An Early Warning System for Human West Nile Virus: Generalizing and Extending the Approach

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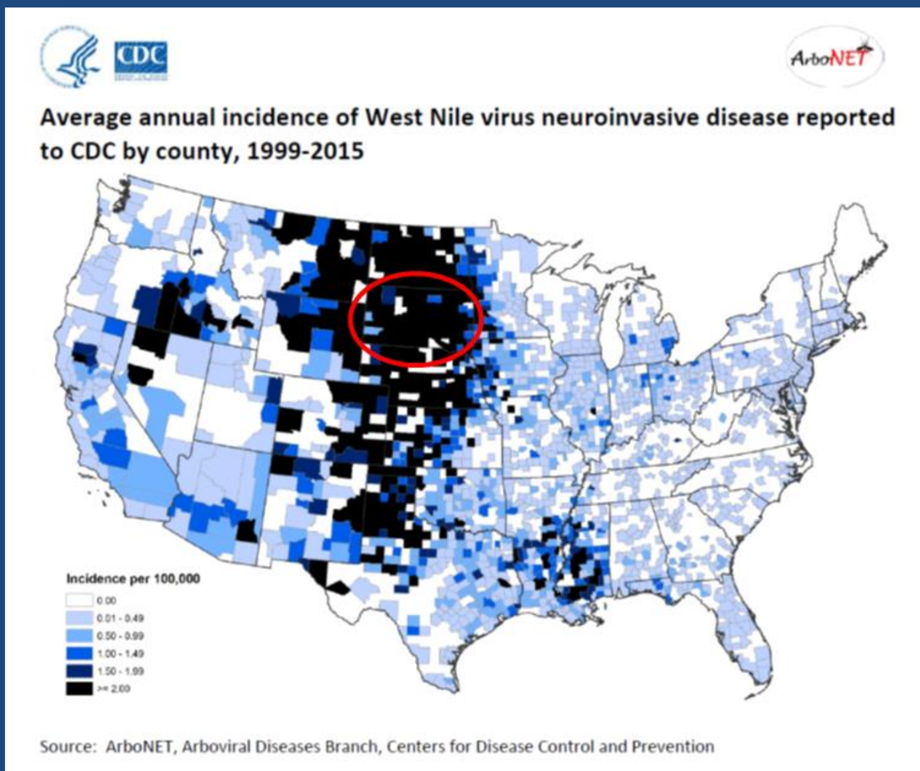
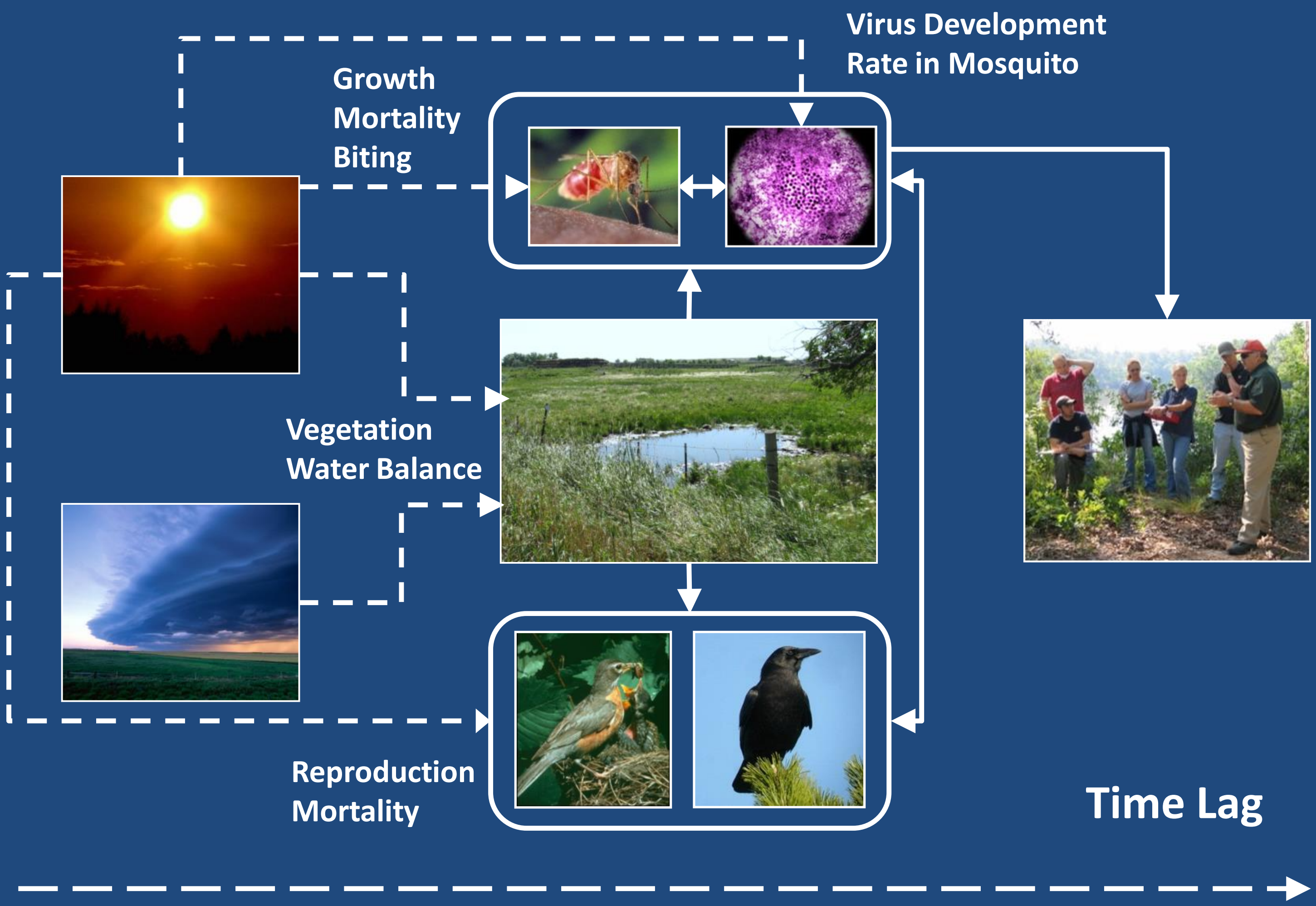
West Nile Virus in South Dakota



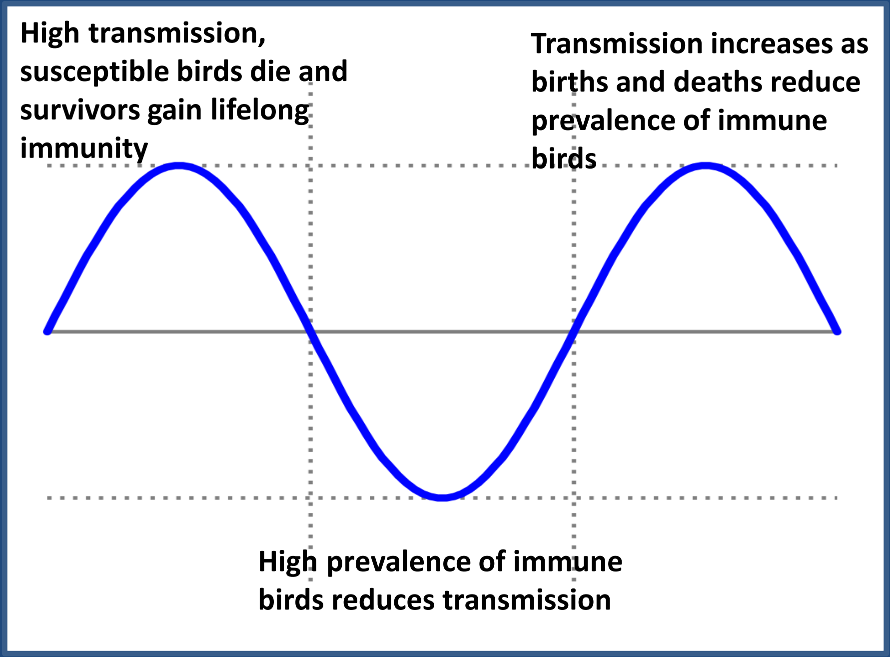
- 2,360 cases since 2002
  - 509 Neuroinvasive
  - 38 Deaths
  - 865,000 Population (2016)
- Highest annual incidence of all WNV disease (19.4/100,000)
- Highest annual incidence of WNV neuroinvasive disease in the United States (4.1/100,000)

Environmental factors influence WNV transmission through multiple pathways.

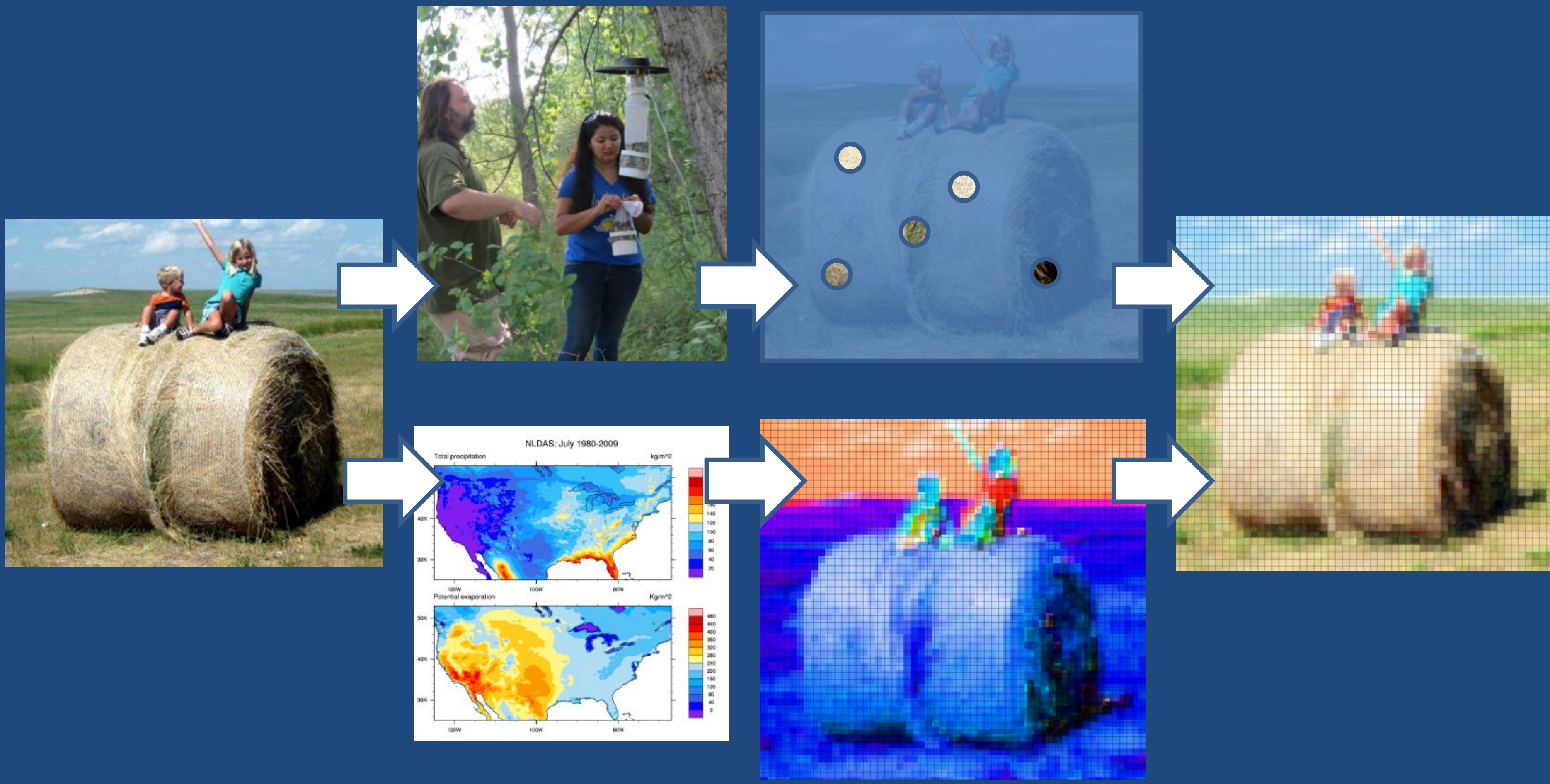


But there's a catch: Environmental drivers are not the only determinants of disease outbreaks.

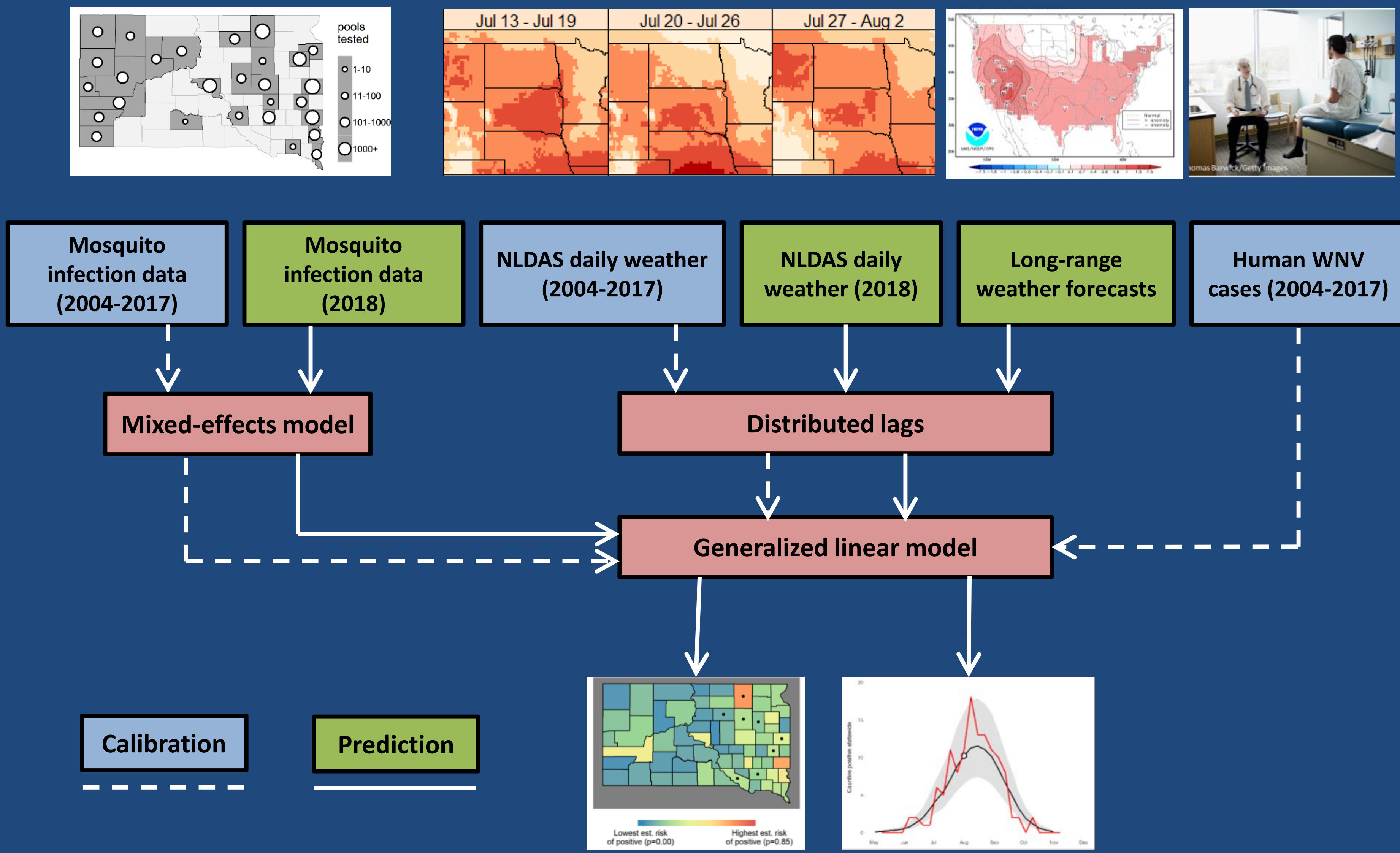
- Endogenous processes (immunity cycles in avian hosts) can limit WNV transmission even when climatic conditions are suitable.
- These processes are difficult to measure and model directly.
- Trapping and testing mosquitoes is the most practical and direct way to measure transmission levels.



Our forecasting approach integrates environmental monitoring with other types of surveillance data to generate accurate forecasts.

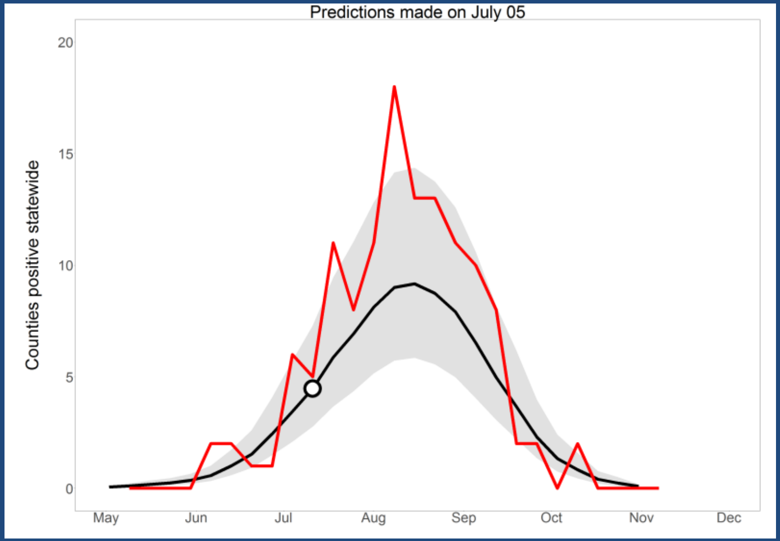


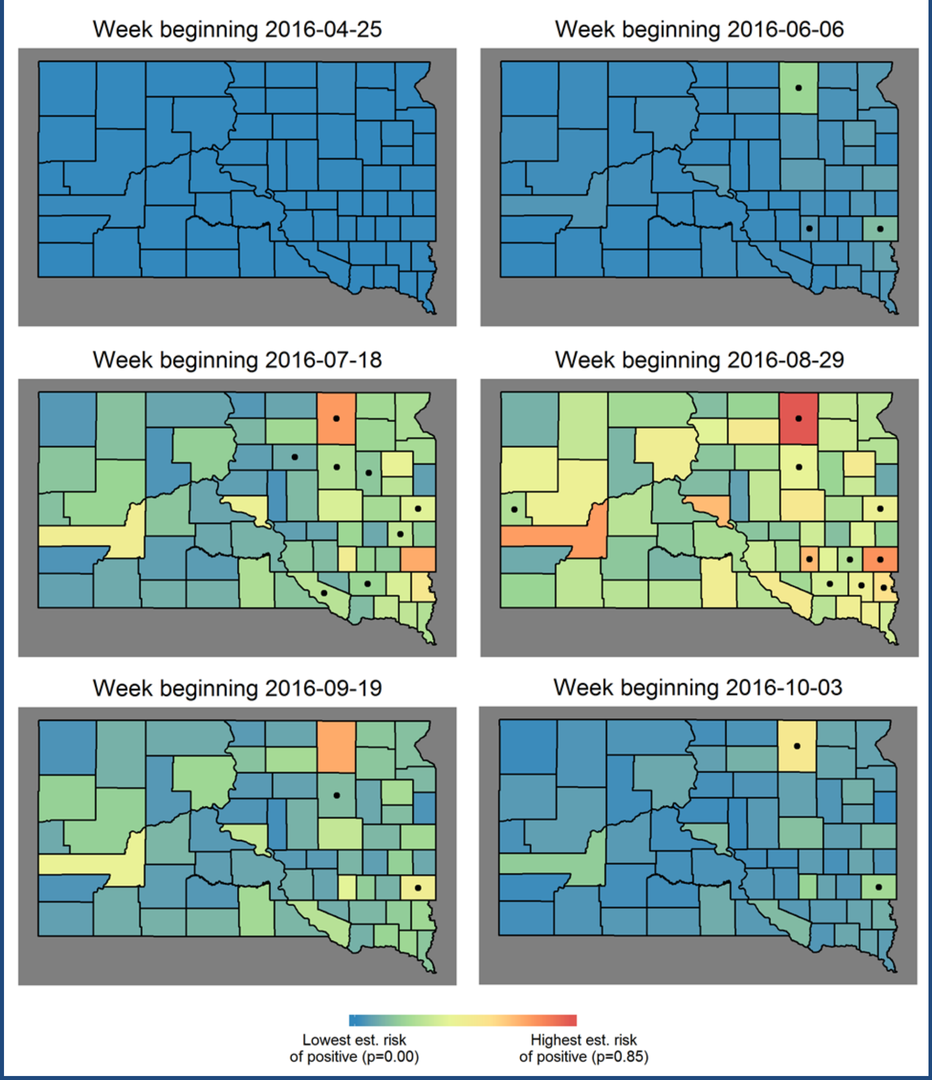
Flowchart for the Arbovirus Monitoring and Prediction (ArboMAP) system



ArboMAP produces weekly WNV risk maps for the upcoming week (right).

Predictions can also be extrapolated multiple weeks into the future to predict WNV cases throughout the entire season (below).

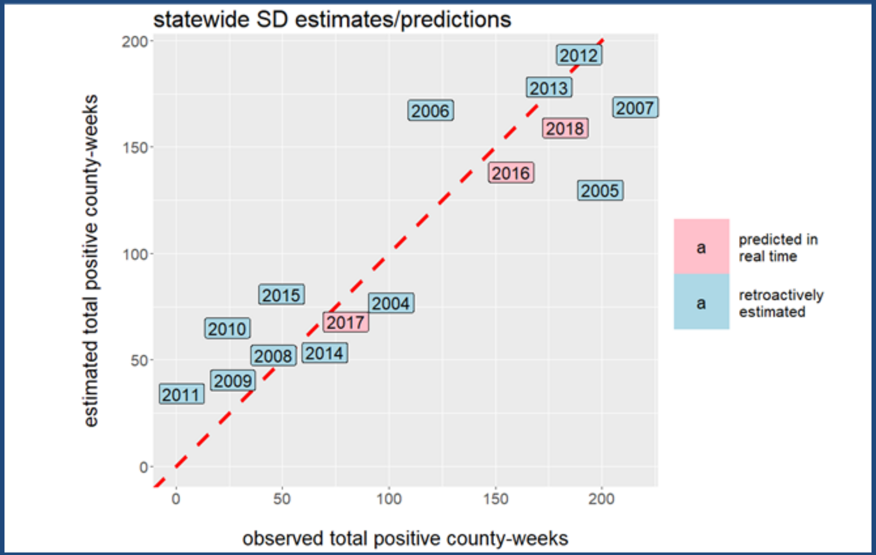


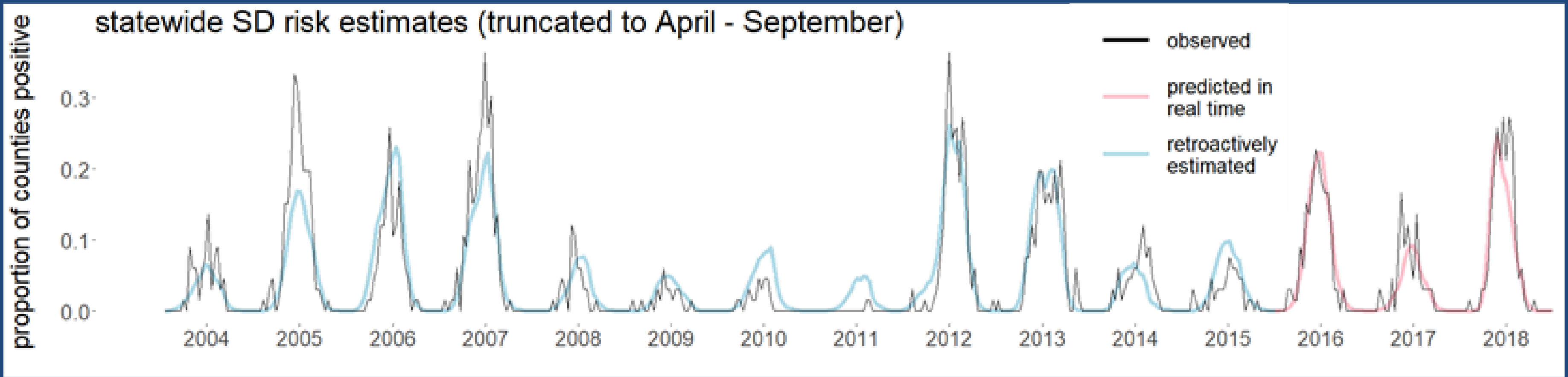


Davis et al. (2017) *PLoS Currents: Outbreaks*

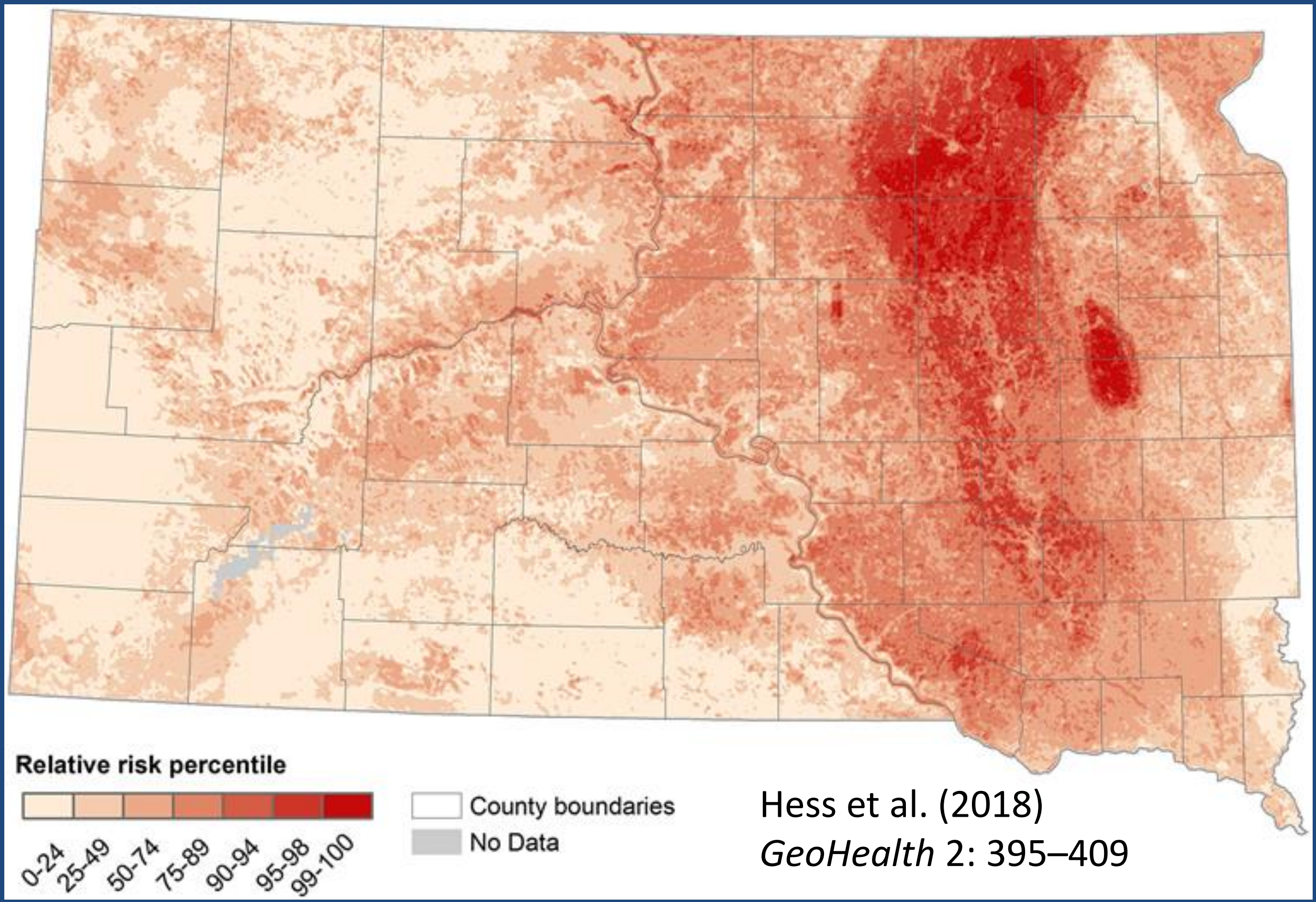
We applied ArboMAP from 2016-2018 in South Dakota and we were able to predict the timing and magnitude of WNV transmission in each year.

In these graphs, **blue** represents the model fit to historical data and **red** represents predictions for 2016-2018 made for each year using data from all preceding years.





We developed a detailed West Nile virus risk map for South Dakota using MODIS BRDF-adjusted reflectance data combined with meteorological data from the NLDAS and other sources of data characterizing topography, soils, and land cover



Hess et al. (2018)
GeoHealth 2: 395–409

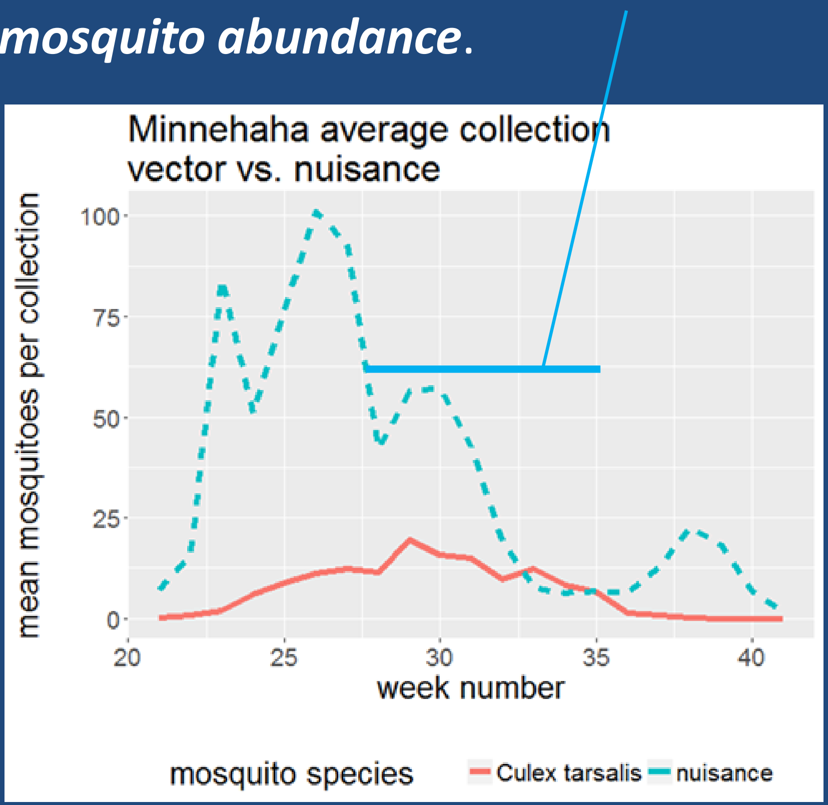
An epidemiological risk model was calibrated using 1,381 geocoded WNV case records from 2004-2017. ***Springtime surface wetness from MODIS and summer relative humidity from the NLDAS were important predictors of WNV risk***.

ArboMAP is needed to support public health decision-making because other sources of information have substantial limitations:

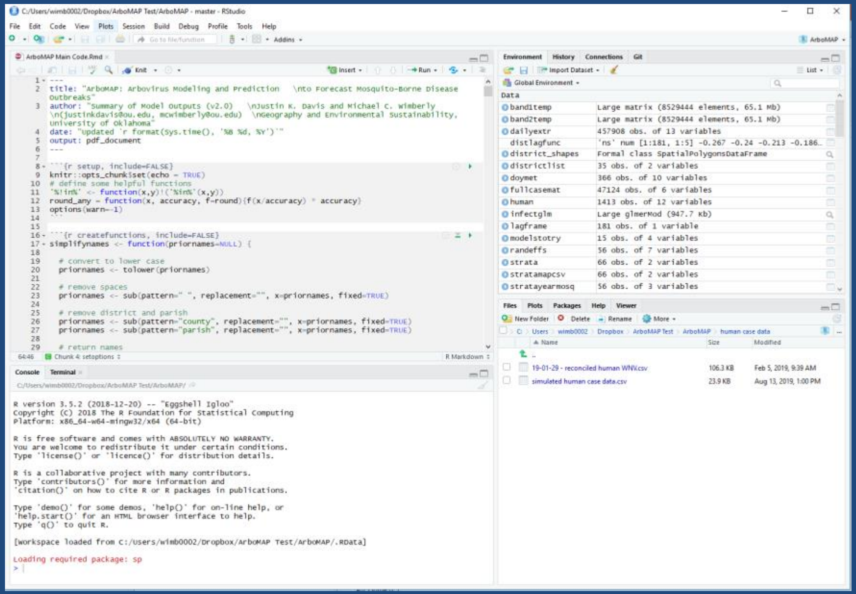
- Reports of human cases are delayed by weeks or months.
- Mosquito abundance is not a reliable predictor of WNV transmission risk

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. ***Our WNV forecasts predicted a higher-than-usual level of WNV risk in early July,*** highlighting the need for aggressive prevention messaging and vector-control.

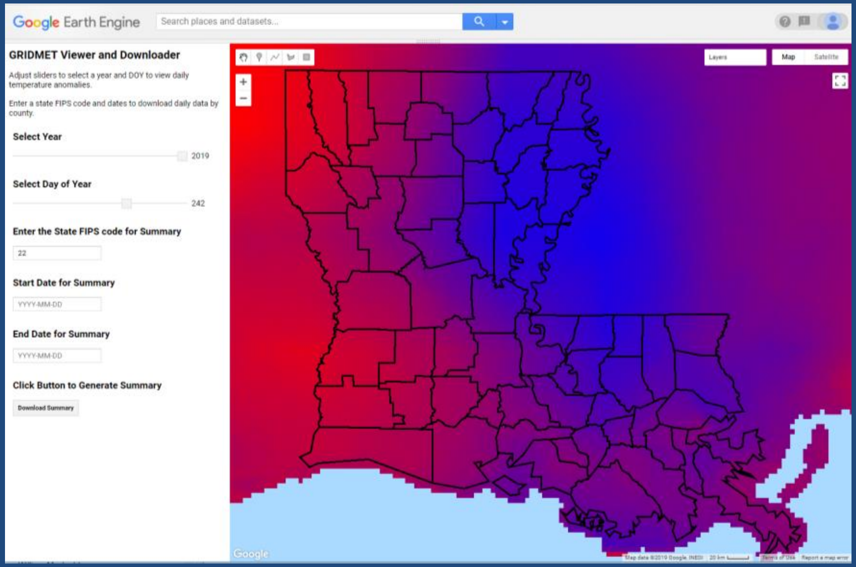
Most WNV cases occur between weeks 27-34, ***after the seasonal peak in mosquito abundance***.

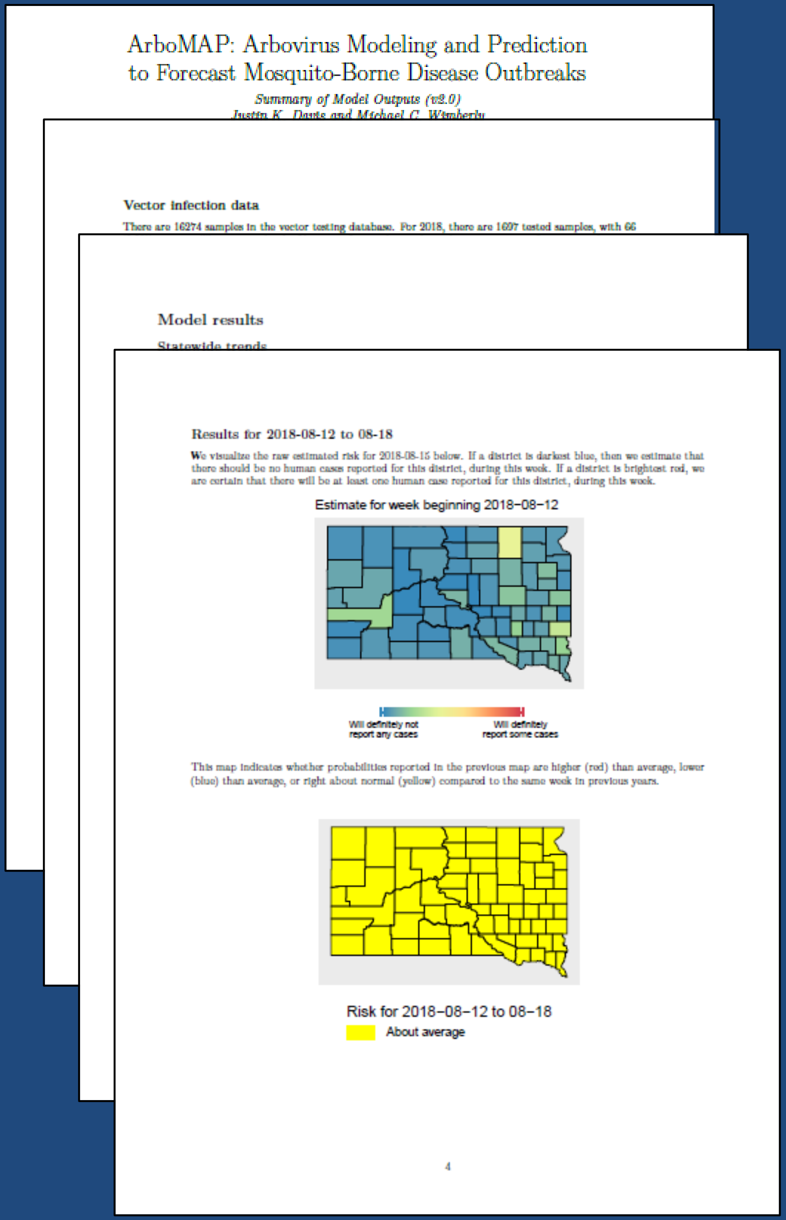


RStudio



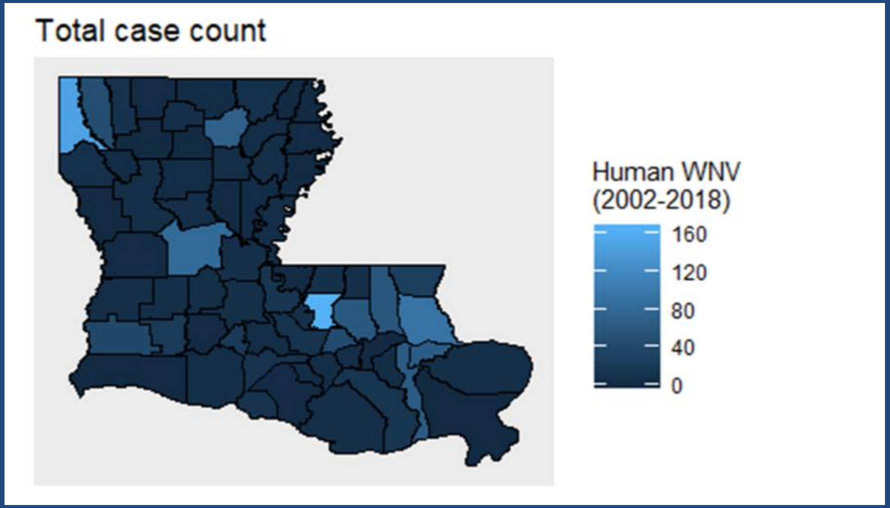
Google Earth Engine

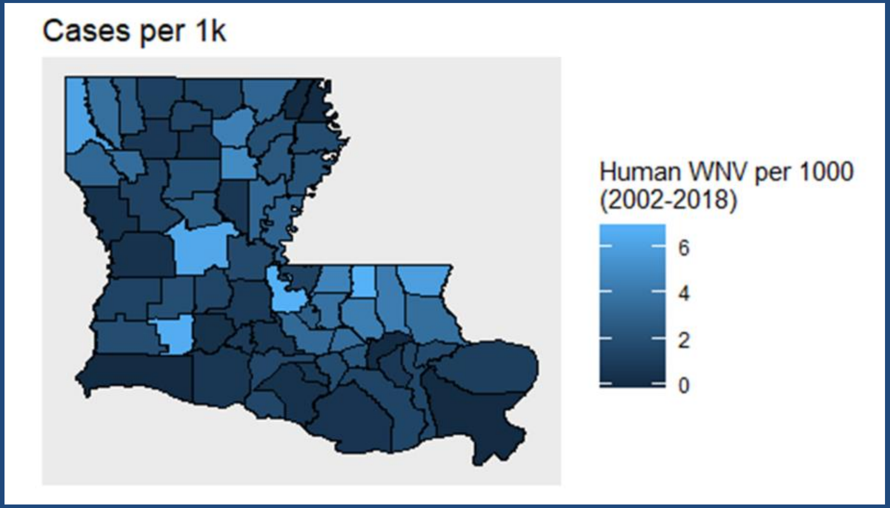




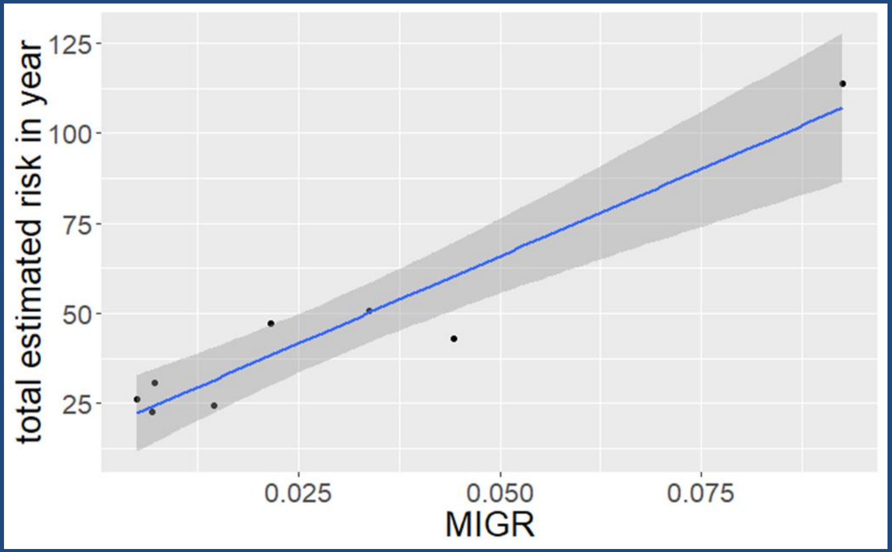
The ArboMAP modeling framework has been successful in South Dakota, but can it be extended to other locations?

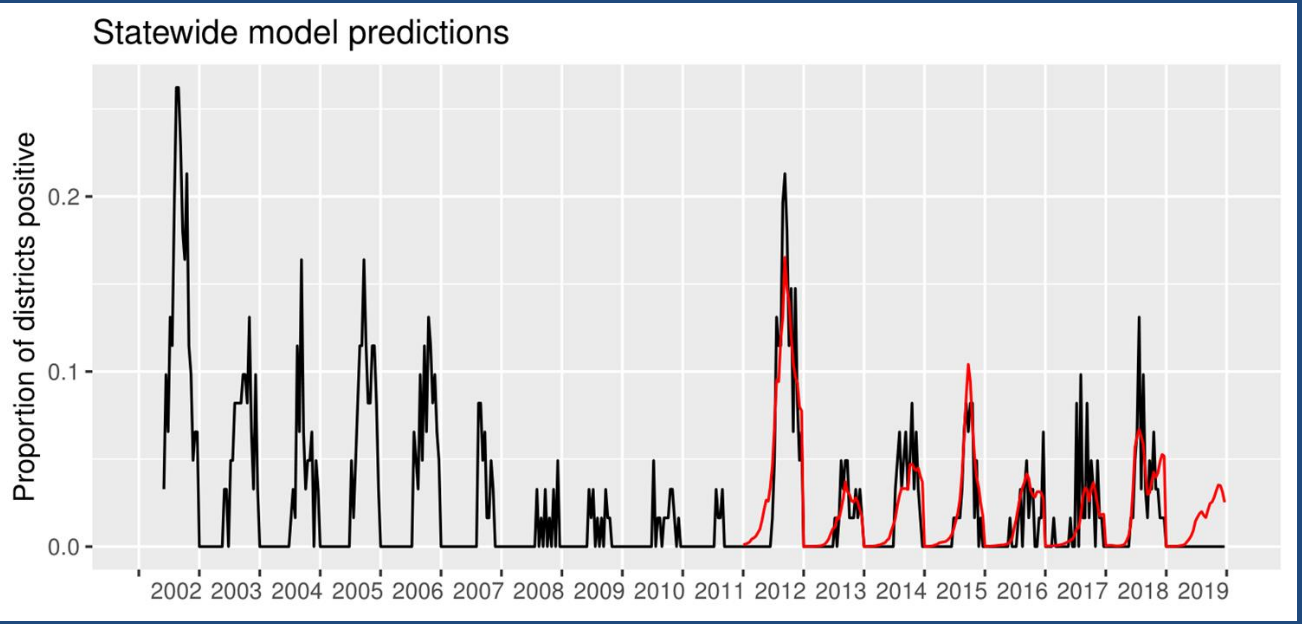
- Critical factors
  - Mosquito vector species
  - Avian host species
  - Climatology
  - Landscape and hydrological characteristics
  - Human behavior and exposure
- New locations
  - Louisiana
  - Oklahoma
  - Colorado (?)





(Very) preliminary analyses suggest that our basic modeling approach will in fact work in Louisiana





Next Steps

- Finish processing the LA mosquito infection data and generate a final version of the 2019 forecast.
- Evaluate the 2019 forecast once final human case data are available.
- Update to the modelling approach.
  - Implement new technique for modelling distributed lags
  - Develop and test approaches for incorporating extreme events (e.g., hurricanes)
  - Compare alternative (process-based) modeling approaches
- Update the software.
  - Allow for more user interaction and flexibility in selecting different modeling options

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