

United States Disease Outbreak Simulation/United States Animal Movement Model

Sam Smith, MS
Webb Lab, Colorado State University

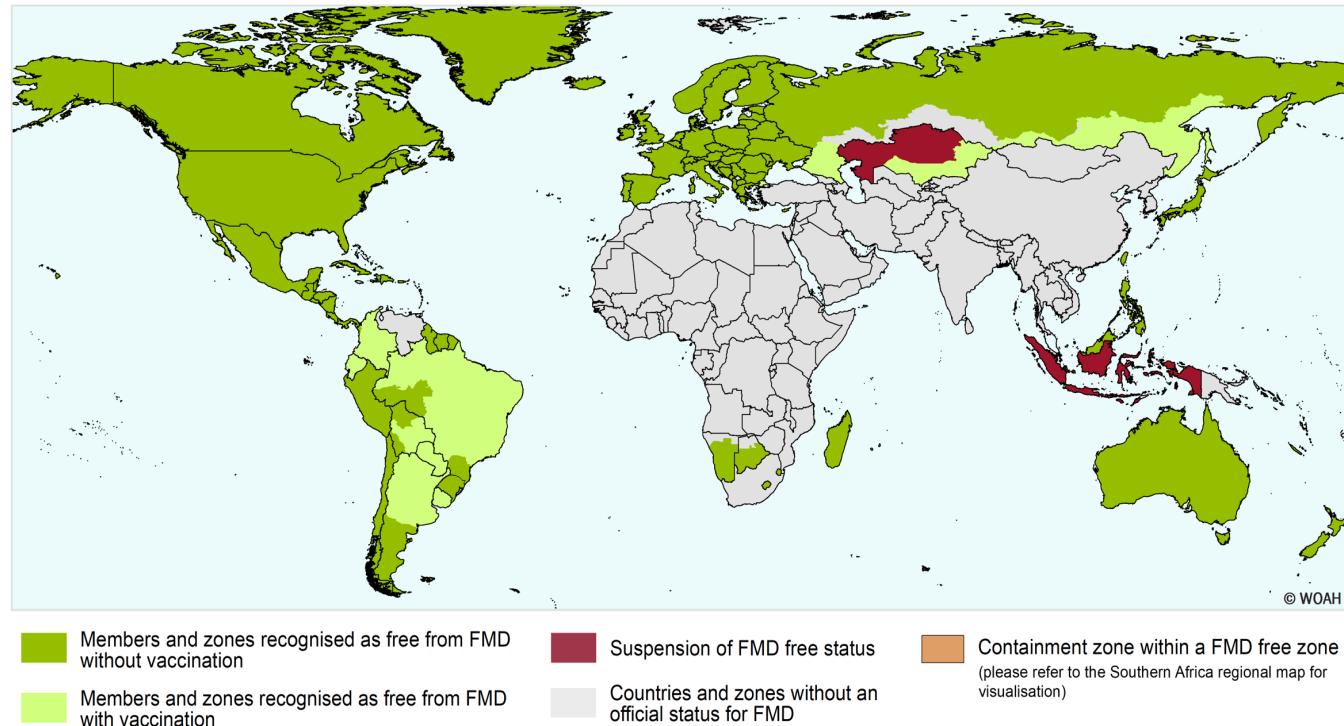


Linköping University

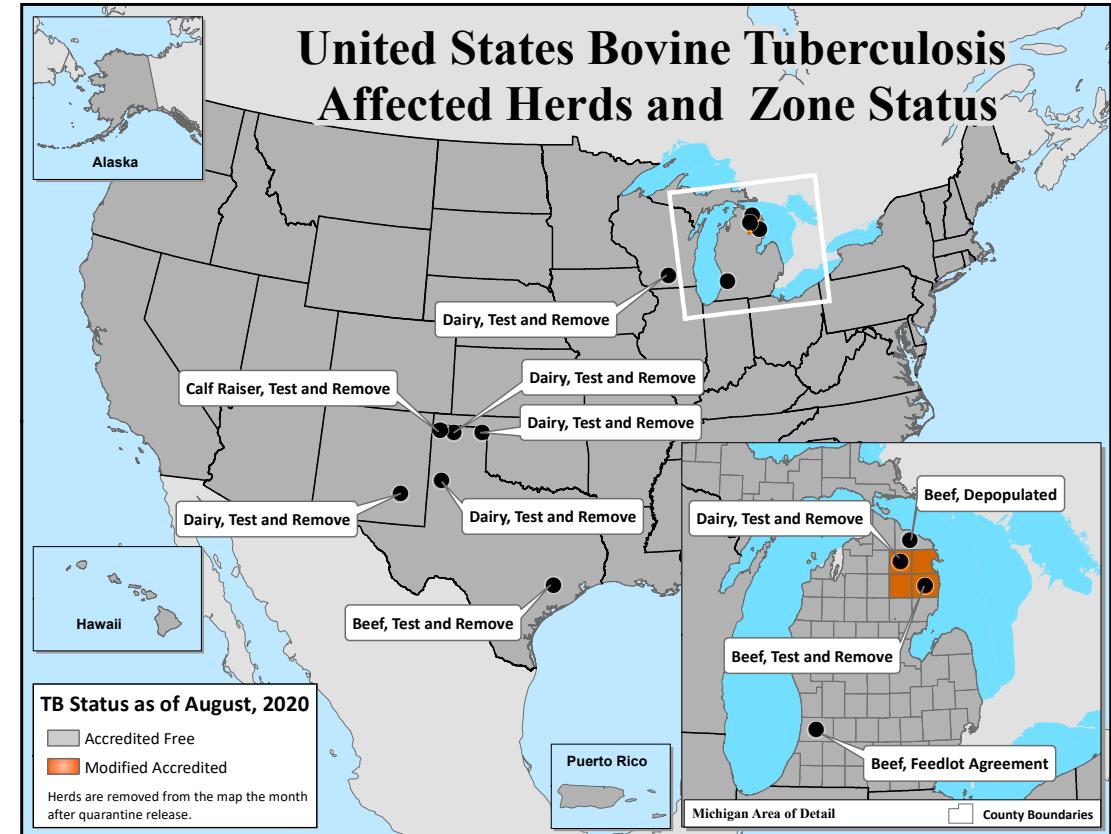


There are many animal diseases that pose a persistent threat to the U.S. livestock population

Foot and mouth disease (FMD)



Bovine tuberculosis (bTB)



United States Disease Outbreak Simulation (USDOS)

- National scale model premises-to-premises livestock disease transmission model (Tsao et al. 2019)

United States Animal Movement Model (USAMM)

- Bayesian Model based software for estimating county-to-county animal shipments (Sellman et al. 2022)

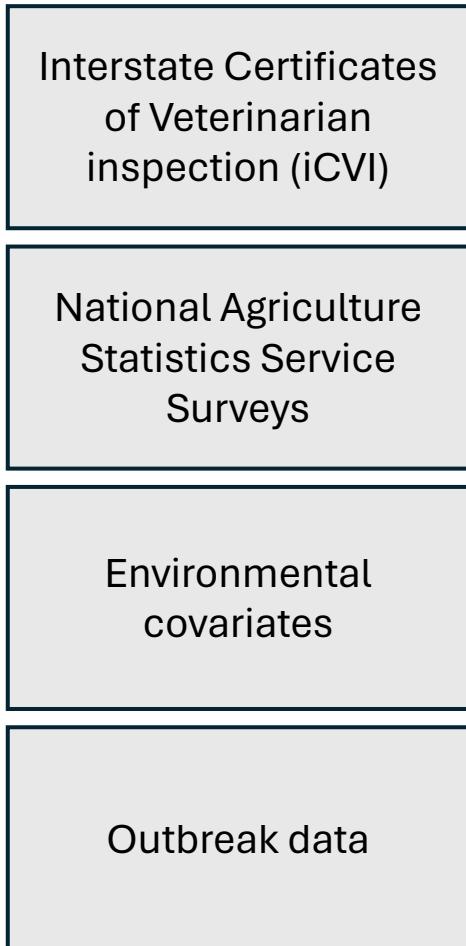
Goals

1. Provide data-driven predictions of livestock shipments and disease spread in the United States
2. Characterize uncertainty in these predictions

Philosophy

1. Strongly data-based modeling
2. Close working relationship with state and government agencies
3. Parsimonious modeling choices whenever possible

Data



Parameters

United States Animal Movement Model
shipment network realizations

Simulated farm locations

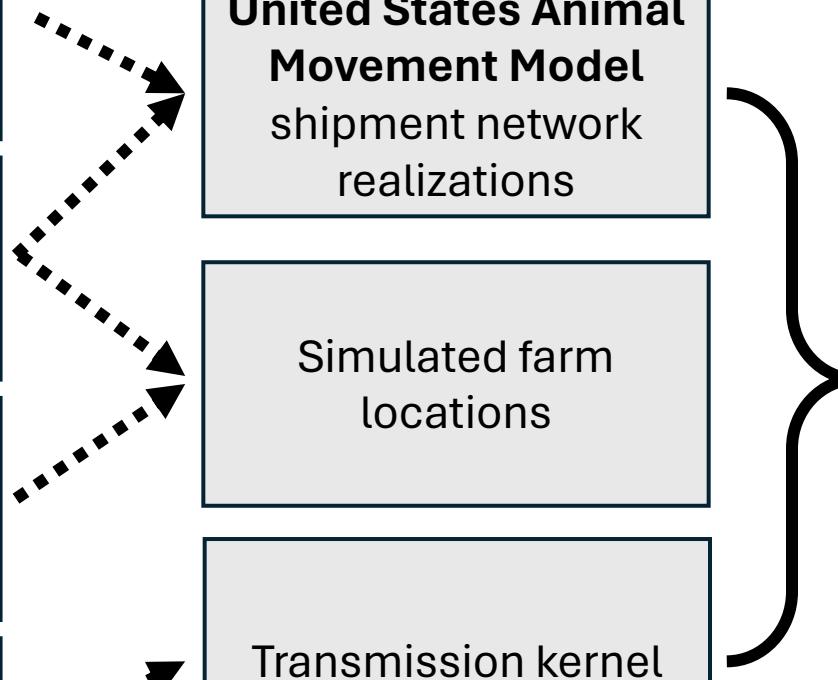
Transmission kernel

Model

United States Disease Outbreak Simulation

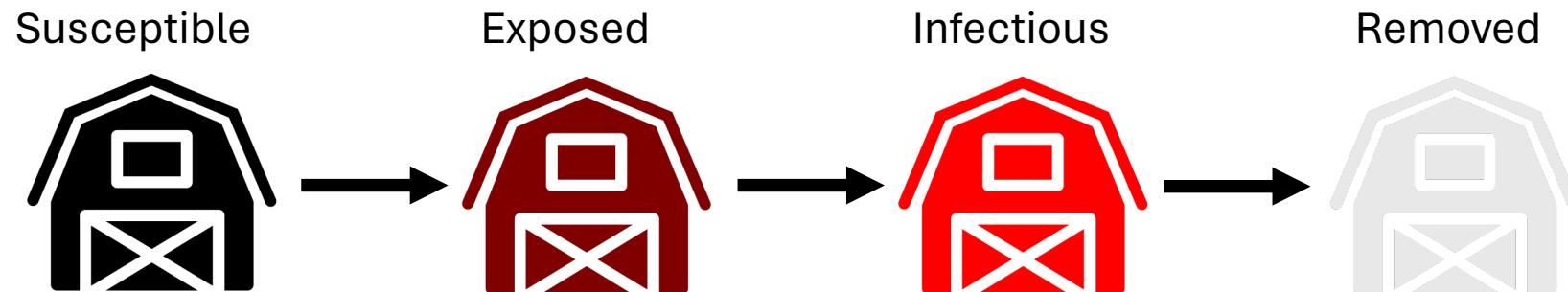
Predictions

Outbreak predictions



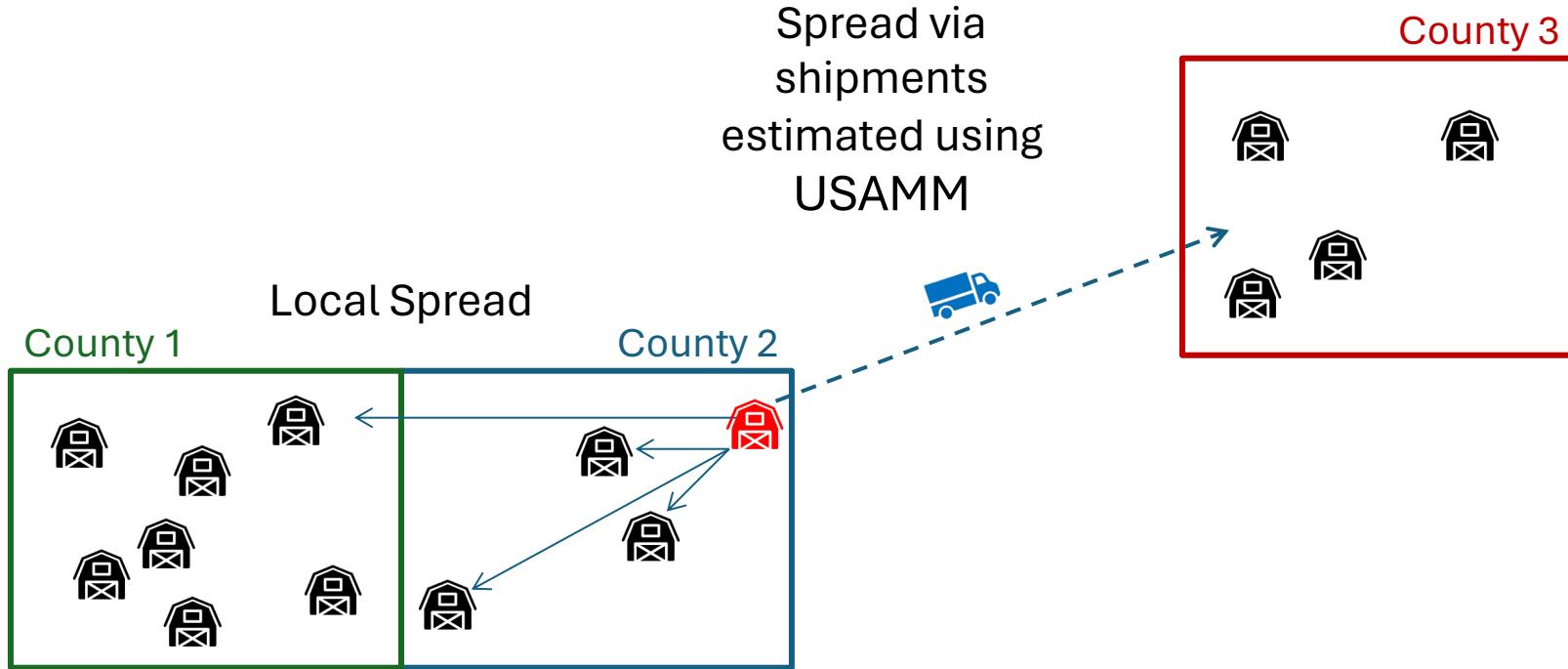
United States Disease Outbreak Simulation

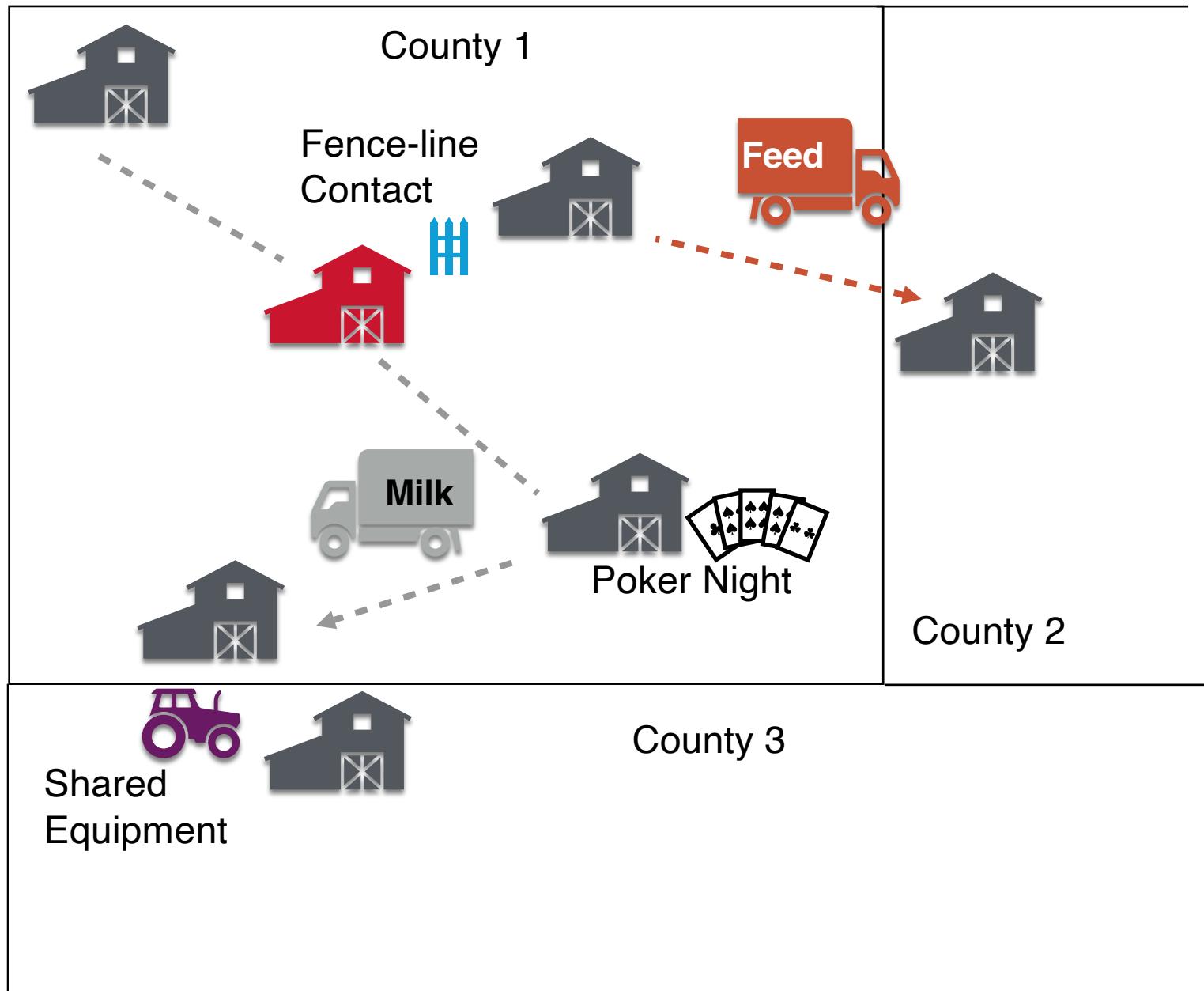
- National scale model of premises-level livestock disease transmission in cattle and swine



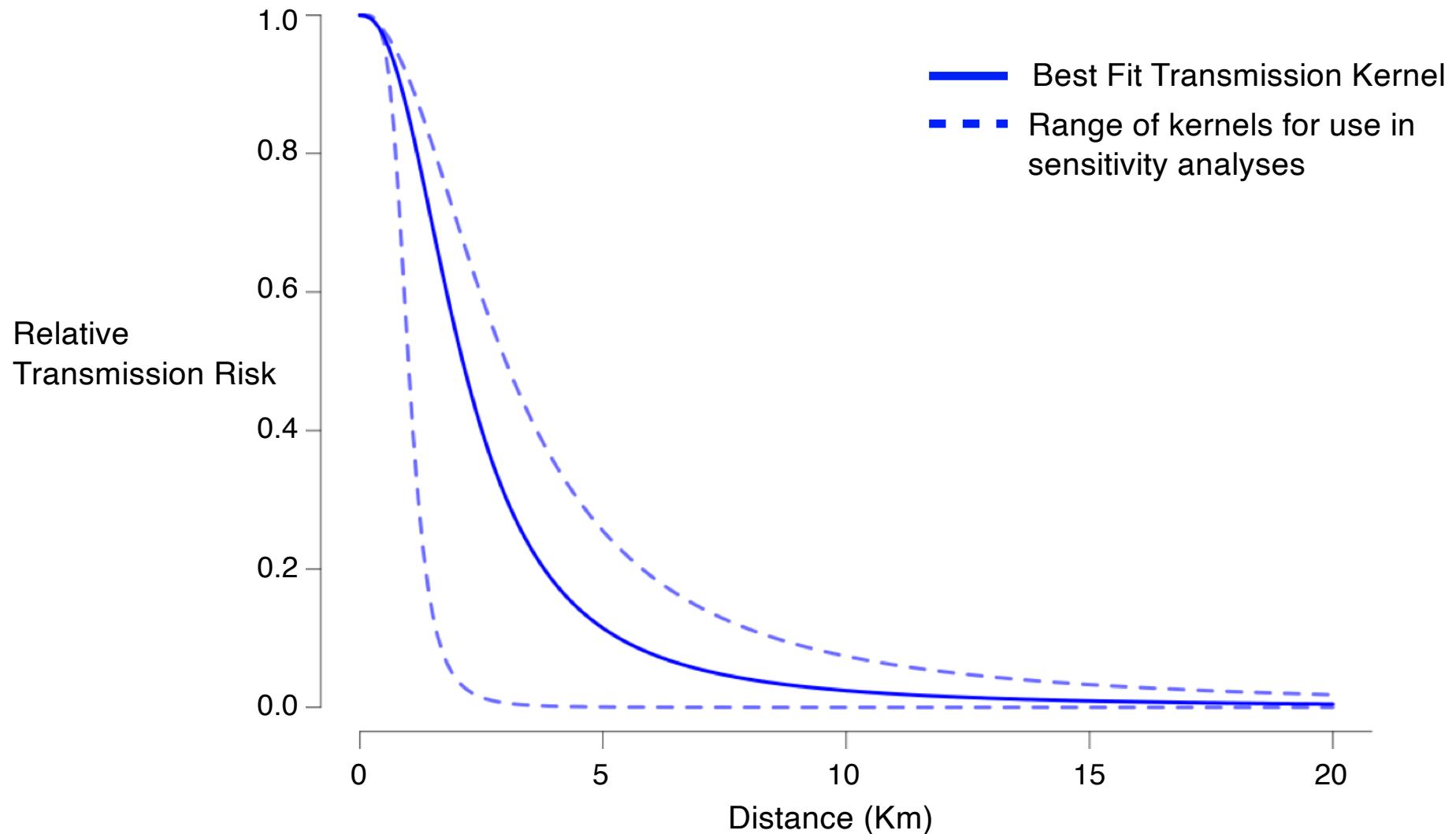
Gilbertson et al. 2022,
Tsao et al. 2019,
Sellman et al. 2018

Premises may be infected via local or shipment-based transmission

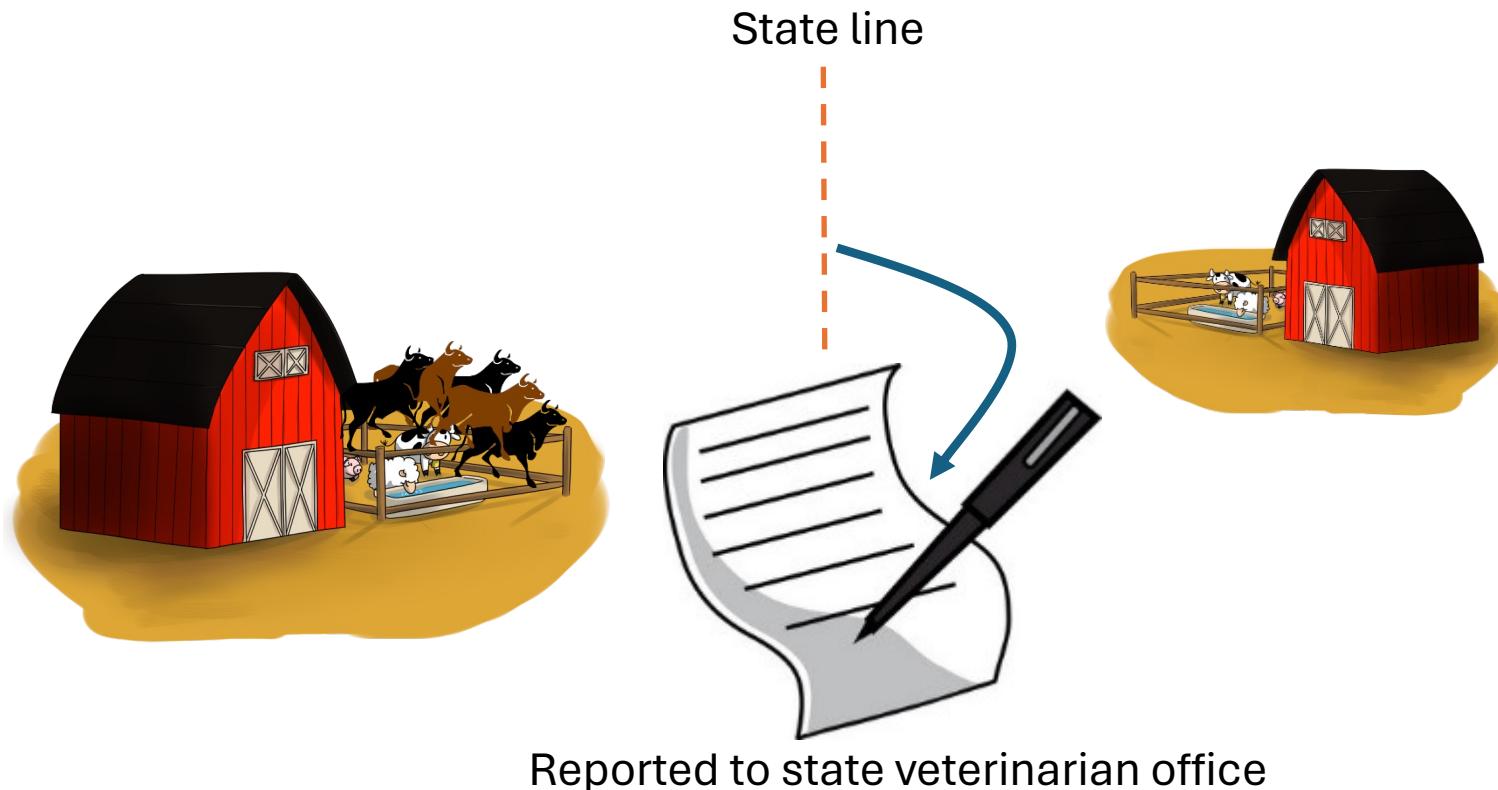




Local transmission in USDOS estimated using transmission kernel fit to outbreak data



Shipments necessary for long-distance transmission are predicted by the United States Animal Movement Model (USAMM)



Lindström et al. 2013,
Sellman et al. 2022, Computers
and Electronics in Agriculture
Sellman et al. 2022, Epidemics

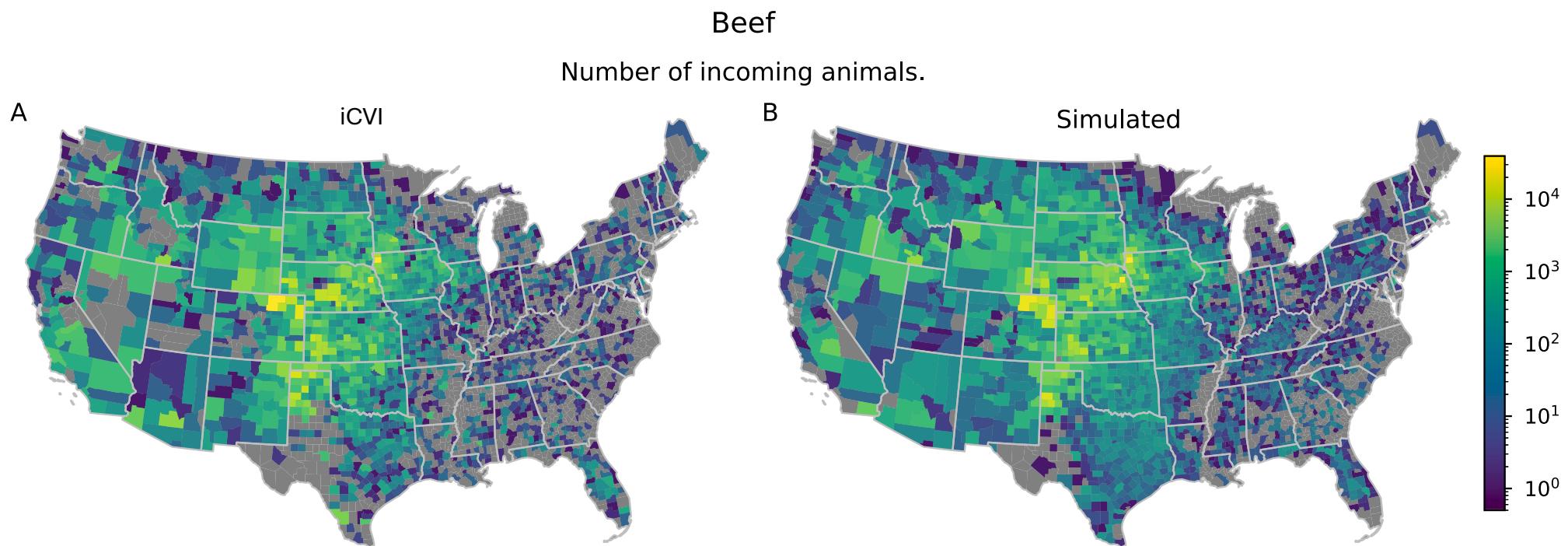
United States Animal Movement Model

- Hierarchical Bayesian statistical model that estimates livestock shipment networks for the U.S.
- Developed independently for cattle and swine
 - USAMM – Cattle estimates networks for beef and dairy animals separately

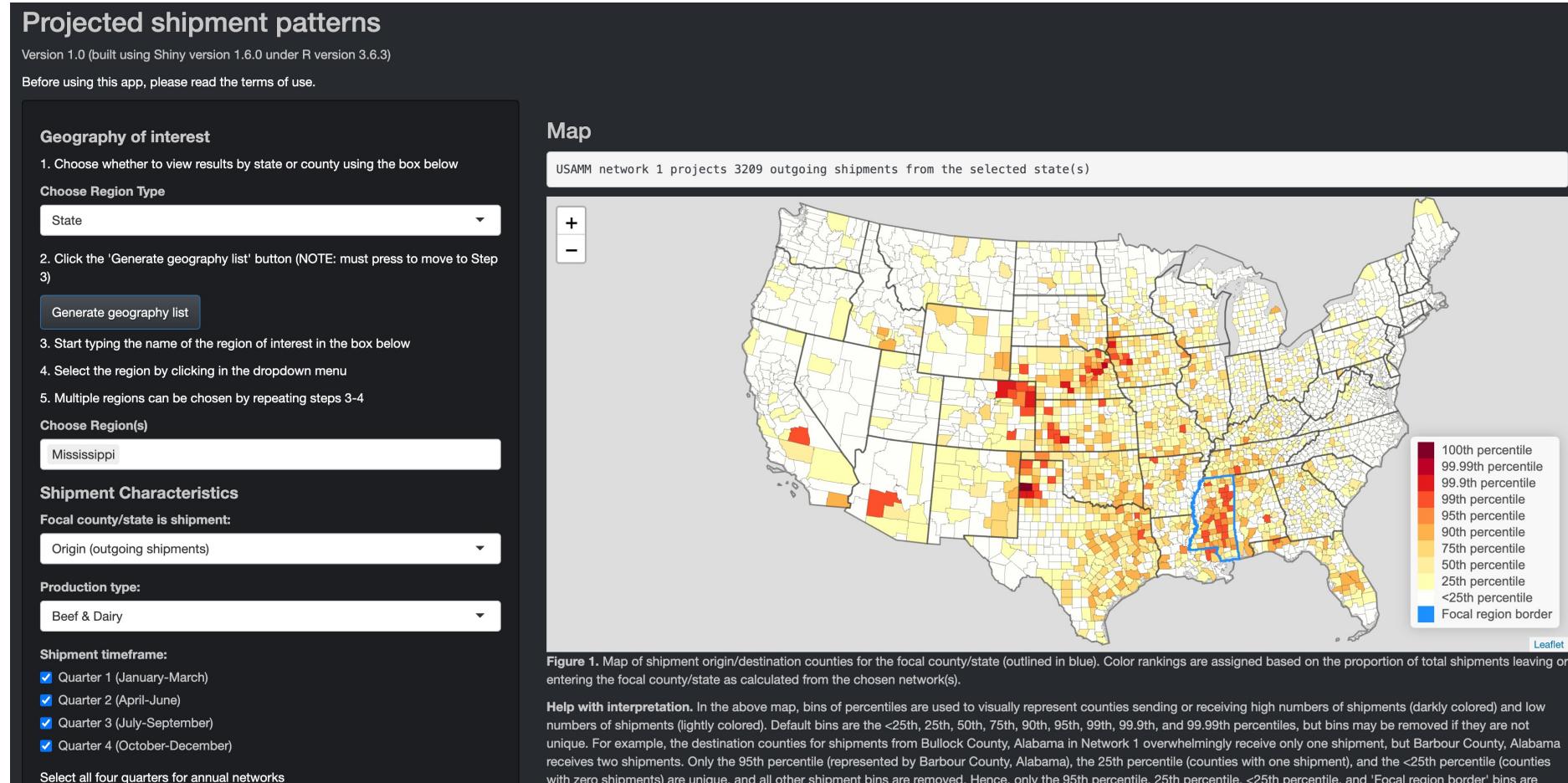


<https://webblabb.github.io/usammusdos/usamm.html>

USAMM—Cattle

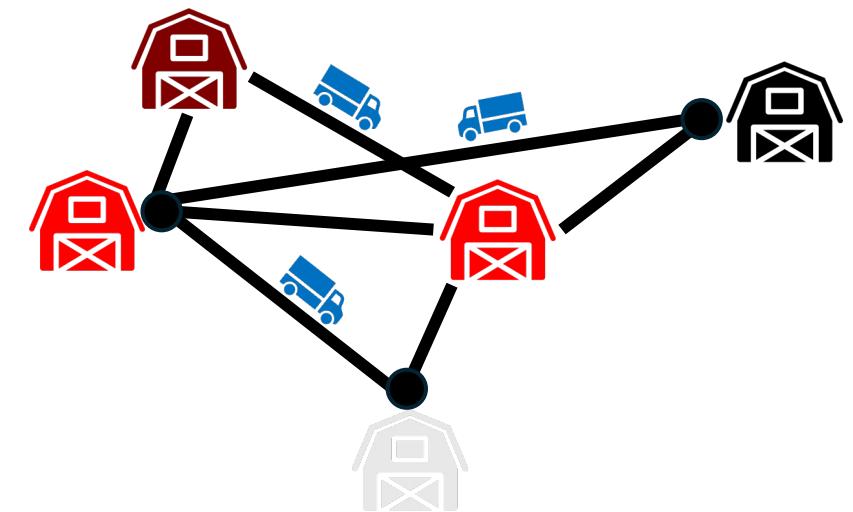
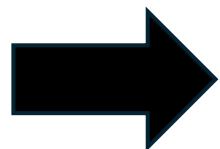
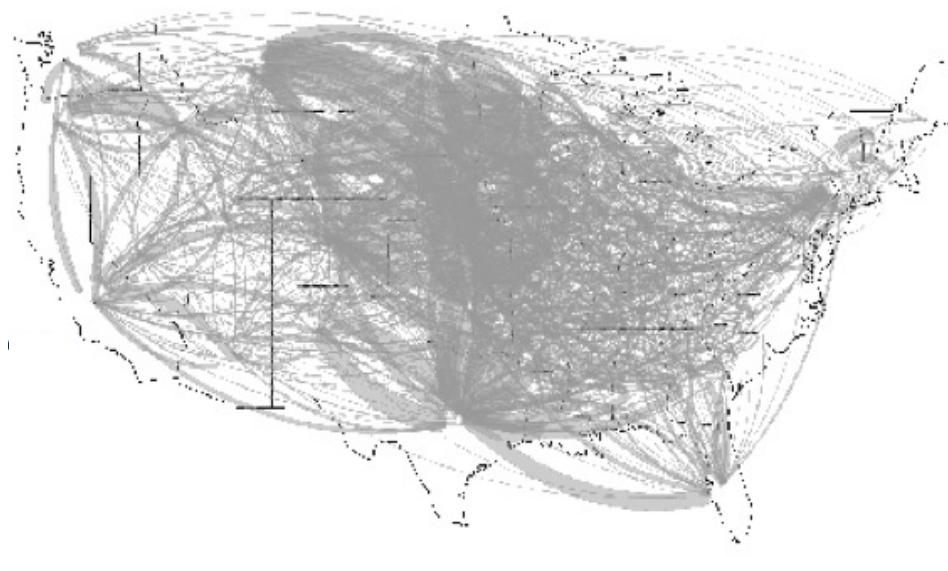


Visit the Shiny application to visualize USAMM-predicted networks or download summary tables



https://usamm-gen-net.shinyapps.io/v3ShinyApp_1000Nets/

Posterior distributions of USAMM-predicted shipment networks
are put into USDOS to predict long-distance transmission

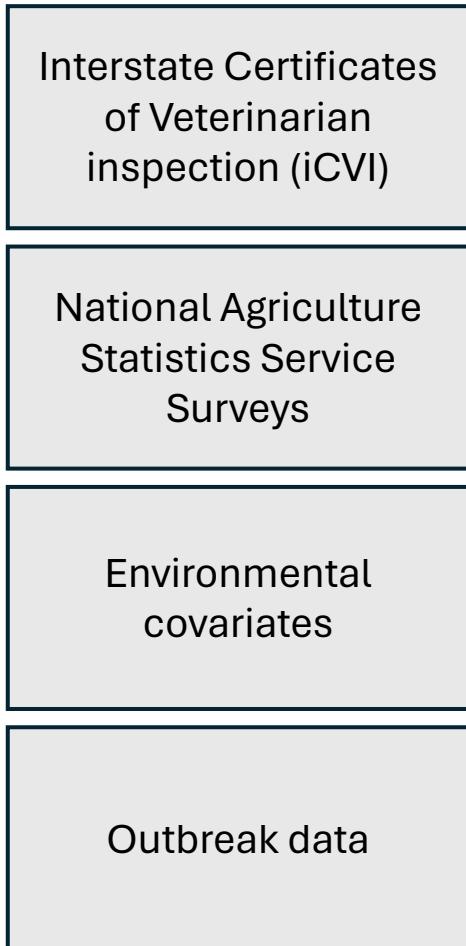


Farm locations in USDOS are estimated using the Farm Location and Agricultural Production Simulator

One realization of U.S. farm locations



Data



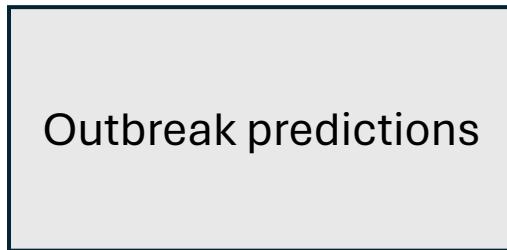
Parameters



Model



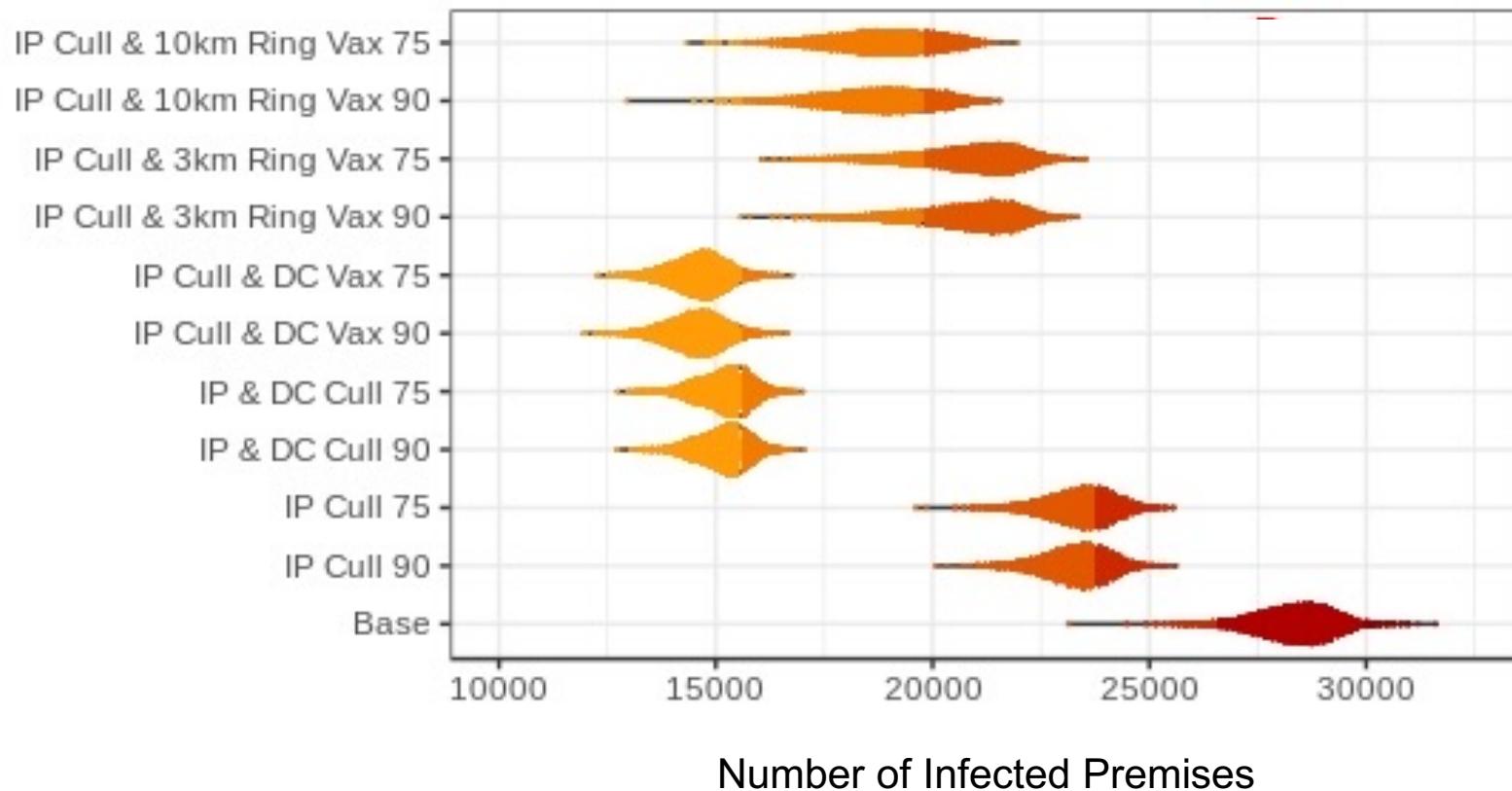
Predictions



USDOS outbreak response actions

- Diagnostics
 - Diagnostic tests of various types targeted at same premises types as control actions
 - Can be implemented for test to confirm infection, testing at risk premises or both
- Control
 - Shipment bans: State or County level
 - Culling: infected premises, dangerous contact premises, rings of defined diameter
 - Vaccination: targeting same as culling

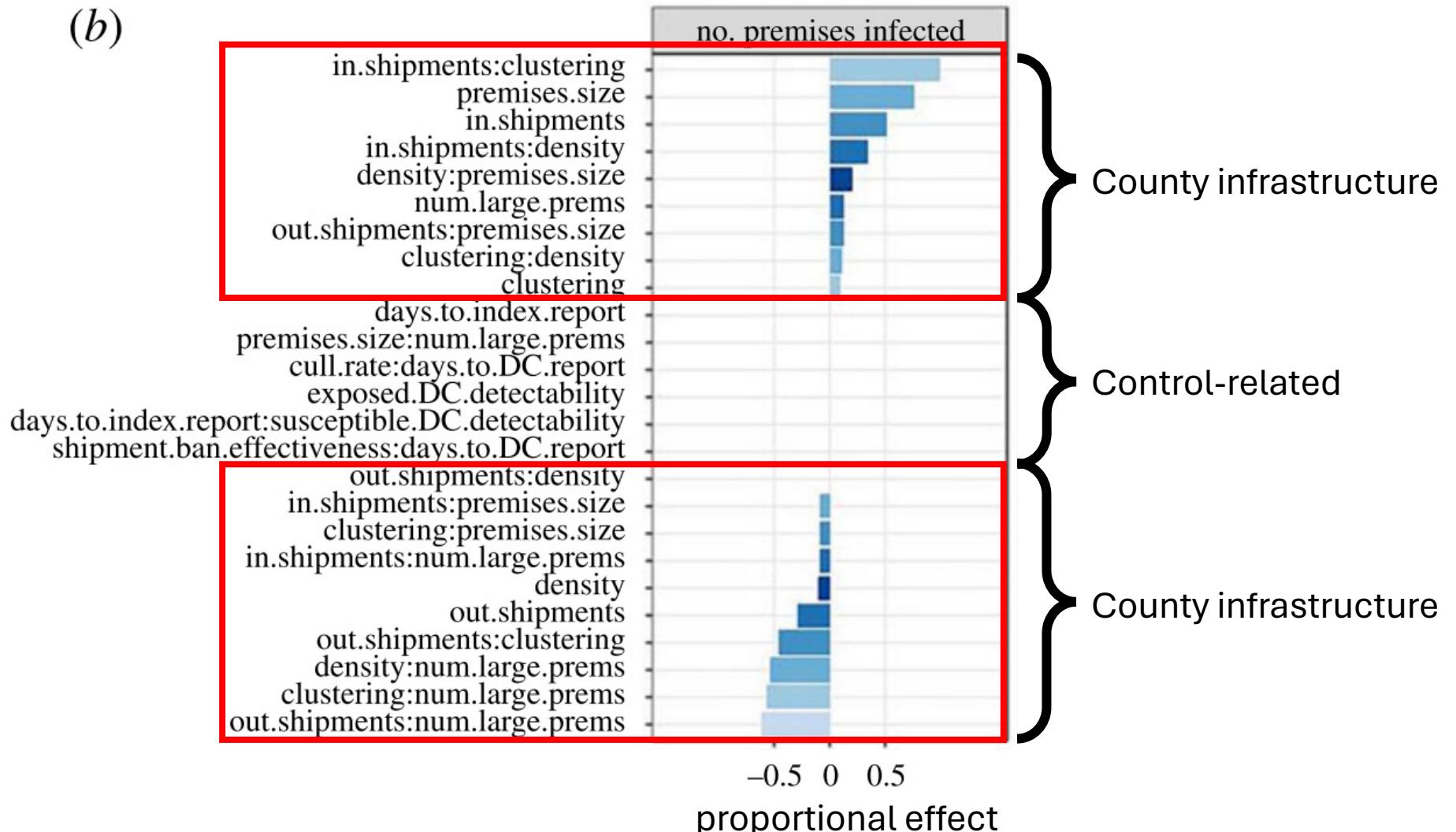
What can we learn from USDOS simulations?



*only the largest 2.5%
of outbreaks shown

Sensitivity analyses can be used to understand what parameters USDOS is most sensitive to

(b)



Current USAMM/USDOS work

- Exploring the impact of diagnostic testing on FMD outbreaks
- Developing USDOS to be capable of simulating multi-species (cattle and swine) outbreak scenarios
- Exploring how decision-making time impacts outbreak outcomes
- Developing USDOS to simulate bTB outbreaks
 - Evaluating how diagnostics, tracing, and slaughter surveillance impact bTB outbreak outcomes

More information about USAMM/USDOS (including interactive visualizations) can be found at:

<https://webblabb.github.io/usammusdos/>

USAMM/USDOS

About Literature USAMM USDOS search...

U.S. Animal Movement Model and Disease Outbreak Simulation

Summary: Our overall goal is to provide strongly data-driven predictions of U.S. livestock shipments and simulations of livestock disease and to characterize uncertainty in these predictions in order to support decision-making in both response and planning contexts.

[!\[\]\(0c960be1d8eb5c895b7cfaefee87832a_img.jpg\)](#)

About
Objectives, philosophy, people, and FAQ.
[Learn More](#)

[!\[\]\(80335a63fee2473f73a56a7eeec73bb7_img.jpg\)](#)

Literature
Published literature from the project
[Learn More](#)

[!\[\]\(629054d8fa2878d1979526f1a73b671f_img.jpg\)](#)

USAMM
Instructions and documentation to run the USAMM model
[Learn More](#)

[!\[\]\(34831a98efec4b970f48f15ba3aa393b_img.jpg\)](#)

USDOS
Instructions and documentation to run the USDOS model
[Learn More](#)

This work is supported by funding provided by the United States Department of Homeland Security, Science and Technology Directorate under contract numbers 2010-ST-108-000017, HSHQDC-13-B-0028, and D15PC00278. This work was supported by USDA Cooperative Agreements: USDA-APHIS-10025-VSCEA-H00-17-0013, 13-9208-0353-CA, 13-9208-0344-CA, 13-9208-0345-CA, 15-9200-0400-CA, 15-9200-0440-CA. Data were provided by the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services. The analyses, views and conclusions contained in this document are those of the authors and should not be interpreted as representing the regulatory opinions, official policies, either expressed or implied, of the USDA-APHIS-Veterinary Services or the U.S. Department of Homeland Security. We also thank the state


Colorado State University

LINK&DING



Acknowledgements

People

- Colleen Webb
- Lindsay Beck-Johnson
- Tom Lindström
- Stefan Sellman
- Ryan Miller
- Katie Portacci
- Clayton Hallman
- Uno Wennergren
- Michael Tildesley
- Kimberly Tsao
- Erin Gorsich
- Michael Buhnerkempe
- Clif McKee
- Peter Brommesson
- Amanda Minter
- Katie Owers Bonner
- Catherine Herzog
- Lauren Smith

Funders

- DHS grants (ST-108-000017, HSHQDC-13-C-B0028, D15PC00278)
- USDA cooperative agreements (11-9208-0269-CA 11-1, 09-9208- 0235-CA, 13-9208-0344-CA, 13-9208-0345-CA, 13-9208-0353-CA)
- U.S. Department of Agriculture, National Institute of Food and Agriculture grants (2022-67015-36923 and 2018-67015-28289)
- The findings and conclusions in this preliminary presentation have not been formally disseminated by the U. S. Department of Agriculture and Should not be construed to represent any agency determination or policy
- The analyses, views and conclusions contained in this document are those of the authors and should not be interpreted as representing the regulatory opinions, official policies, either expressed or implied, of the USDA-APHIS-Veterinary Services or the U.S. Department of Homeland Security.