RESAS
Rural & Environmental Science and Analytical Services

Systems approaches and simulation for disease control

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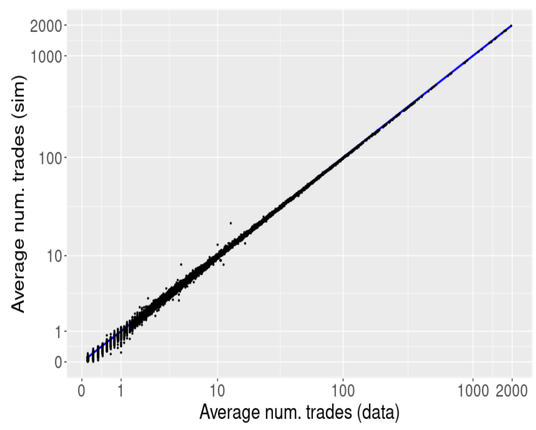
BioSS

The BioSS Large-scale and Systems Modelling SRP project is developing systems approaches for Agent-Based Models (ABMs) of complex real-world systems to address pressing challenges.

With a current emphasis on the Scottish cattle trading system, a model has been developed to capture time-varying farm trading behaviour to investigate the role of trade behaviours in the spread and persistence of endemic disease. Our approach yields quantitative and qualitative insight into: the effectiveness of novel disease control measures including the impact of compensatory behaviours; how trade can assist traditional controls; and the potential for sharing disease risk information at farm-level to facilitate risk-averse trading behaviour.

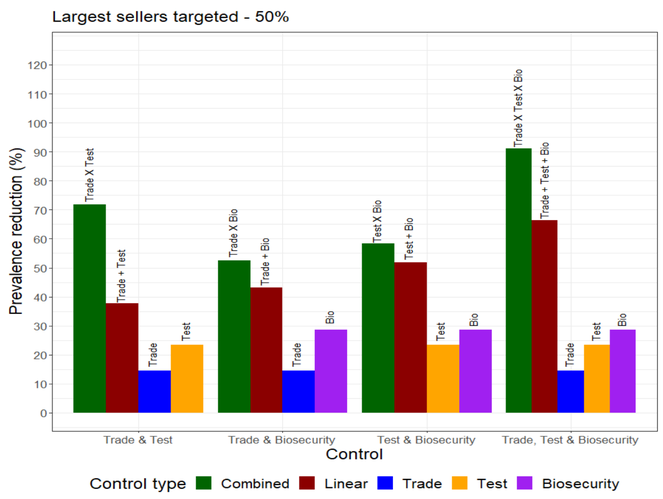
Representing complex real-world systems

- We use the Cattle Tracing System (CTS) dataset to obtain long-term trading properties for individual farms in Scotland.
- These include number of trading partners, frequency of trades, batch sizes, and animal flows.
- Model parameterised so that each farm behaves as observed in data.



Model captures key features of system across several orders of magnitude

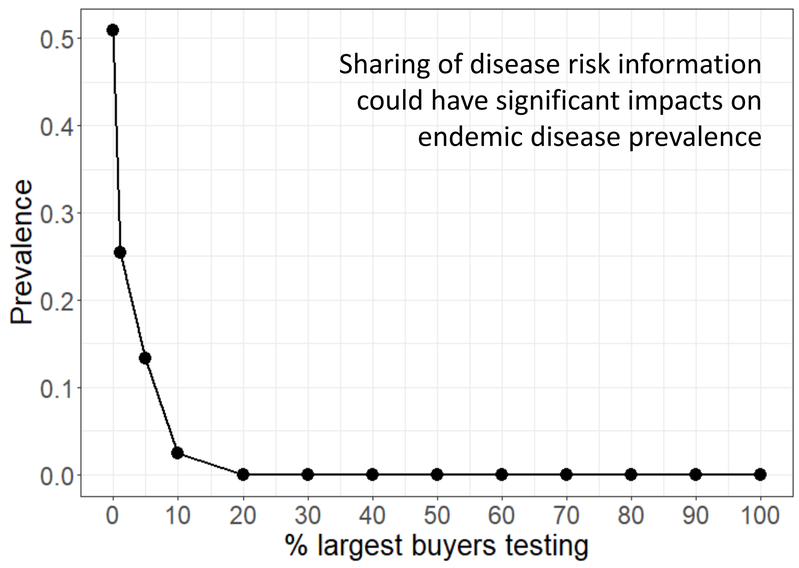
Leveraging trade to supplement standard disease control measures



- Our model captures farm-level adaptation of trade patterns in response to controls that restrict trade frequency.
- In the context of endemic disease control, these adaptations undermine the effectiveness of controls.
- However, in combination with "traditional" interventions, e.g. post-movement batch testing and improved on-farm biosecurity, trading adaptations assist these controls.
- Leading to outsized reductions in prevalence.

Potential impact of sharing disease risk information

- We model farm-level adaptive trading behaviour in response to obtaining disease risk of selling farms.
- Can lead to rapid removal of disease if all farms comply.
- However, targeting controls onto a small number of large farms achieves similar benefits to the whole system.



Future work

- Investigate the potential for trading health schemes to control endemic disease.
- In particular, the dynamics of scheme growth, barriers for farm uptake, and critical sizes for schemes to succeed.
- Consider how our general approach to modelling complex systems, and the dynamic behaviours of individuals, can be applied to address issues in other complex real-world systems.

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Collaborations

This work is being done with collaborators Ross Davidson and Mike Hutchings from SRUC.
Under project *"Achieving improvements in the health of Scottish livestock through increased uptake of biosecurity practices"*, this model is being applied to assess the effectiveness of the Premium Cattle Health Scheme, an in-operation health scheme, in controlling paratuberculosis in cattle.