Outfoxing Rabies: Capturing the Spatiotemporal Dynamics of Fox Rabies in Eastern Germany

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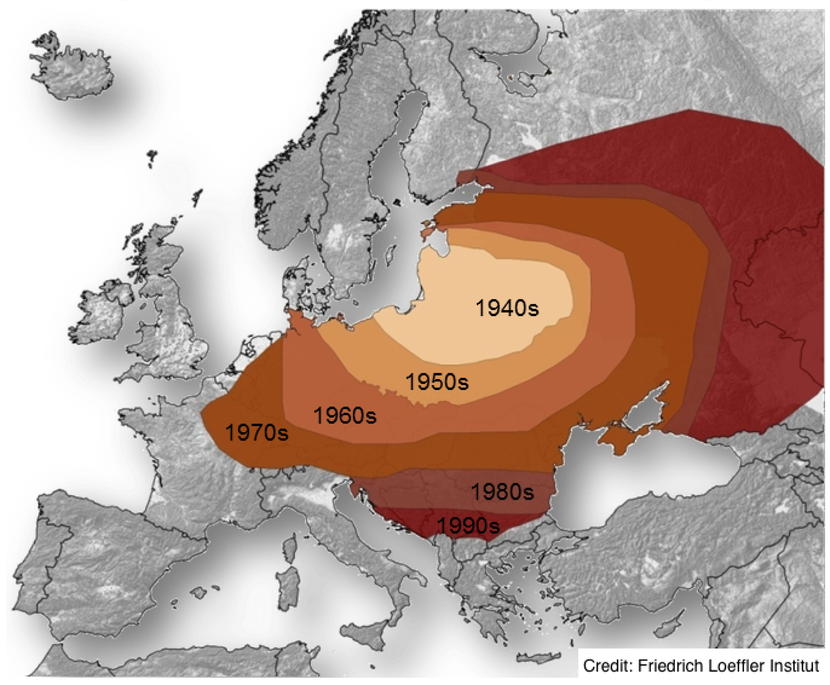
Introduction

Rabies is a Deadly and Terrifying Disease

- Over 50,000 human deaths worldwide
- Red fox is primary reservoir in Europe



- Result of spill-over from dogs to foxes in 1940s
- Rapidly spread throughout Europe

Oral Rabies Vaccination (ORV)

- Introduced in 1978 to combat the disease
- 3 decades and 2.36 mil vaccine-baited km^2 later, rabies eliminated from 9 countries!!!

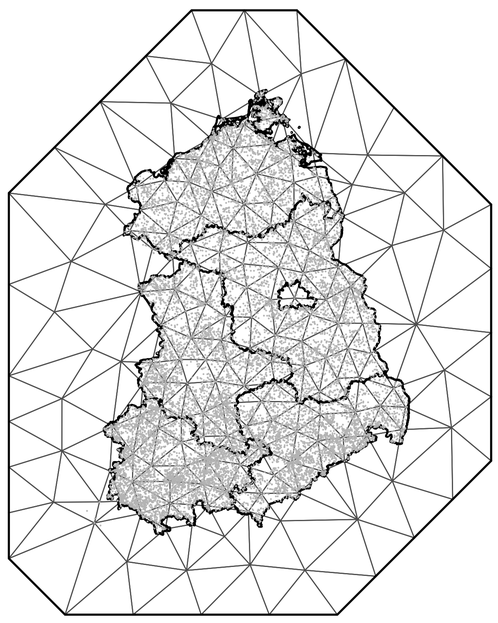
What Can We Learn From Fox Rabies Elimination?

- Understand patterns in persistence
- Gain insights for ongoing ORV in Europe and vaccination elsewhere
- Apply advanced spatiotemporal modelling techniques to develop spatially targeted vaccination

References

- Rue et al. 2009, J. R. Stat Soc.; Simpson et al. 2016, Biometrika; Krainski 2018, NTNU PhD Thesis.

Methods



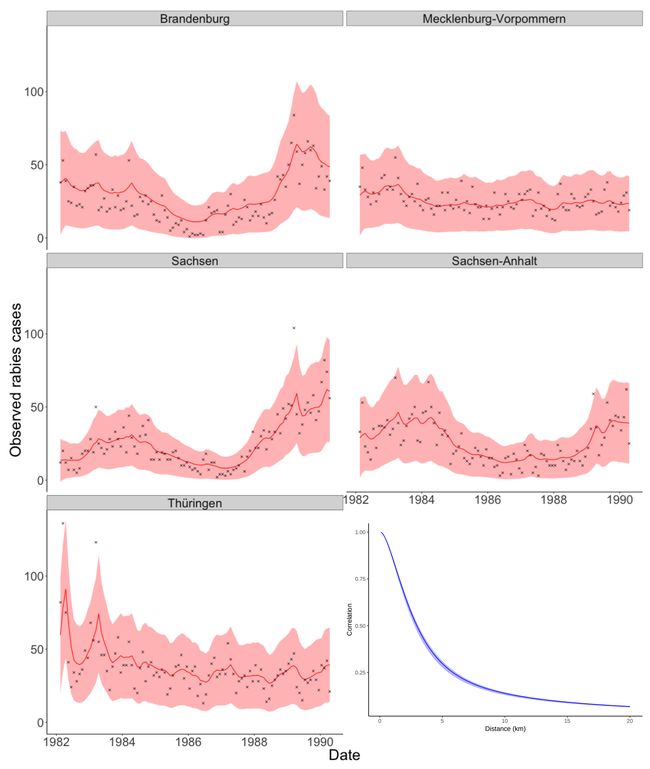
CRDT triangulated mesh

- Modeled infected individuals I from space-time locations of rabies cases in Eastern Germany (1982-2006) using space-time SPDE model in INLA (Rue et al. 2009).
- Used a log-Gaussian Cox space-time point process (Simpson et al. 2016) with likelihood:

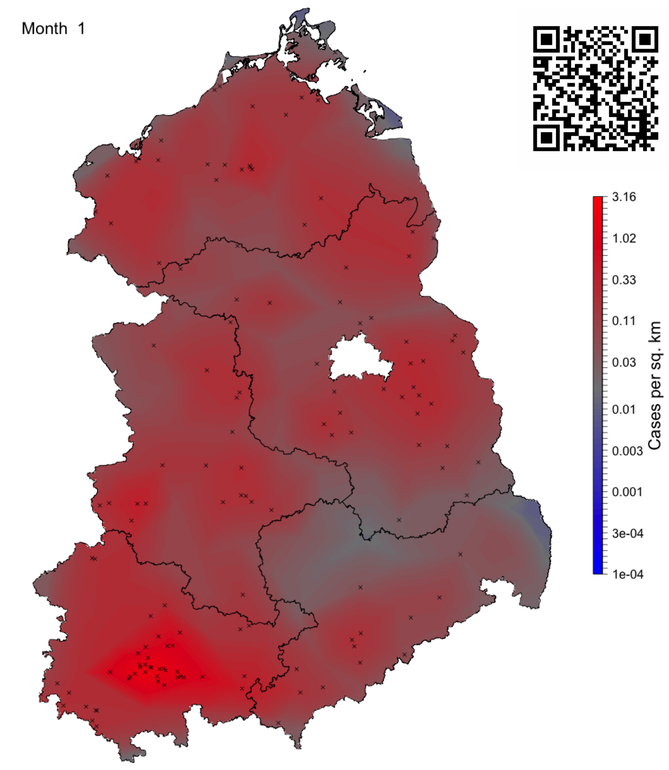
$$\pi(I|\lambda) = \prod_i \lambda(s_i, t_i) \exp(|\Omega||L| - \int_{\Omega,L} \lambda(s,t)\partial s \partial t) \quad (1)$$

where $\lambda(s,t)$ = intensity function, Ω = spatial domain; L = time domain, (s_i, t_i) = space-time coordinates of cases, i.

Results



Estimated cases by federal state: red = mean fit and CI, X's = reported cases. Blue line = spatial dependence (km).



Estimated true infected individuals in space and time. Rabies incidence: dots (cases), red (high), gray (low), and blue (none).

Findings and Future Directions

- Rabies cases clustered within 5km, decaying to 20km
- Captures spatiotemporal dynamics of disease incidence
- Provides a close fit to regional case data.
- Expedient approach for modelling disease spread
- Next steps, explore the effectiveness of different spatial vaccination configurations on disease elimination.