

**Update: Modeling transmission of  
bovine tuberculosis in Uruguay using  
dynamic cattle movement networks -  
A potential model for the US**

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# Bovine TB in Minnesota, 2005-2009



- Identified in cow at slaughter plant
  - 12 infected beef cattle herds
  - 27 free-ranging deer
- Source and transmission
  - All but 2 herds connected through known cattle movements
  - *M. bovis* in positive cattle and deer linked to isolates from cattle in SW US and Mexico



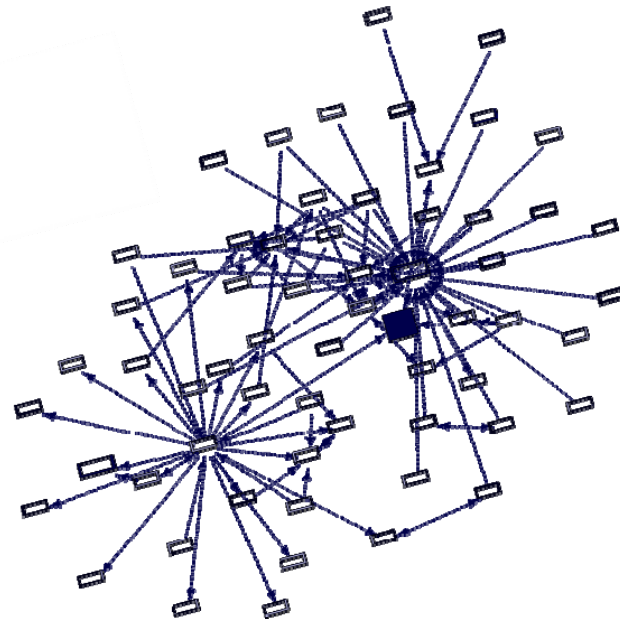
# Bovine TB surveillance

- Limitations
  - Slaughter surveillance only: 5 year delay in detection of infected herds (Fischer, 2005)
  - Impossible to perform cost-effective TB testing in all herds
- **How to target surveillance?**
  - Focus on the strata of the population more likely to have a case of disease as a consequence of their risk profile
  - Cattle movements
    - 90% of purchased cattle in index herd in 2005 MN BTB outbreak originated in other states (Shaw, 2008)
    - Number of cattle introductions and origin of trace-in cattle are known risk factors for Bovine TB (APHIS, 2009)



# How evaluate cattle movement data as risk for disease transmission?

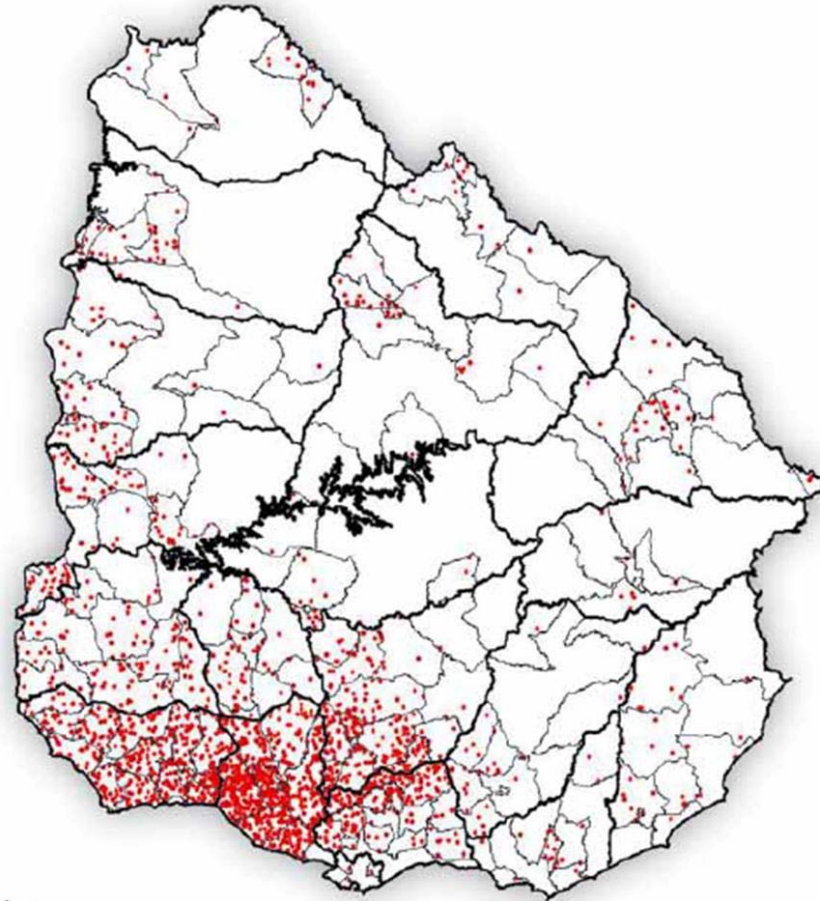
- Social Network Analysis uses **graph theory** and the **social science** of interactions
- A network of contacts is represented by a graph with “*nodes*” (individuals) connected by “*edges*” (contacts or movements)
- Model the **contact structure** of population based on **behavior** of individuals



# Uruguay

- Complete, electronic-based animal traceability system for cattle.
- Since 2011, all cattle uniquely identified with electronic ear tag ID.
- Every cattle movement recorded by date, number animals by type, origin, destination.
- Since 2005, cattle movement database complete and electronically available.

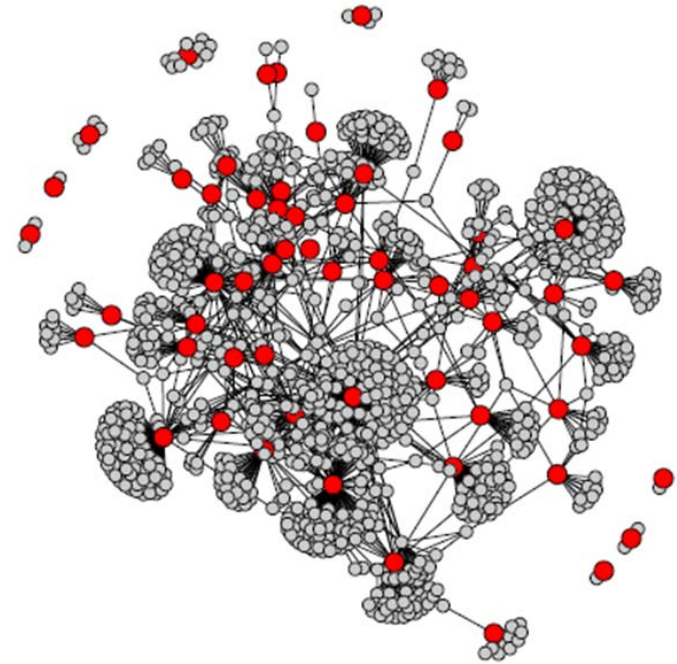
## Uruguayan dairy herds (2011)





# Study objectives

- 1) Identify Bovine TB risk factors including herd-specific factors and between-herd interactions.
- 2) Develop simulation model of spread of Bovine TB within and between cattle herds.
- 3) Assess cost-effectiveness of targeted surveillance strategies for early detection of Bovine TB in cattle herds.



Network of *M. bovis*-infected farms and their immediate connections in Uruguay



# Risk factors for Bovine TB in Uruguayan dairy herds

(C. Picasso, MS thesis, University of MN)

Variable	Category (N)	OR	95% CI	P-value
<b>Herd size (# cattle)</b>	<116 (76)	1.00		
	116-360 (73)	5.79	1.58-21.21	0.008
	>360 (79)	14.38	4.06-50.90	<0.001
<b>Incoming steers</b>	No (198)	1.00		
	Yes (30)	2.88	1.12-7.37	0.027
<b>Total incoming cattle (# cattle moved)</b>	≤1 (79)	1.00		
	>1-≤44 (71)	0.77	0.29-2.06	0.608
	>44 (78)	1.90	0.81-4.44	0.138

No significant two-way interactions



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# Modeling infectious diseases

- Why use dynamic epidemiologic models?
  - Represent “simplified” dynamics of system
  - Understand variability of epidemic outcomes due to stochasticity
  - Help determine plausibility of epidemiologic explanations and predict impact of changes to the system
- How develop simulation model?
  - Within-farm transmission dynamics captured by age-structured stochastic SORI model with a 1-mo. time step
  - Between-farm transmission
    - Local spatial spread modeled using a transmission kernel with exponential decay
    - Cattle movement modeled using a dynamic contact network

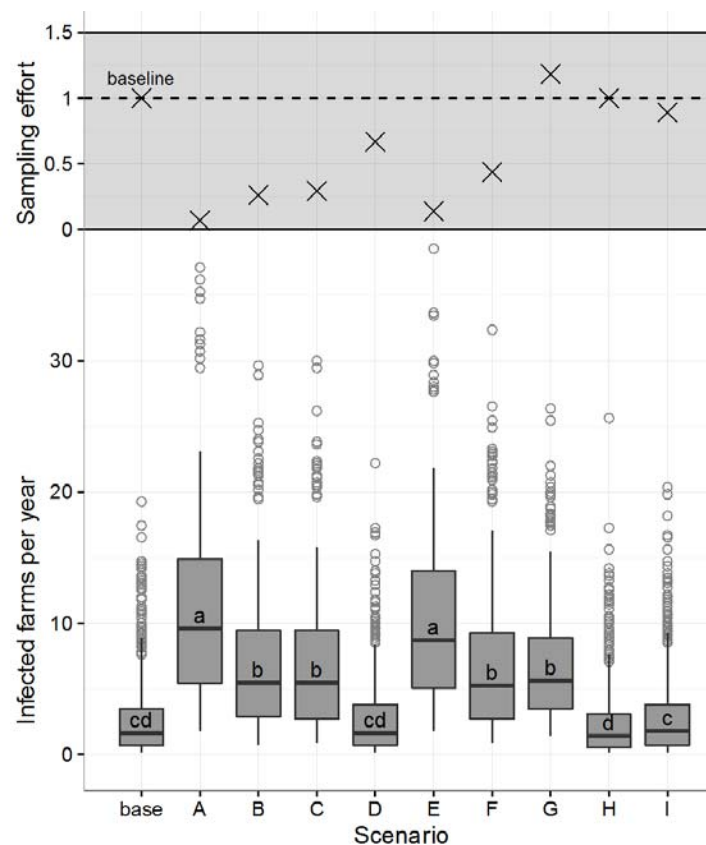


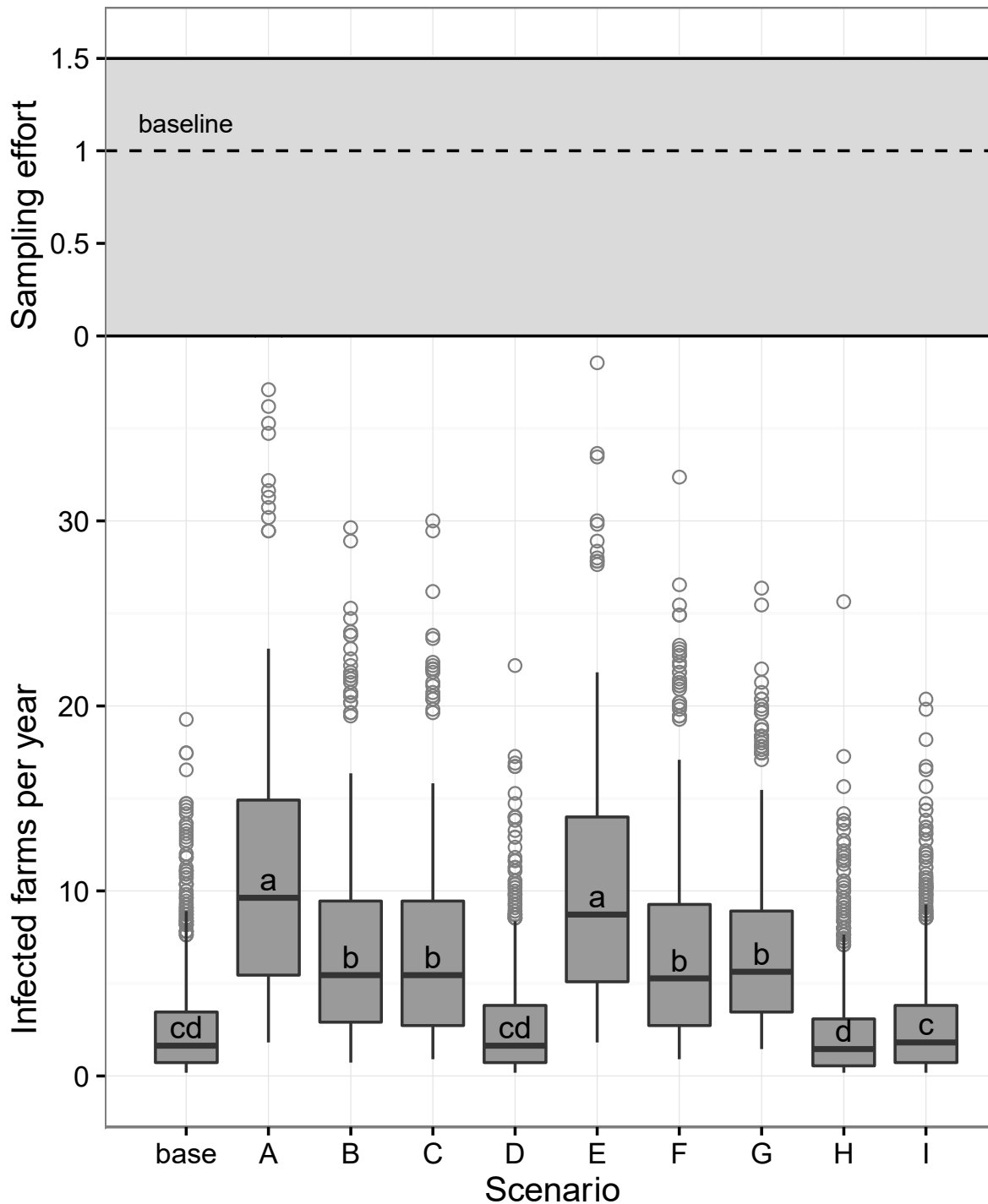


# Cost-effectiveness of surveillance strategies for bovine TB in Uruguay

VanderWaal et al.

Scenario	Type	Size criteria	Movement criteria	Description of farms tested annually
Baseline	Dairy	---	---	All dairies
A	Dairy	>360 &	>44	High risk by size AND movements
B	Dairy	>115 &	>1	Med/High risk by size AND movements
C	Dairy	>360 OR	>44	High risk by size OR movements
D	Dairy	>115 OR	>1	Med/High risk by size OR movements
E	Dairy	>360	---	High risk by size
F	Dairy	>115	---	Med/High risk by size
G	All		Top 10 <sup>th</sup> percentile	High risk by movement
H	Dairy	---	---	Improved slaughter surveillance (10%)
I	annual	Dairy >115 OR	>1	Scenario D + all dairies every other year
	biennial	Dairy ---	---	





- Scenarios D, H, and I resulted in similar epidemic sizes as baseline strategy

- Scenario D (targeting moderate to high risk farms by herd size and movements) required ~40% fewer farms to be sampled

# Next steps

- Adapt Uruguay model for US context
- Use Uruguay model to test assumptions necessary for US adaptation
  - Uncertainty about movements



# United States - Limited Cattle Movement Data

- Simulated farm movements
  - FLAPS: farm location and farm size
  - USDA county level cattle movement data
  - NAHMS dairy and beef cow-calf survey data
- Simulate bovine TB spread with simulated cattle movement
  - Evaluate strategies for bovine TB surveillance



# United States – County Level Movement

- Simulated county-level network from Lindström et al., 2013



County-level in movements  
to Minnesota

County-level out movements  
from Minnesota





# Conclusions

- From location with movement data available (Uruguay)
  - Cattle movements key risk factor for disease spread
  - Relaxing surveillance on low-risk farms would reduce testing effort with no apparent increase in number of infected farms
- From location without movement data available (US)
  - Work currently ongoing



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