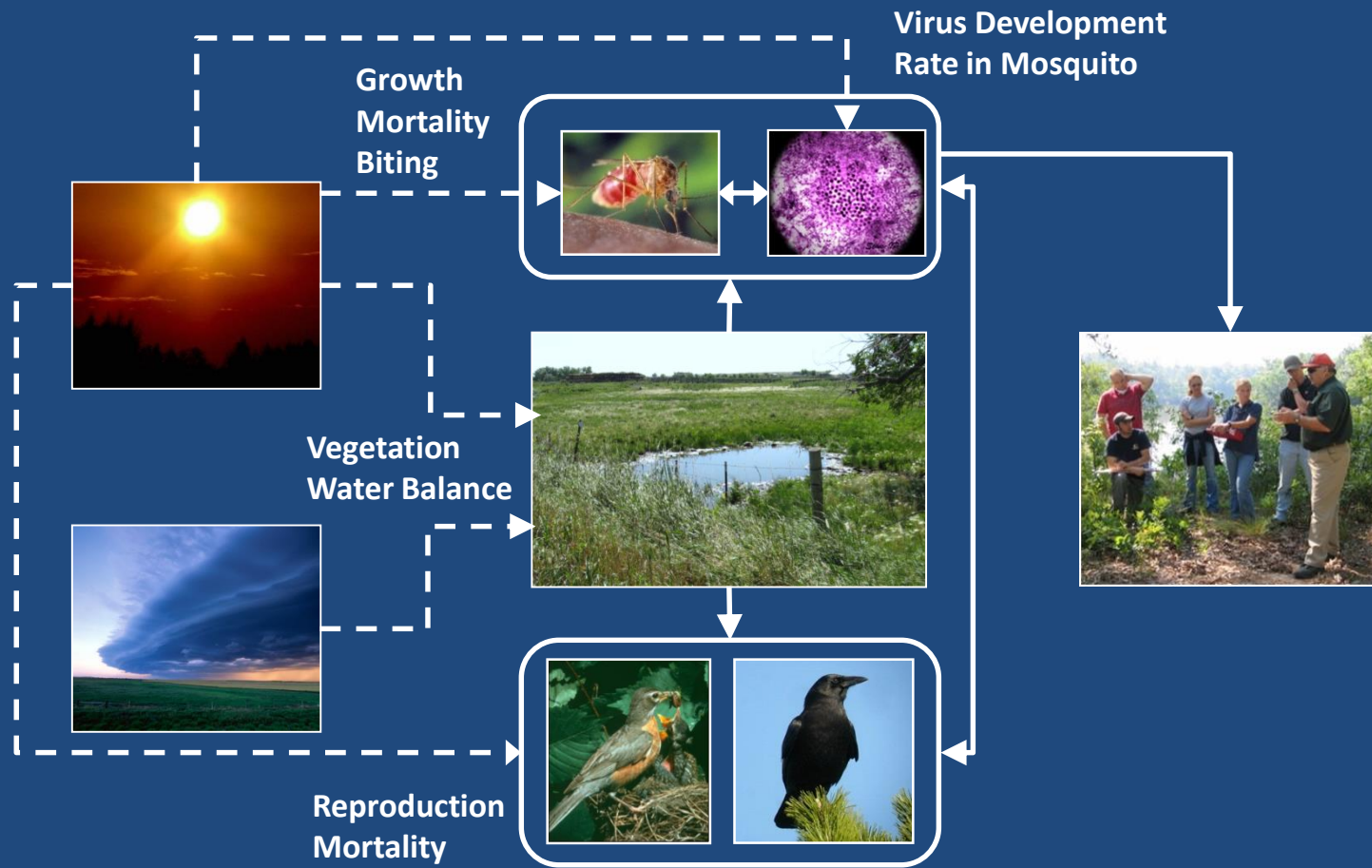
Emil Ferris, *Chicago Magazine*

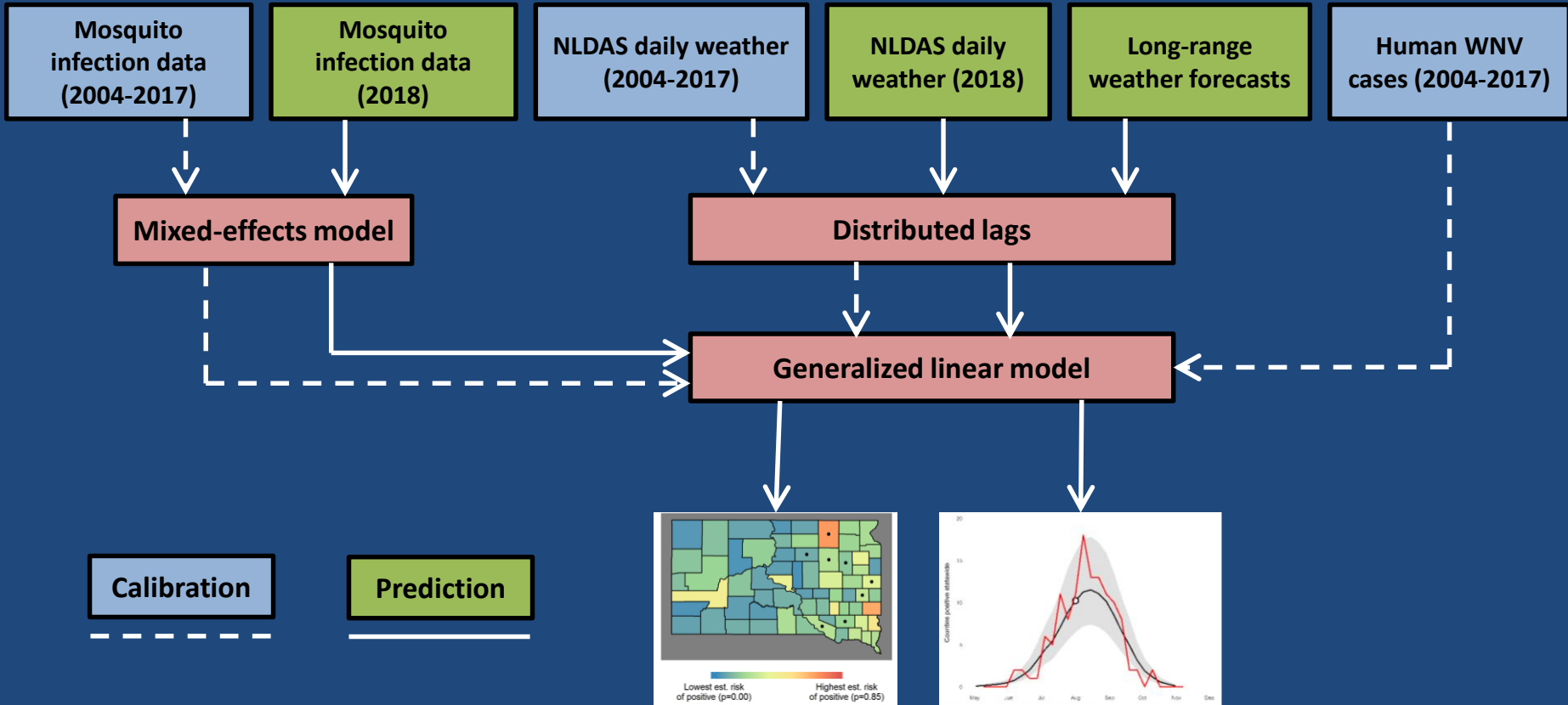
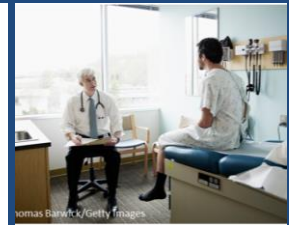
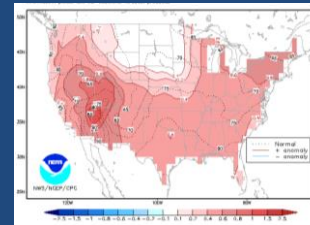
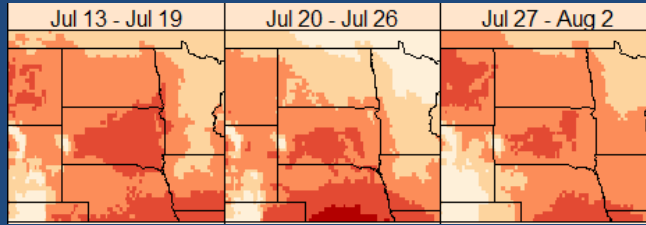
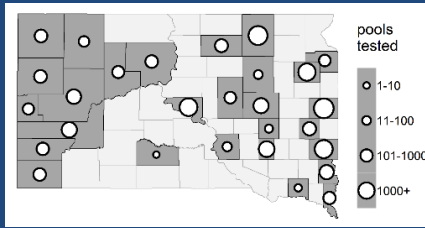
Where did we do it? South Dakota, of all places...



- 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.

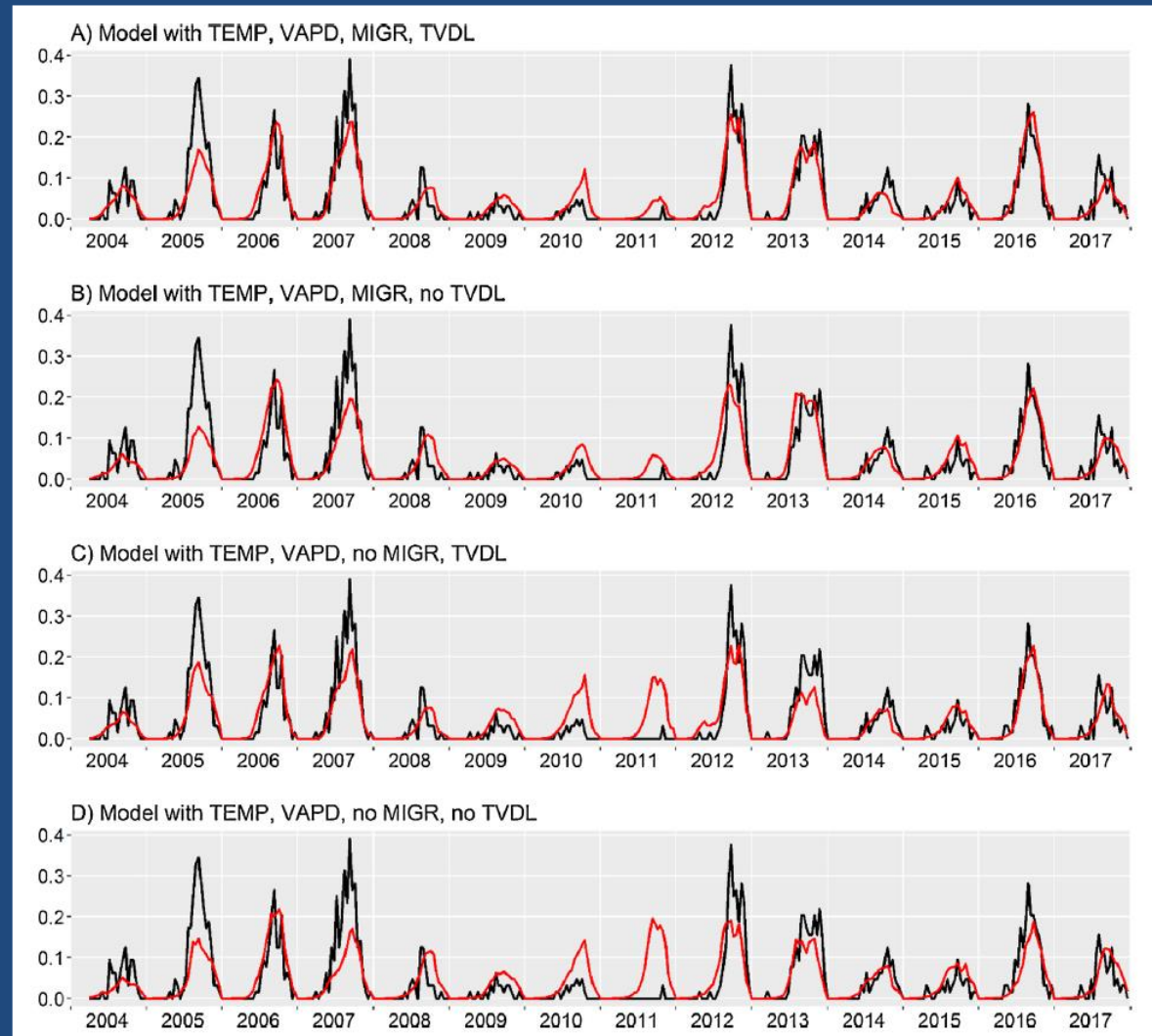




How did we do it? Developed a weekly model of county-level WNV case occurrence.

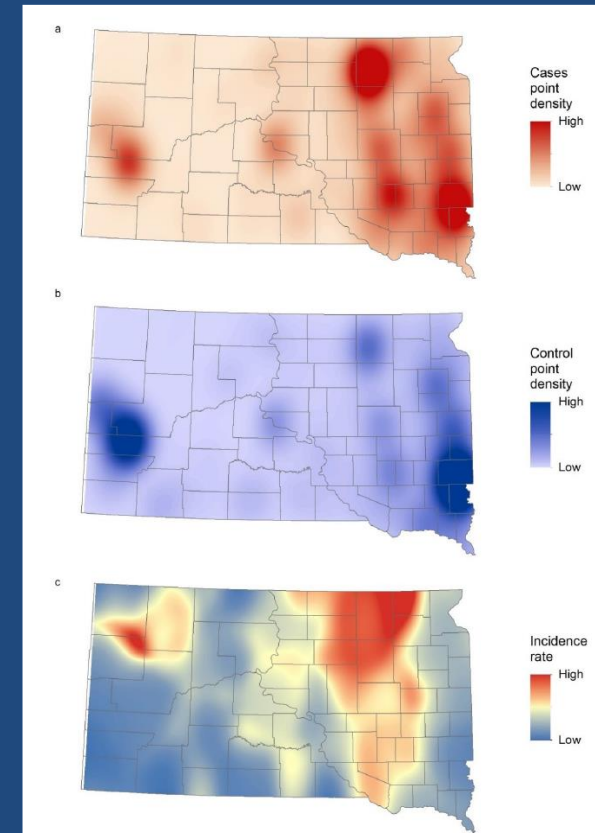
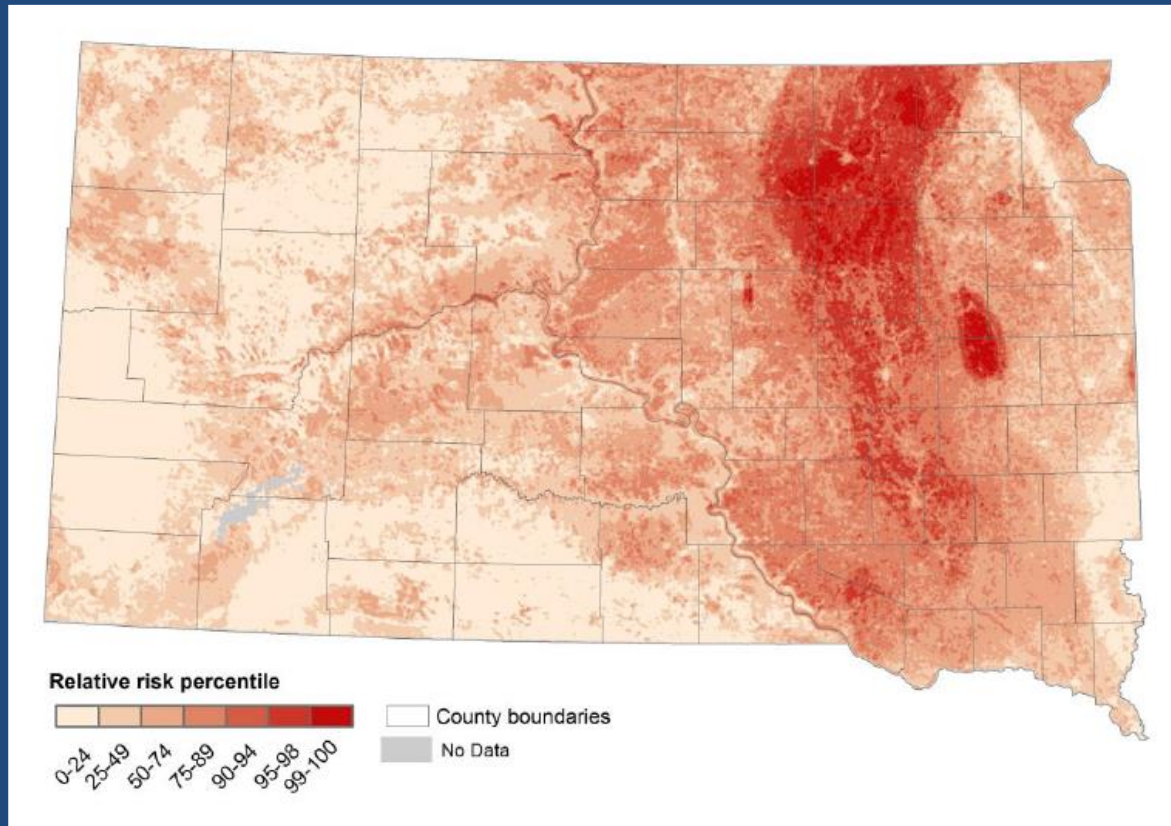
The best model included:

- 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.



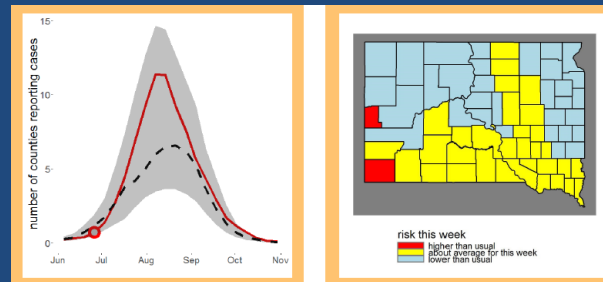
Main Predictors: Topography, MODIS NDWI (SD), Humidity (Mean & SD), Precipitation (Mean & SD), Land Cover, Soils (Ponding Freq)

Hess et al. (In Review)
GeoHealth

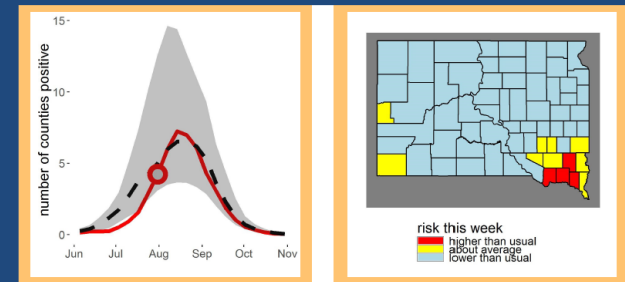
How did we do it? Seasonal WNV predictions were updated on a weekly basis in 2016, 2017, and 2018.

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

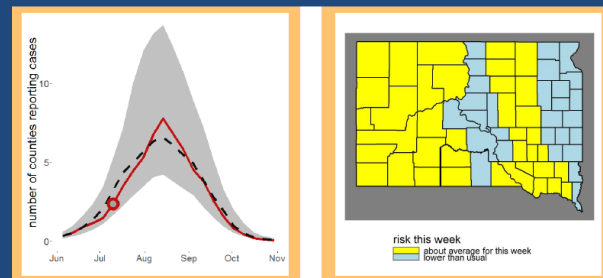
June 26



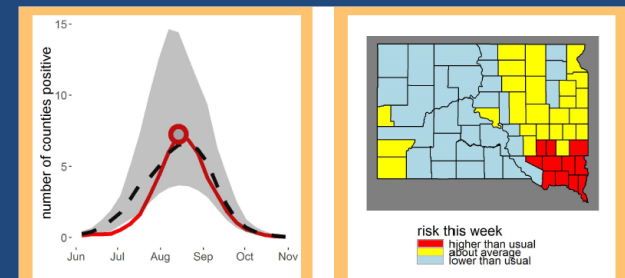
July 24



July 10



August 7



2017 West Nile virus predictions

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

The image displays a collage of screenshots from the website <http://mosquito.sdstate.edu>, illustrating its functionality for data collection and dissemination.

Left Column (Forecasting and Risk Assessment):

- Most recent weekly forecast:** A line graph showing the number of counties positive (0 to 15) from June to November. A red line represents the current forecast, and a grey shaded area represents the confidence interval.
- Map of South Dakota:** A map showing the state divided into counties, with some counties highlighted in yellow to indicate risk levels.
- Textual Content:** Articles such as "What does this week look like?" and "What to expect?" provide context and model estimates. A section titled "Is There Transmission?" discusses the potential for Zika virus spread.
- Figure 1:** A graph showing the estimated risk average risk in other years, with a red line and a grey shaded confidence interval.

Middle Column (Data Entry Form):

- Create Mosquito Collection Form:** A form for entering new data. Fields include "Trap" (Brookings), "Collection Date" (Month: Sep, Day: 18, Year: 2016), and "Trap Location".
- Important Species List:** A list of mosquito species including *Aedes*, *Anopheles*, *Coquillettidia*, *Culex*, *Culiseta*, *Ochlerotatus*, *Orthopodomyia*, *Psorophora*, and *Uranotaenia*.

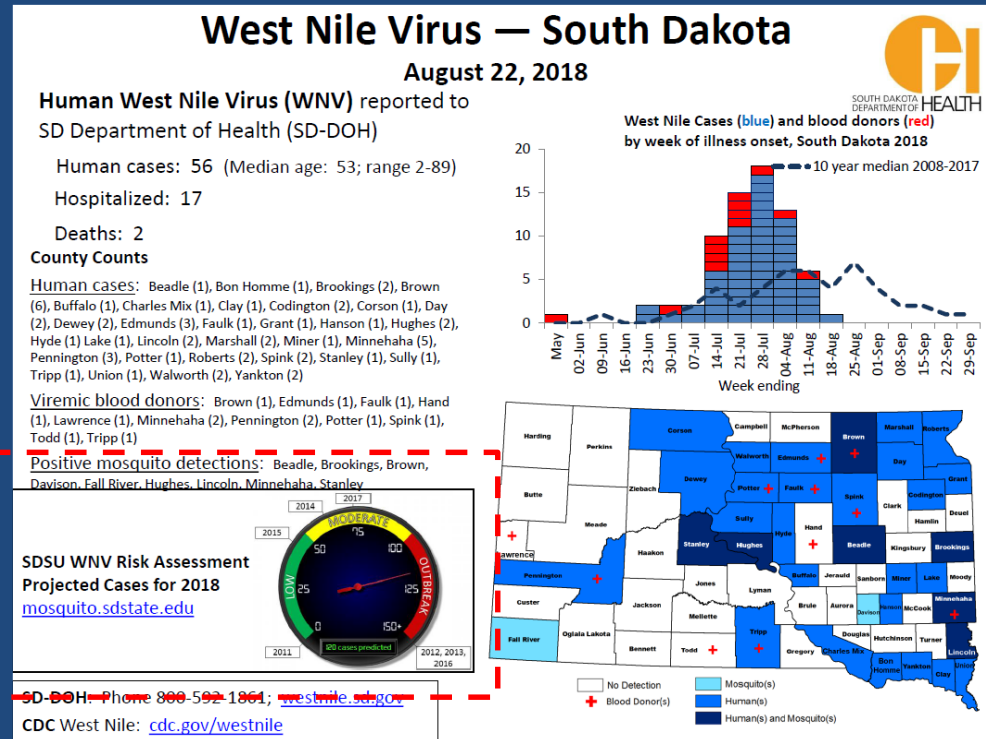
Right Column (Data Management and Visualization):

- Testing Records Listing:** A table showing a list of testing records with columns for Title, VR, and Col Date.
- Map of South Dakota:** A map showing the locations of traps marked with red pins across the state.
- Active Data Views:** A list of available data views, including "Enter New Collections", "Enter New Tests", "Testing Records", "Collection Records", "MIR-Cumulative", "VI-Cumulative", "Monthly Statewide Collection Graph", and "Trap Listing".
- Sponsors:** A list of sponsors including NASA, SDstate, and SDDOH.

<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**

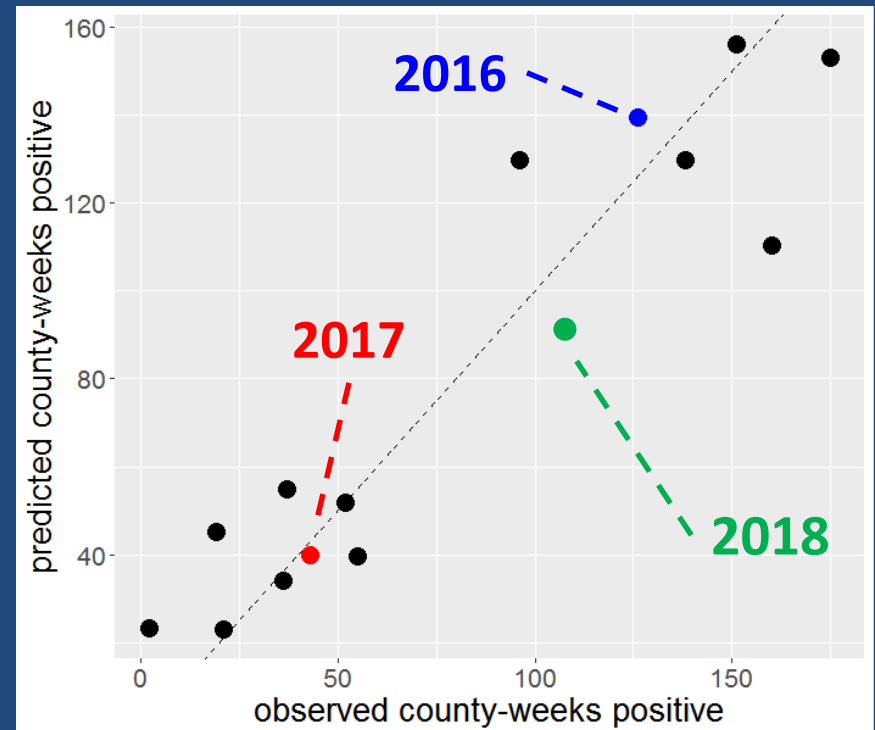
- 139 positive county-weeks predicted on July 15th
- 123 observed county-weeks

- **2017**

- 40 predicted positive county-weeks
- 43 observed county-weeks

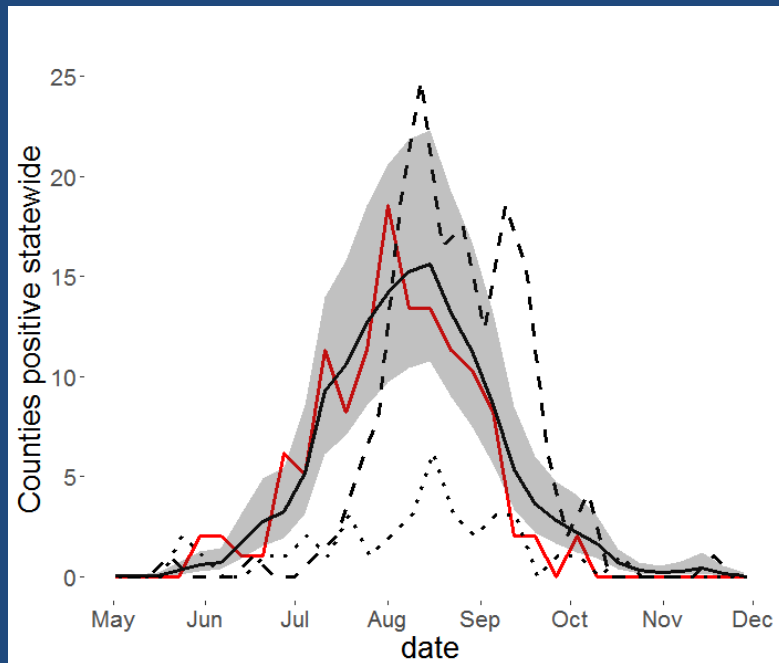
- **2017**

- 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.

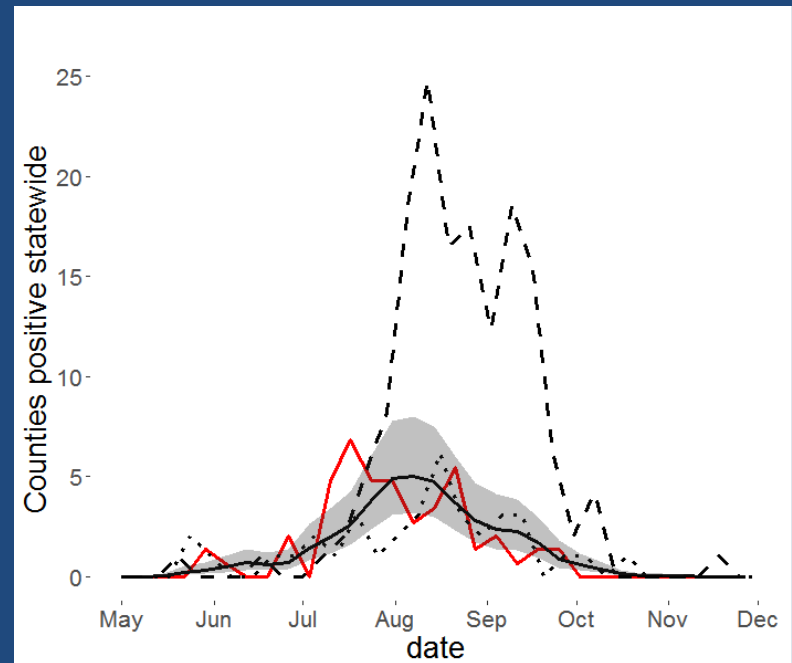


Did it work? Yes, predictions accuracy captured the seasonal trends in WNV occurrence.

2016



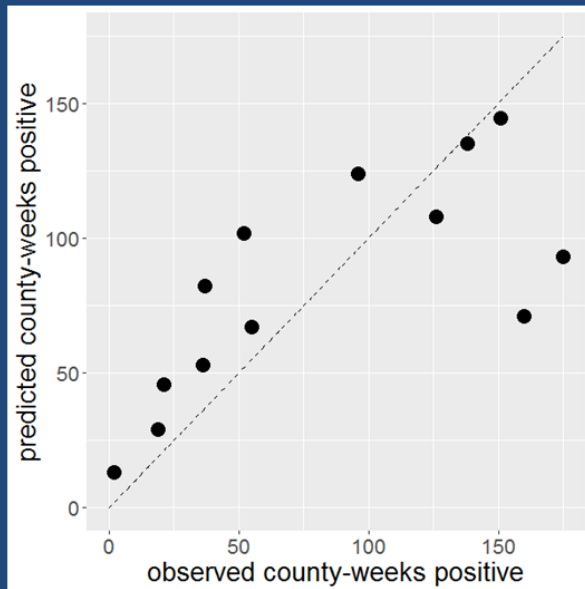
2017



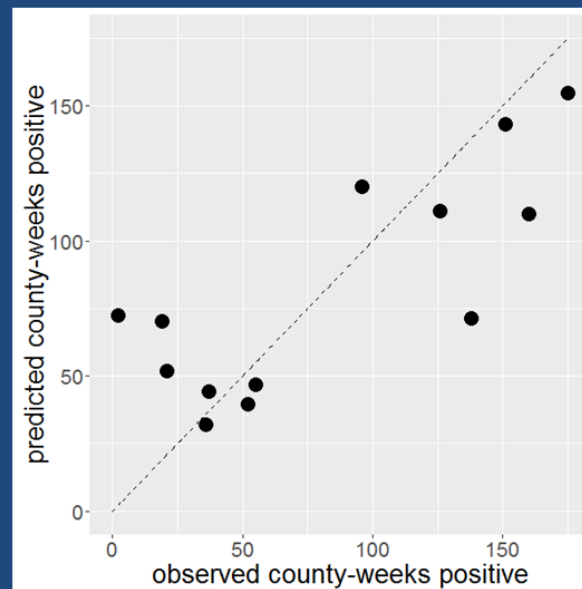
Black line/Gray Shading: Seasonal predictions made on July 15th with 95% prediction intervals.
Red line: Observed cases in 2016 or 2017.
Dashed line: Observed cases in 2012. Dotted line: observed cases in 2015.

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

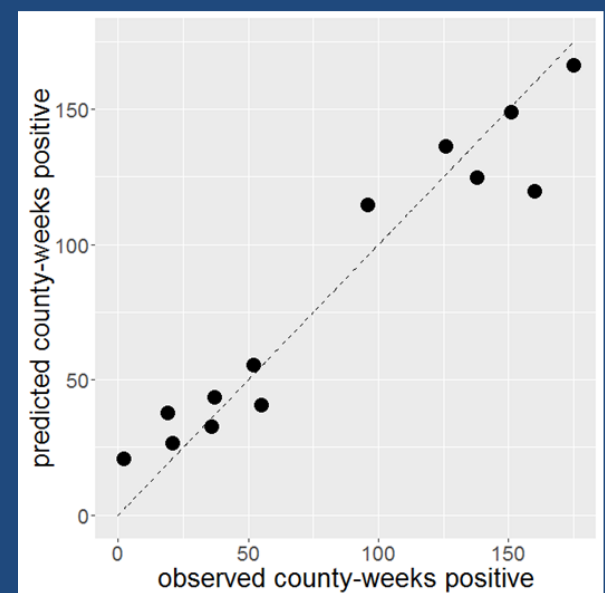
Mosquito infection data only



Meteorological data only



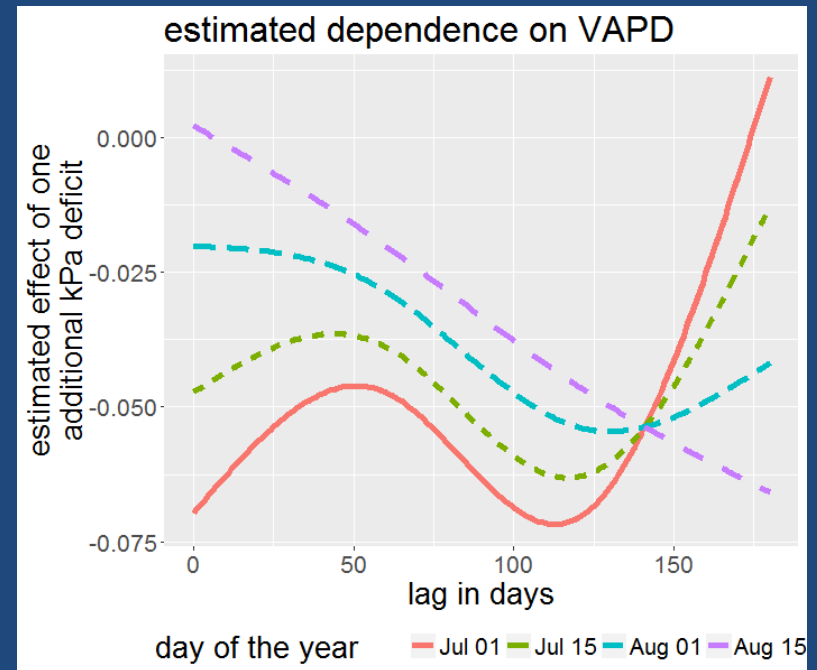
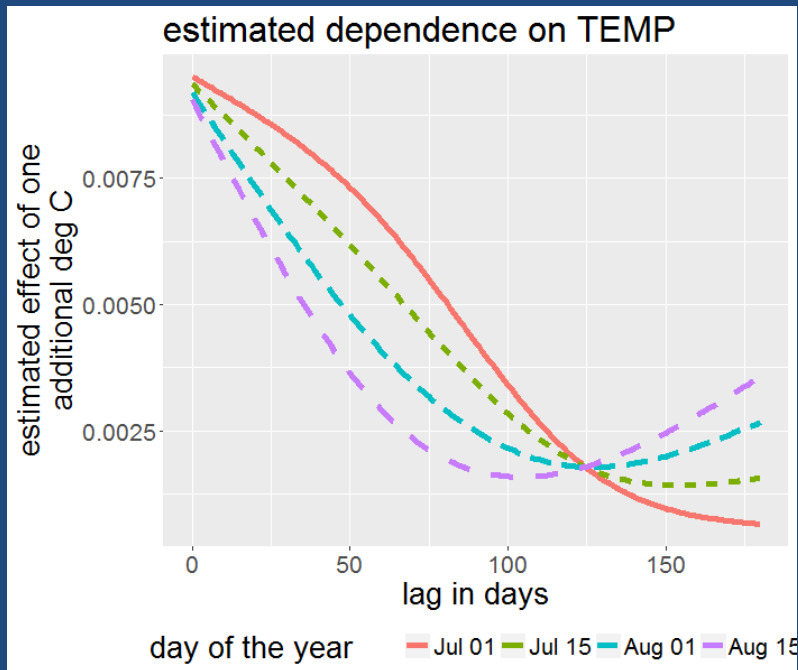
Combined mosquito infection and meteorological data



Annual predictions made on July 15th of each year.

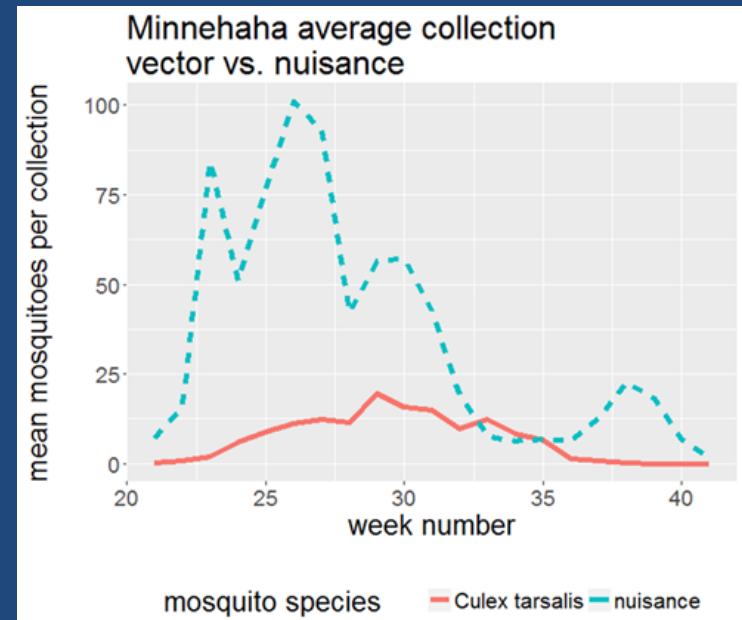
What did we learn? Meteorological effects change throughout the WNV transmission season

- 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.



Acknowledgements

- South Dakota State University 
 - Justin Davis, GSCE
 - Andrea Hess, GSCE
 - Mike Hildreth, Dept. of Biology
 - Geoffrey Vincent, Dept. of Biology
 - Student workers and former postdocs, grad students, and technicians



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 - Joshua Clayton
 - Eric Grimm
 - Chris Carlson



- South Dakota Mosquito Control Programs
 - Denise VanRoekel, Sioux Falls
 - Mark Hoven, Aberdeen
 - 100's of other statewide contributors to mosquito surveillance and control

- Funding
 - NIH/NIAID (R01 AI079411)
 - NASA Applied Sciences Program



Project Website

<http://mosquito.sdstate.edu>

Project Video

<http://tinyurl.com/nasawnv>

Or Google “Mosquito Meets MODIS”

Email

michael.wimberly@ou.edu

