ArboMAP: A West Nile Virus Forecasting System for Translating Data Into Decisions
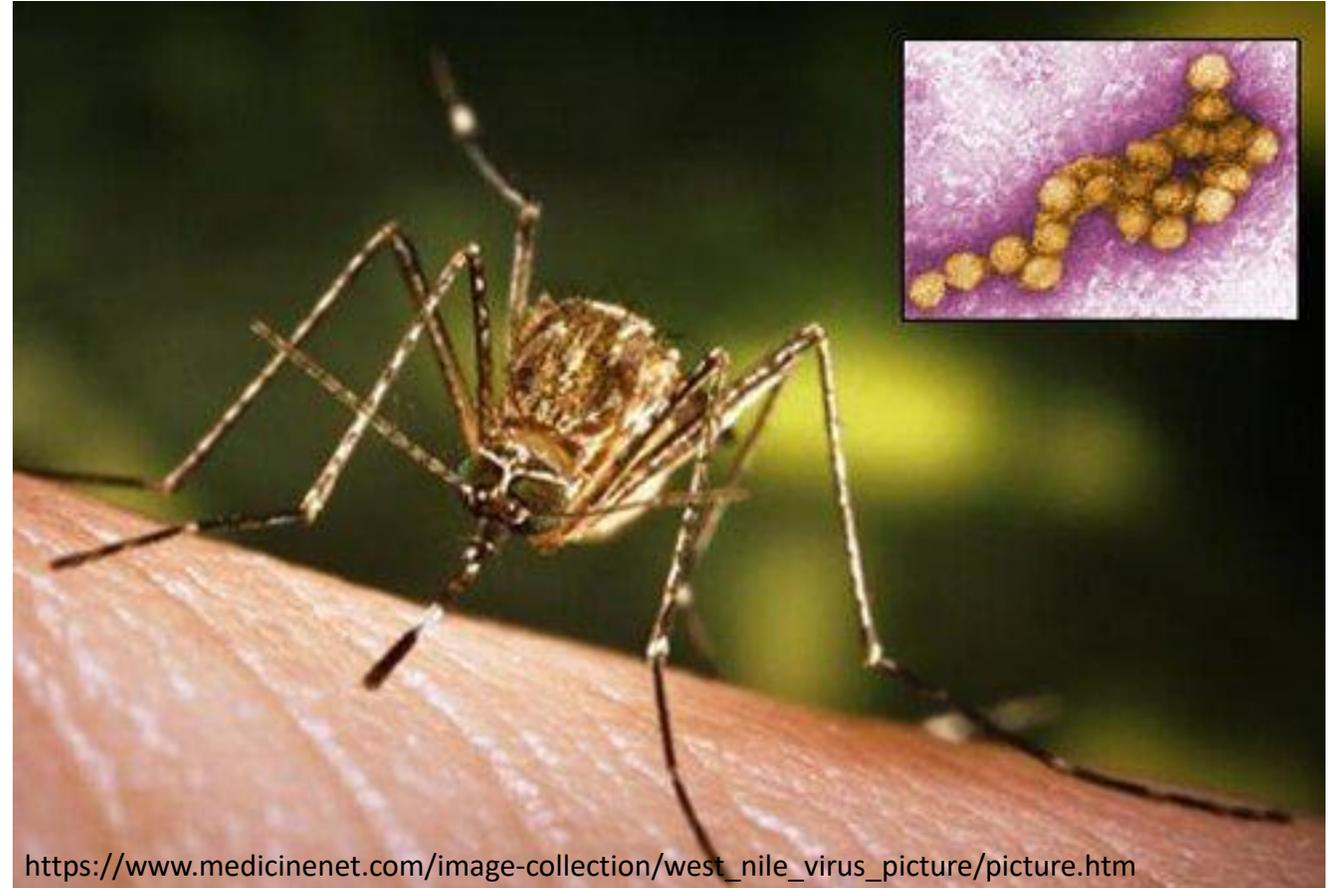
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OU DATA INSTITUTE FOR SOCIETAL CHALLENGES
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Developing an operational system for ecological forecasting of West Nile virus

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

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

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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*
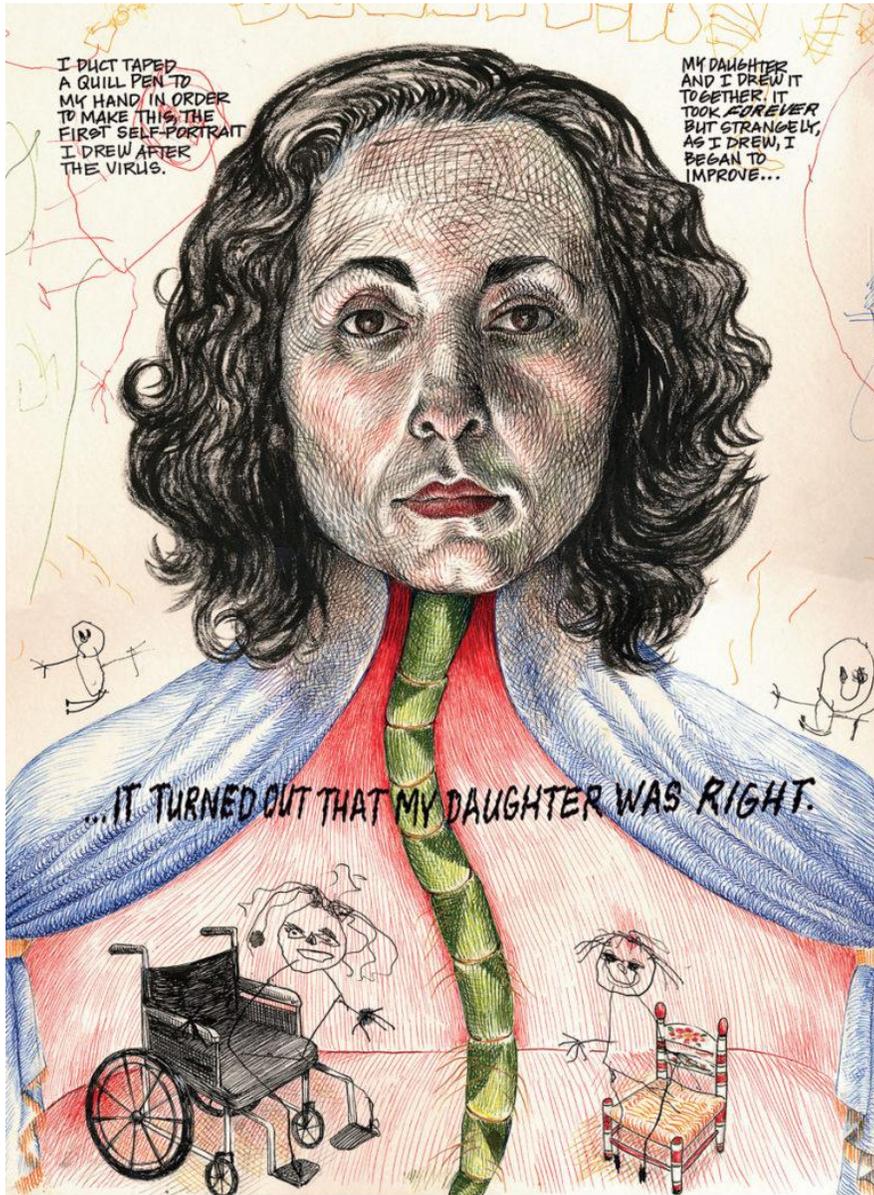
Where did we do it? South Dakota, of all places…
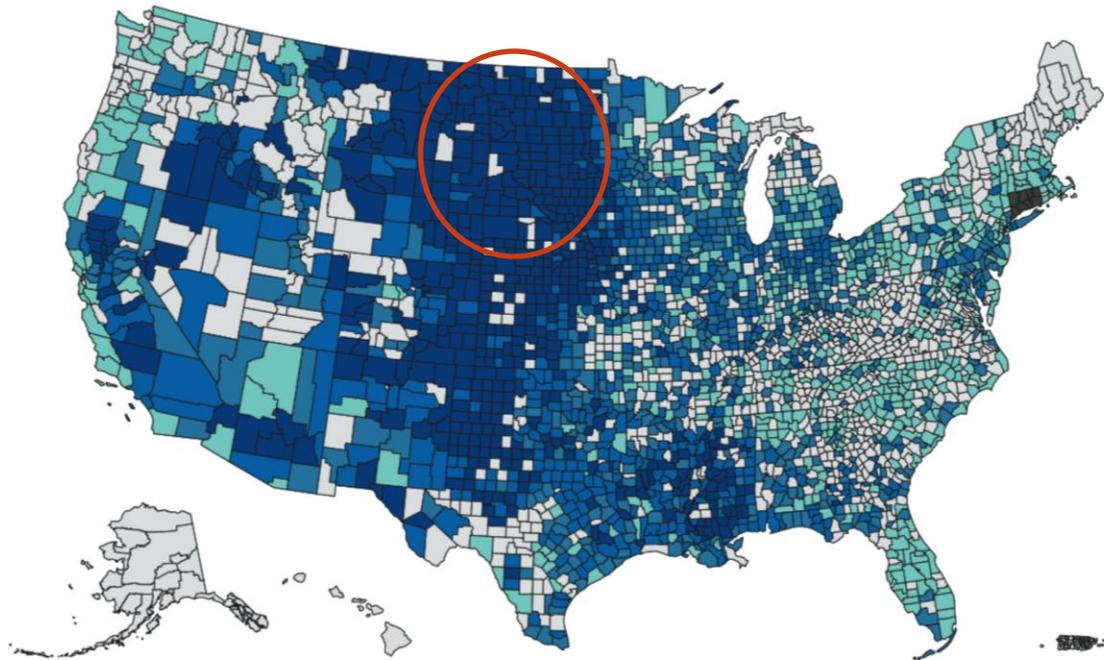
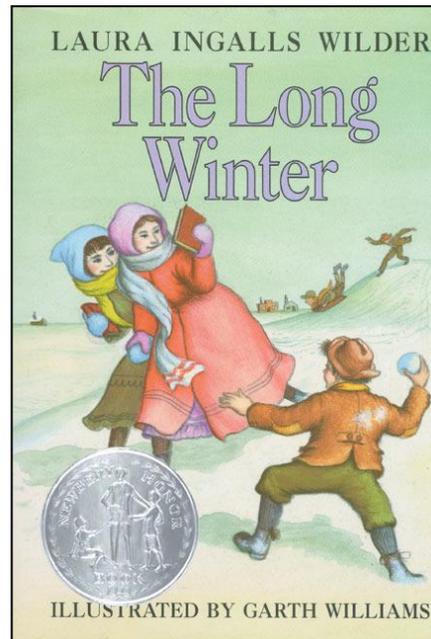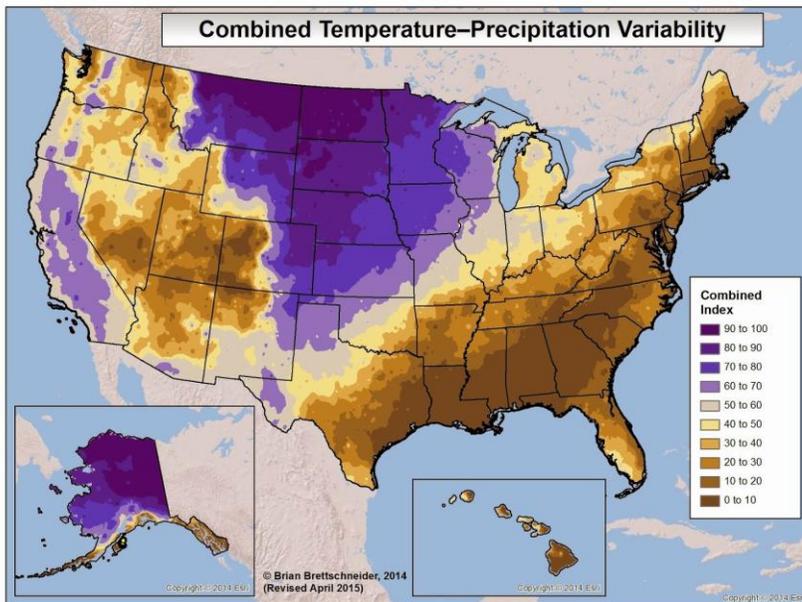Incidence per 100,000 Population

● 0.01 to 0.16 ● 0.17 to 0.37 ● 0.38 to 1.09 ● >1.10 ● Cumulative data unavailable

West Nile virus human neuroinvasive disease average annual incidence per 100,000 population by county of residence, 1999-2024. Source: CDC ArboNET
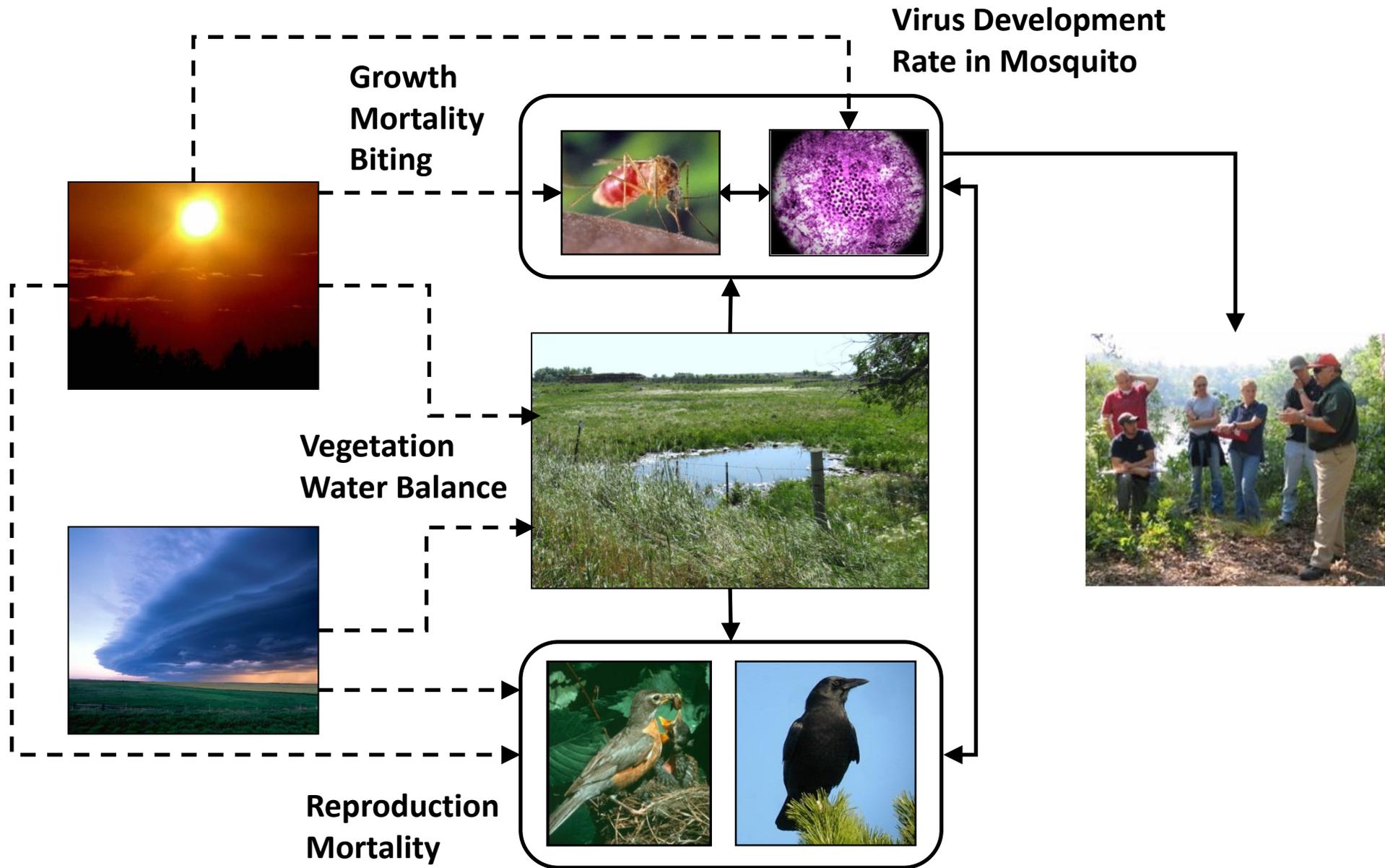
- States with the highest long-term annual incidence of West Nile virus in the United States
  - North Dakota (3.16/100,000)
  - South Dakota (3.06/100,000)
- In South Dakota, from 2002-2024 there have been
  - 2,866 reported cases
  - 683 cases of neuroinvasive disease
  - 54 deaths
  - 924,669 population (2024)

What's unique about South Dakota?

- A place of extremes – the most continental of continental climates
- Abundant habitat for vectors and hosts of West Nile virus

http://us-climate.blogspot.com/2014/12/intra-annual-climate-variability.html

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Virus Development
Rate in Mosquito

Growth
Mortality
Biting

Vegetation
Water Balance
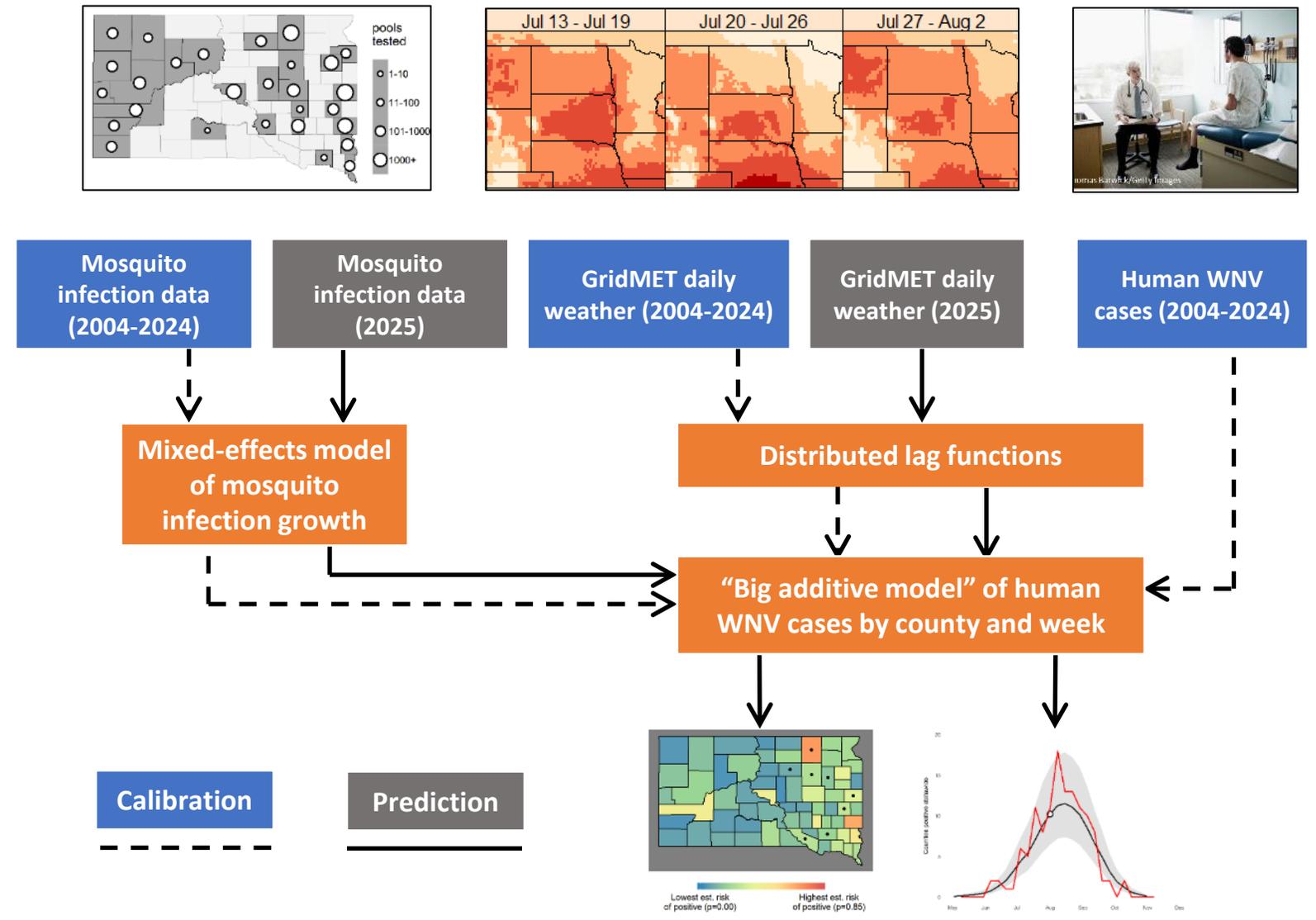
Reproduction
Mortality

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How did we do it? Integrating multiple data sources to improve spatial and temporal predictions of disease risk.
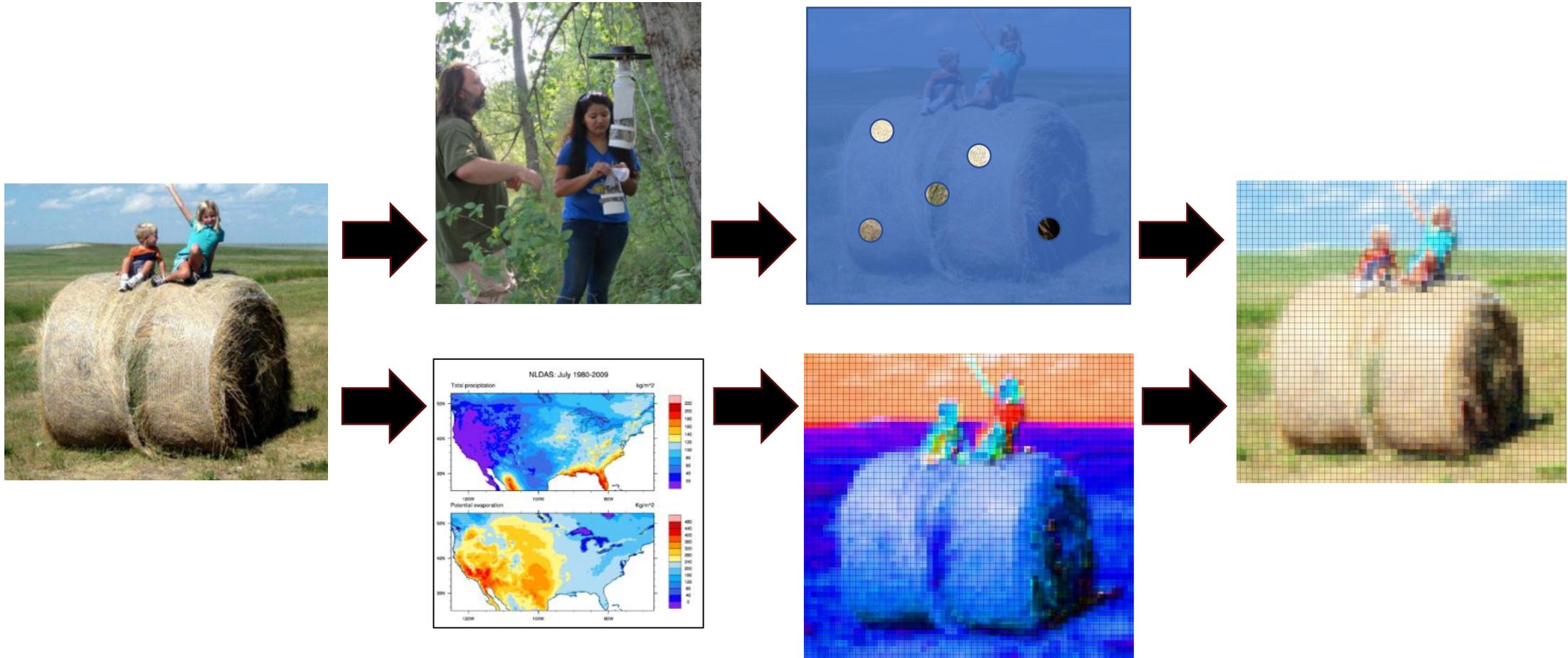
Forecasting models are calibrated with data from preceding years and used to predict the weekly probability of human WNV cases by county in the current year.

Mosquito infection data (2004-2024)

Mosquito infection data (2025)

GridMET daily weather (2004-2024)

GridMET daily weather (2025)

Human WNV cases (2004-2024)

Mixed-effects model of mosquito infection growth

Distributed lag functions

"Big additive model" of human WNV cases by county and week

Calibration

Prediction

Lowest est. risk of positive (p=0.00)   Highest est. risk of positive (p=0.85)

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We developed a set of simple tools (ArboMAP) to facilitate weekly forecasting by public health personnel in state agencies.

AMIA   OXFORD
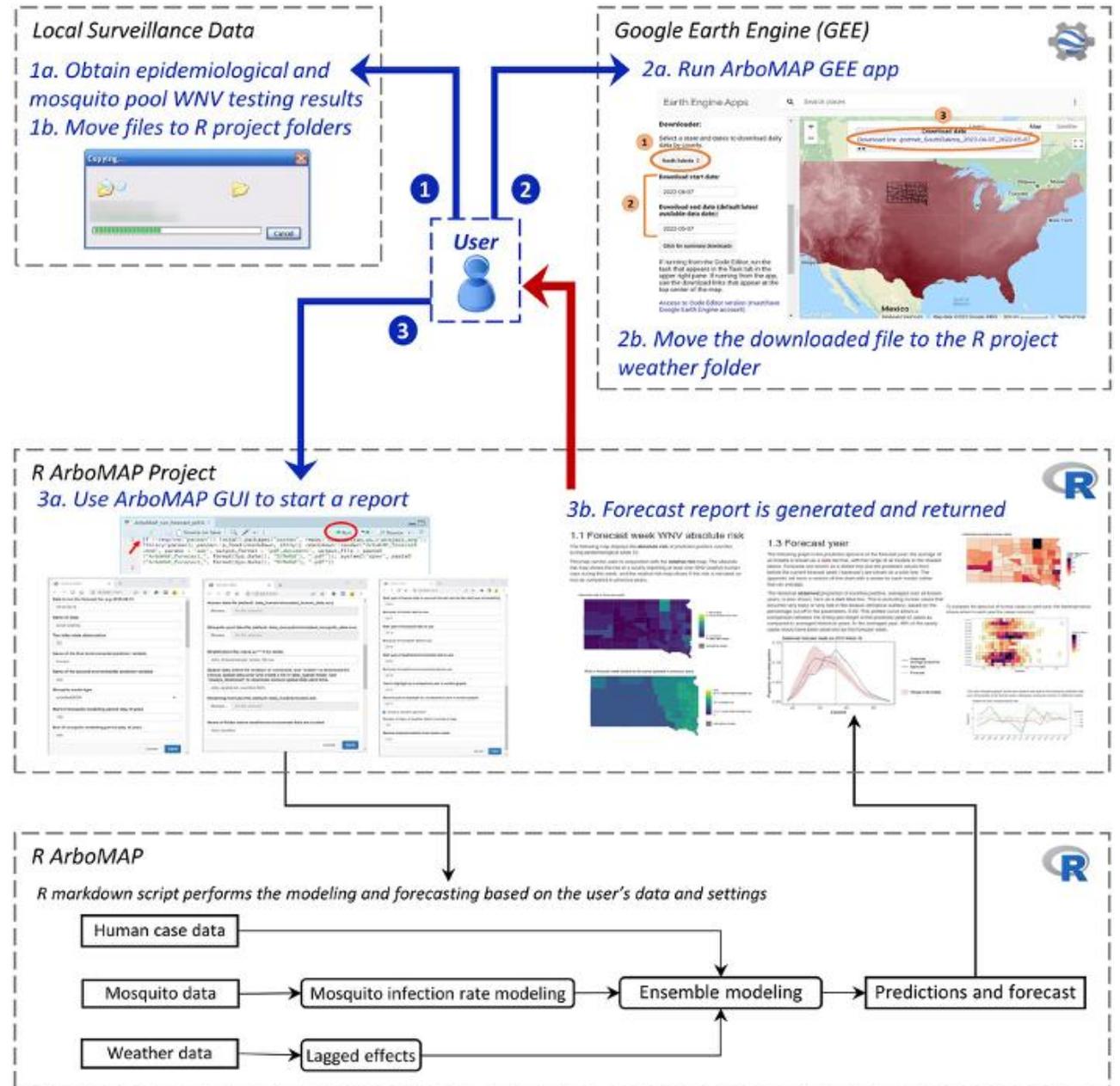INFORMATICS PROFESSIONALS. LEADING THE WAY.

Application Notes

The Arbovirus Mapping and Prediction (ArboMAP) system for West Nile virus forecasting

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The best model, fitted to historical data, captures seasonal and interannual variations

Did it work? The model fit the historical data well and was able to accurately predict seasonal and interannual variation in WNV occurrence.

Calibration
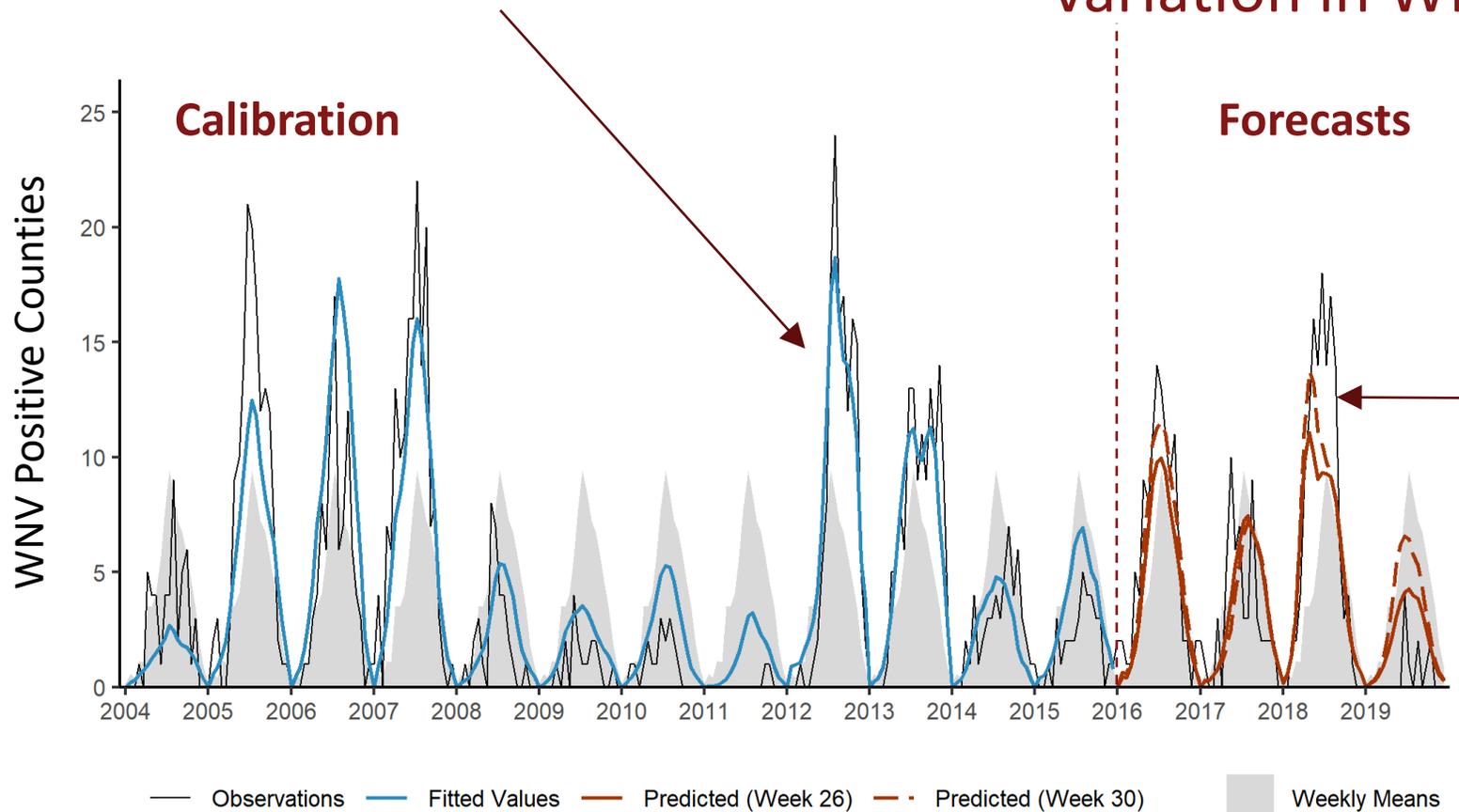
Forecasts

Forecasts made in early July can distinguish high WNV years (2016 and 2018) from low WNV years (2017 and 2019)

WNV Positive Counties
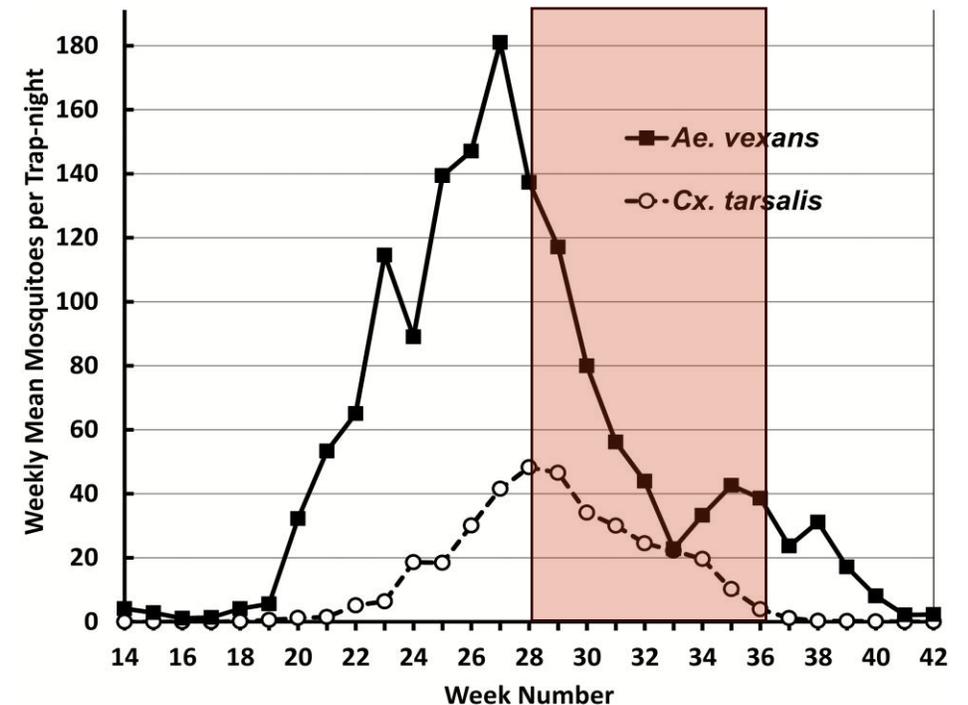
Observations — Fitted Values — Predicted (Week 26) – · Predicted (Week 30) ▨ Weekly Means

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Why does it matter? Forecasting is needed for public health decision-making to address limitations of surveillance data.

Reports of human cases are delayed by weeks to months

In 2018, only 8 cases were reported by July 26th, giving the false impression of low WNV risk. In reality, 50 cases had already occurred, and there were 169 cases during the 2018 season – the highest total since 2012. <u>Our WNV forecasts predicted a higher-than-usual level of WNV risk in early July</u>, highlighting the need for aggressive prevention messaging and vector-control.

In SD, mosquito abundance is not a reliable predictor of WNV risk

Most cases occur between weeks 28-36, after the seasonal peak in mosquitoes.

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We implemented ArboMAP in several other states.
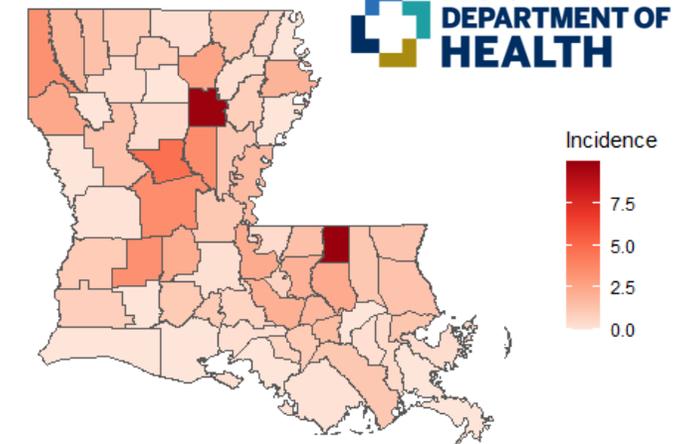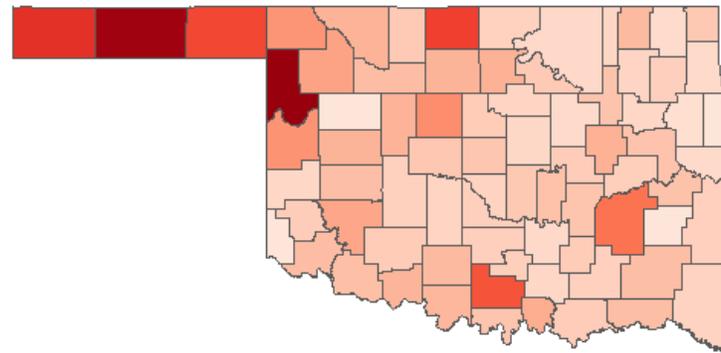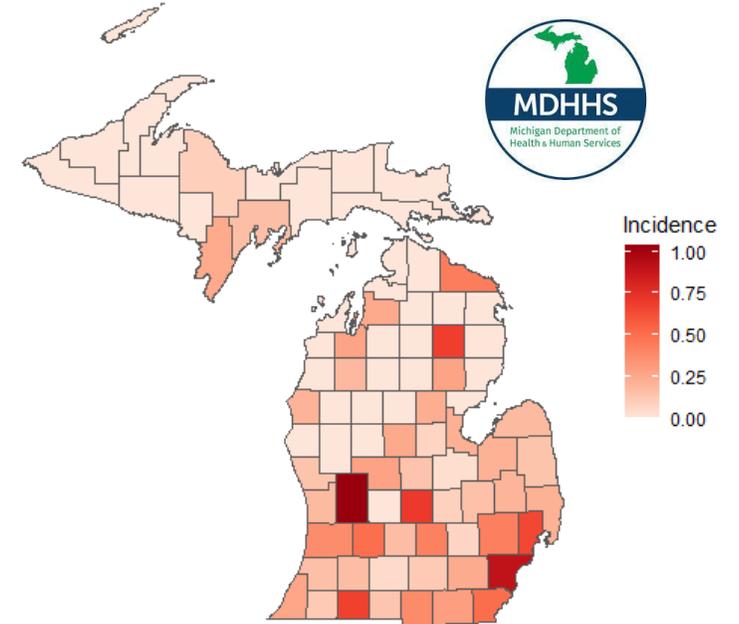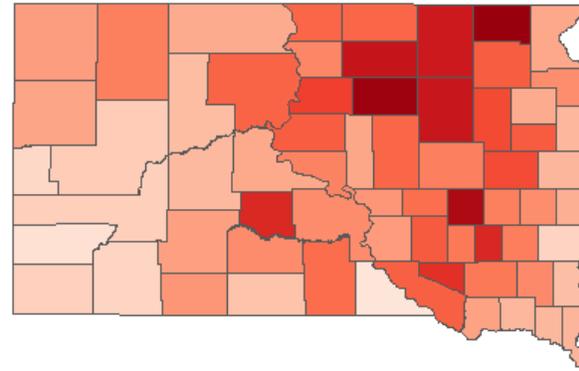
Maps show average annual incidence rates of total confirmed cases per 100,000

What did we learn? There are opportunities…

- Integrating multiple data streams (human case surveillance, mosquito surveillance, and environmental monitoring) improves accuracy of arbovirus risk forecasts.

- The goal of generating operational forecasts of arbovirus risk in a public health setting is feasible.

- Arbovirus risk forecasts can provide a unique source of information that is useful to support decisions about public health messaging and vector control activities.
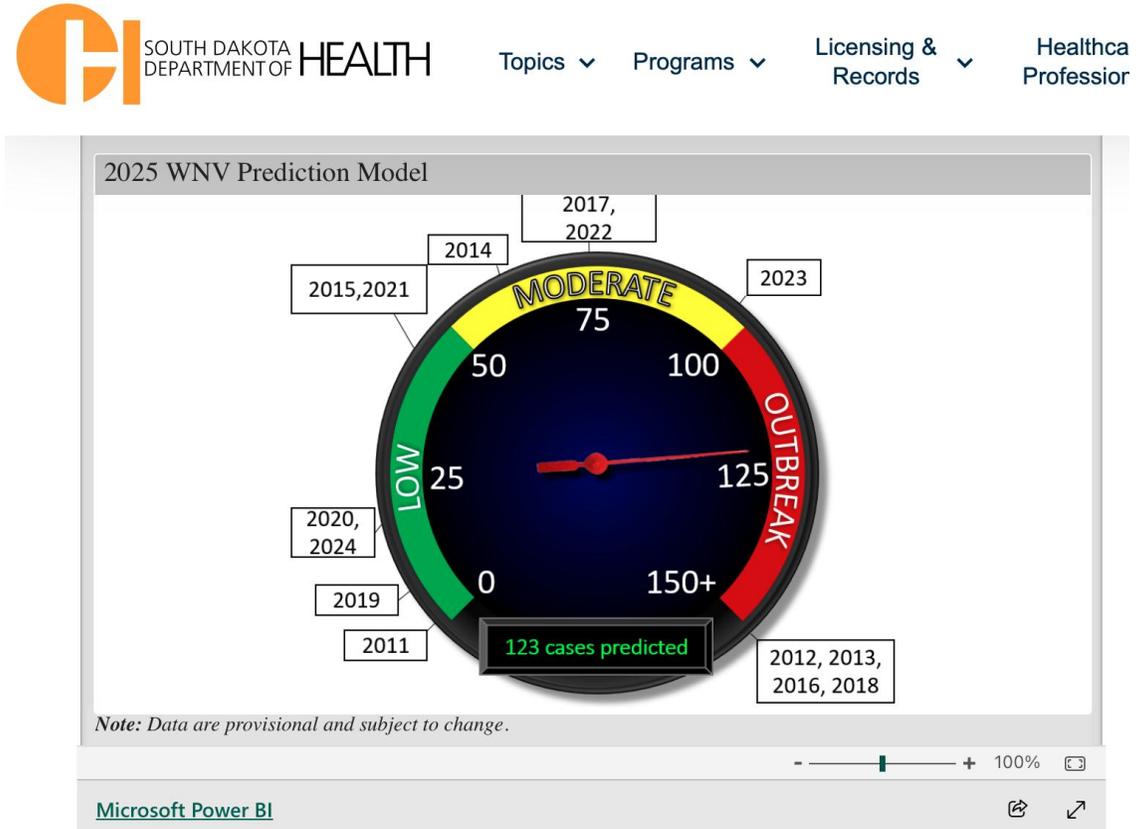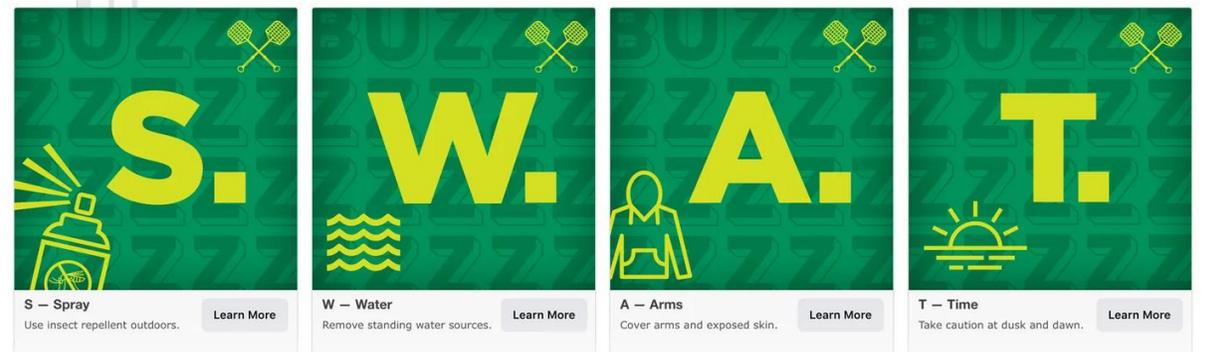
…but also challenges.

- Fragmented and uneven surveillance data create challenges for modeling and prediction.

- Uncertain forecasts needs to be translated into actionable decisions.

- Improved tools and enabling environments are needed to support long-term sustainability and institutionalization.

Acknowledgements

- South Dakota State University
  - Mike Hildreth
  - Geoffrey Vincent
- South Dakota Department of Health
  - Lon Kightlinger
  - Joshua Clayton
  - Chris Carlson
  - Anita Bharadwaja
- South Dakota Mosquito Control Programs
  - Denise VanRoekel, Sioux Falls
  - Mark Hoven, Aberdeen
  - Many other statewide contributors to mosquito surveillance and control
- University of Oklahoma
  - Dawn Nekorchuk
  - Justin Davis
  - Andrea McMahon
  - Eric Bump
  - Bridget Greb

- Southern Nazarene University
  - Caio França
- Louisiana Department of Health
  - Sean Simonson
  - Emma Ortega
- Michigan Department of Health and Human Services
  - Emily Dinh
  - Rebecca Reik
  - Rachel Burkholder
- Oklahoma Health Department
  - Lemac Morris
  - Jolianne Stone
- Funding
  - NASA Health and Air Quality Program, grants NNX15AF74G and NSSC19K1233