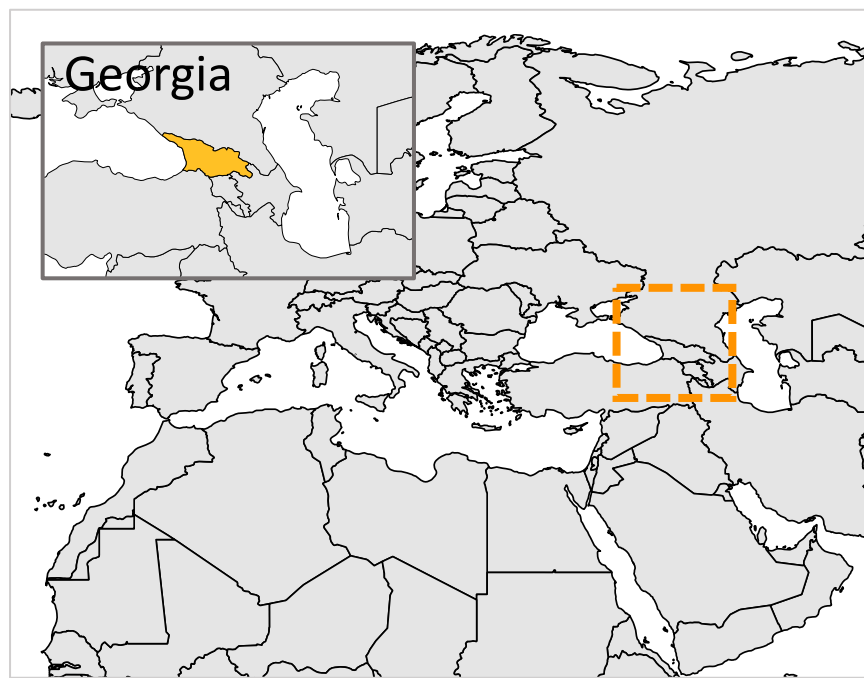


Background: seed health in the Republic of Georgia

- Seed systems are key to the distribution of improved varieties, but also important sources of pathogen spread
- As of 2017, potato ranked highest in terms of annual crop production in the country
- However, yields are among the world's lowest at 8-12 t/ha vs. > 45 t/ha in high income countries



Objectives

- Identify regions at highest risk for the introduction of *Synchytrium endobioticum*
- Identify regions that should be targeted for intervention, based on their risk of disease introduction and limitations of access in the current seed system

2017 expert elicitation workshop

Two day workshop

- A group of 25 experts on Georgian potato production were brought together



Participatory elicitation

- Respondents were interactively asked about variety adoption, disease distribution, major stakeholders, and seed flows

Baseline results

- These baseline results were used to shape models of disease spread risk
- Inform the development of a national seed strategy

Risk assessment with multi-scale network analysis

Seed Network Estimation

- Network of potato seed movement between districts was estimated using a gravity model, incorporating crop harvested area and distance between regions:

$$y_{ij} = \frac{\log(M_i M_j)}{\max(\log(M^2))} * \alpha d_{ij}^{-\beta}$$

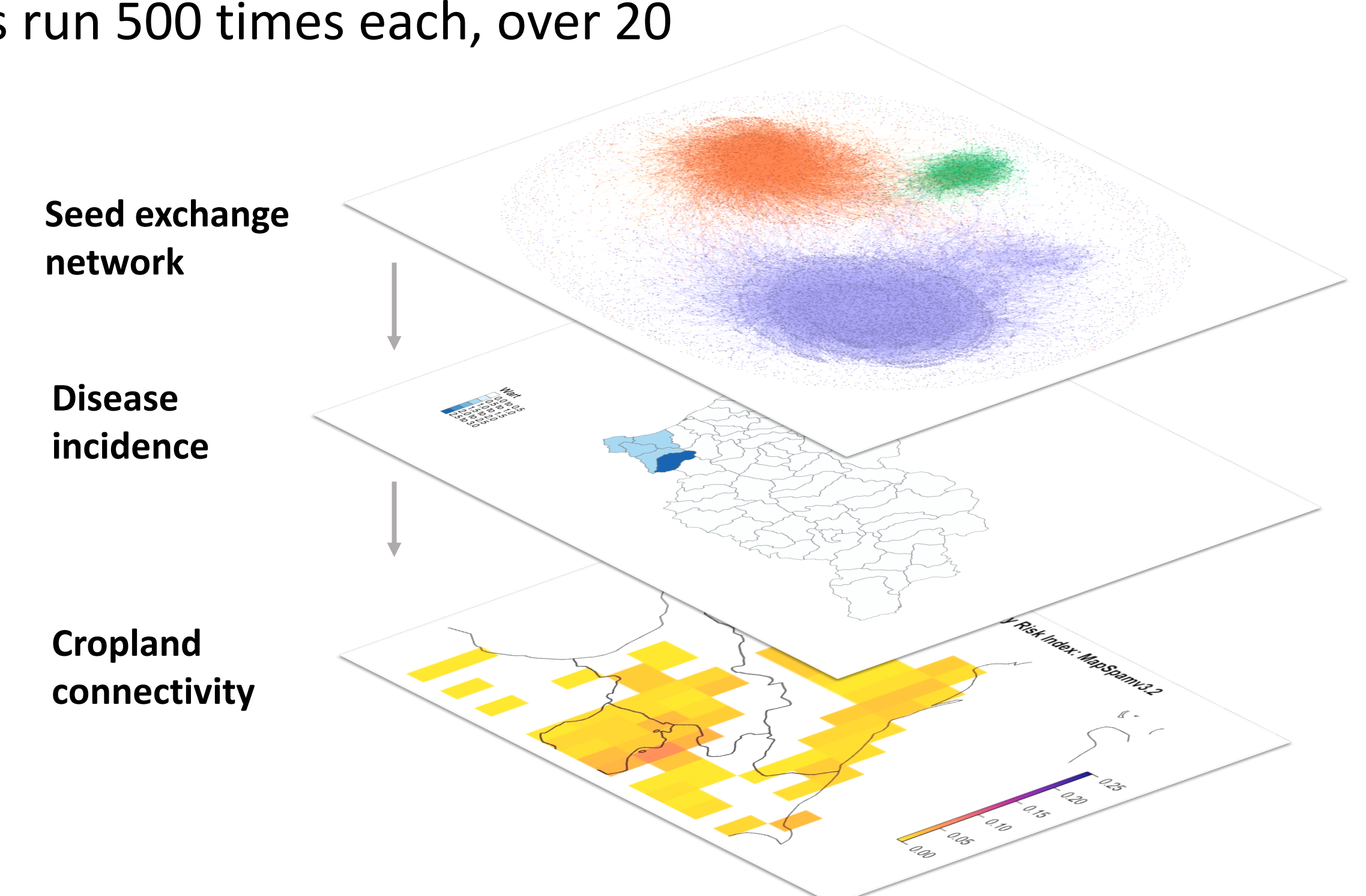
y = probability of seed exchange between districts i and j
 M_i = crop area (ha) of district i in 2017
 β = decay parameter,
 α = scaling factor
 d = distance (km) between districts i and j

Epidemic Simulation

- Epidemics were simulated using network models, where initially only Adjara district was infected
- Seed transaction networks were stochastically re-wired in each time step
- Simulations run 500 times each, over 20 time steps

Risk Index Calculation

- Mean log-transformed number of infections occurring over the course of the epidemic lifecycle

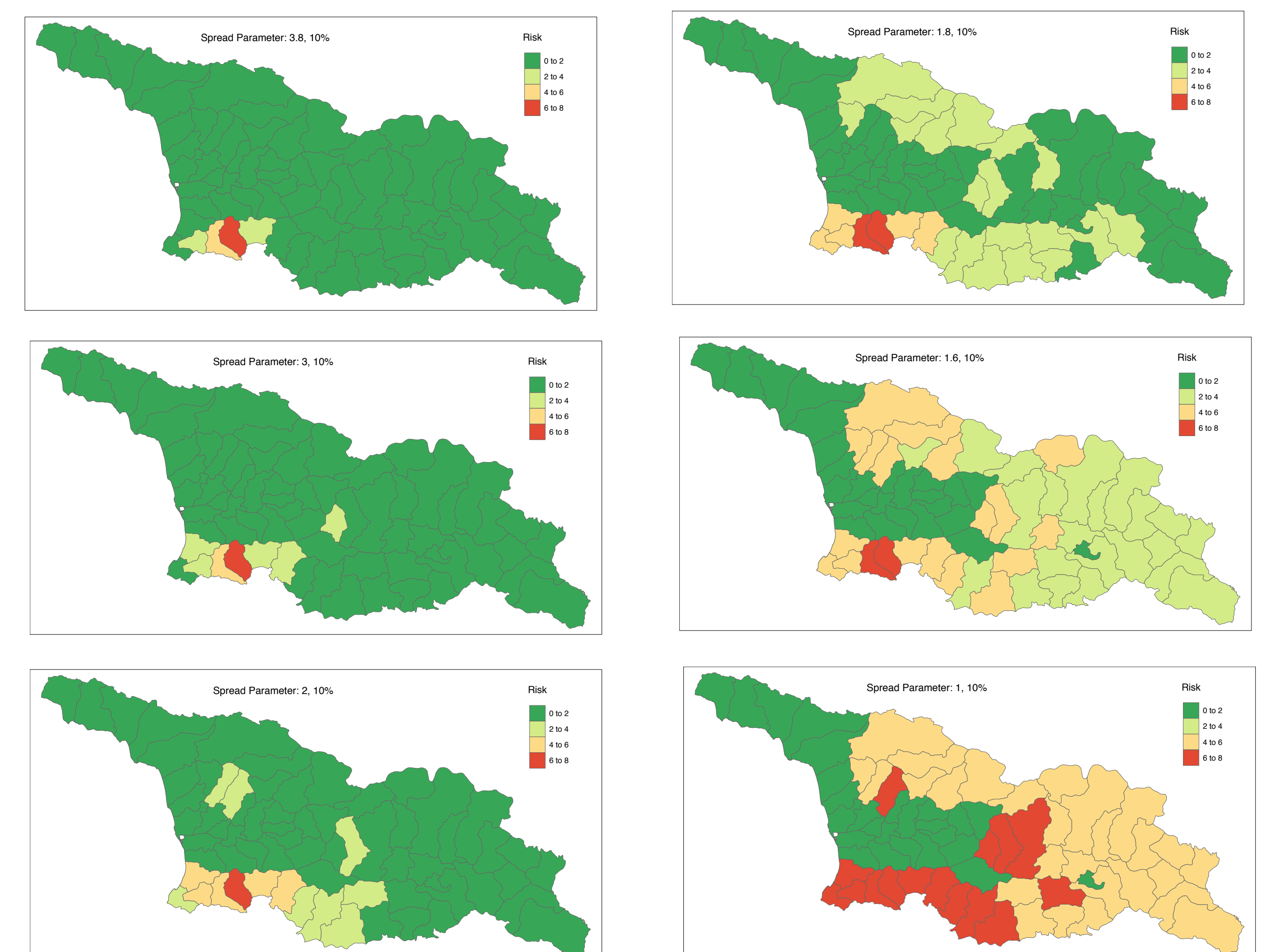


Motivation

Because of its informal nature, the seed system in Georgia may be at particular risk for seed transmitted pathogens. The recent introduction of *S. endobioticum* poses a particular risk. We model potential spread and target regions for risk based surveillance under a range of disease scenarios.



Scenarios of pathogen dispersal



Uncertainty quantification: Six scenarios of pathogen risk for values of β from 3.8 (very few links generated in the seed transaction network, to 1 (many links generated), for the scenario where 10% of seed transactions result in pathogen spread. Risk here is the Mean log-transformed number of infection events occurring over 20 time steps (500 simulations).

Emerging pathogen: *S. endobioticum*

- During surveys conducted between 2010-2013, *S. endobioticum* was reported on several different fields in the southwestern highland region of **Adjara**
- Primarily spread through infected seed potato tubers, this pathogen is a threat for seed systems where there is little or no control of phytosanitary quality
- S. endobioticum* is considered a quarantine organism and many countries have implemented strict regulation to prevent introduction

References

- Andersen, K. F., Buddenhagen, C. E., Rachkara, P., Gibson, R., et al. 2018. Modeling epidemics in seed systems to guide management strategies: The case of sweetpotato in Northern Uganda. bioRxiv:https://doi.org/10.1101/107359.
- Buddenhagen, C. E., Hernandez Nopsa, J. F., Andersen, K. F., Andrade-Piedra, J., et al. 2017. Epidemic network analysis for mitigation of invasive pathogens in seed systems: Potato in Ecuador. Phytopathology 107:1209-1218.
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Conclusions and next steps

- Spread of this pathogen, along with other seed potato transmitted pathogens may be rapid throughout the country without proper restrictions on trade
- Regions most proximate to Adjara are at the highest risk, and districts in administrative regions in Kvemo Kartali and Shida Kartli may also be at high risk. Policy should consider targeting these areas for phytosanitary restrictions and training in integrated seed health strategies
- Future risk assessment modeling will more finely parameterize within-district spread and incorporate other stakeholders involved in seed potato movement