Agri-Food and Biosciences Institute

SHAPING LIVESTOCK FARMING FOR 2030

Dr Andrew Byrne

AFBI

www.afbini.gov.uk

What has veterinary epidemiology ever done for us?

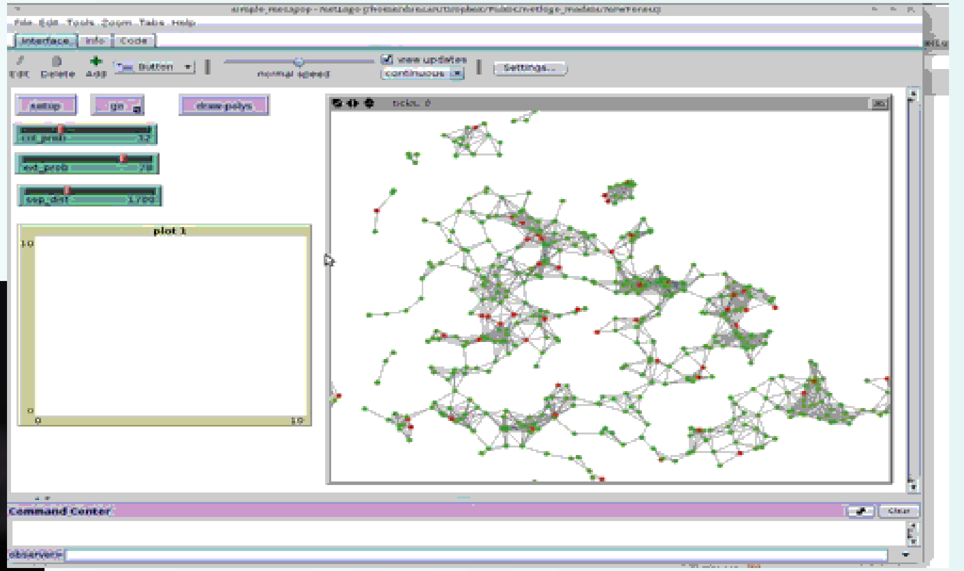
The impact of epidemiological science in helping to understand the patterns of the present to plan for the future

Dr. Andrew Byrne

Agri-Food and Biosciences Institute

Veterinary Epidemiology – What is it?

- Veterinary epidemiology is concerned with the patterns and processes driving infection across animal populations.



"Concerned with quantifying risk, and forms an evidence base for understanding and controlling disease effectively."

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Veterinary Epidemiology
– how does it impact disease control?

- Works with different stakeholders to provide evidence base

The state

Test performance

Evidence:
Does a commercial test work well?

Farmers

Biosecurity risk

Evidence:
How best can I mitigate risk?

Consumers

Food chain risk

Evidence:
Should I be worried about this product?

Veterinary Epidemiology
– how does it impact disease control?

The state
Test performance

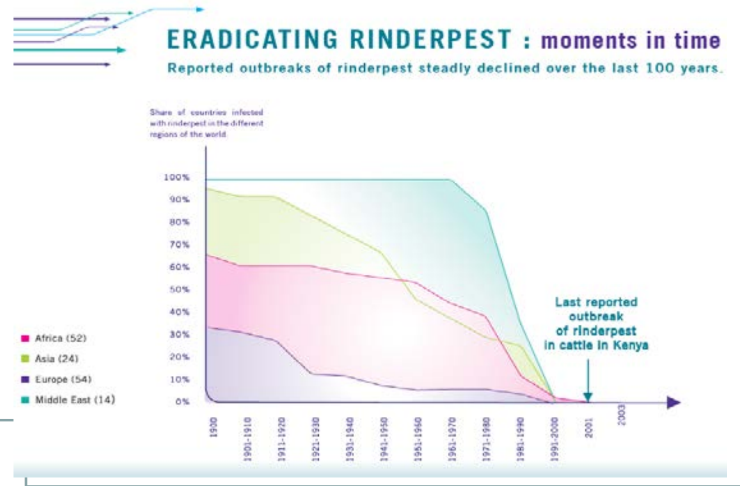
Farmers
Biosecurity risk

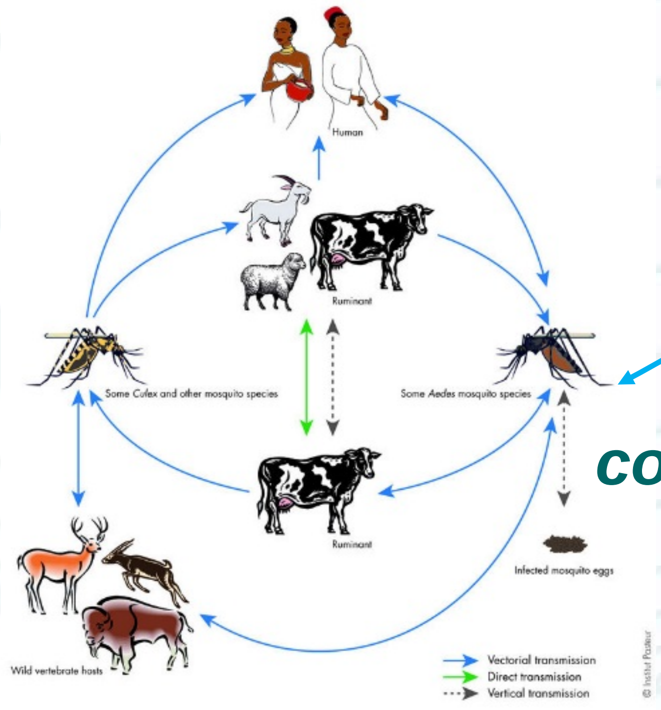
Consumers
Food chain risk

National responses

Global efforts

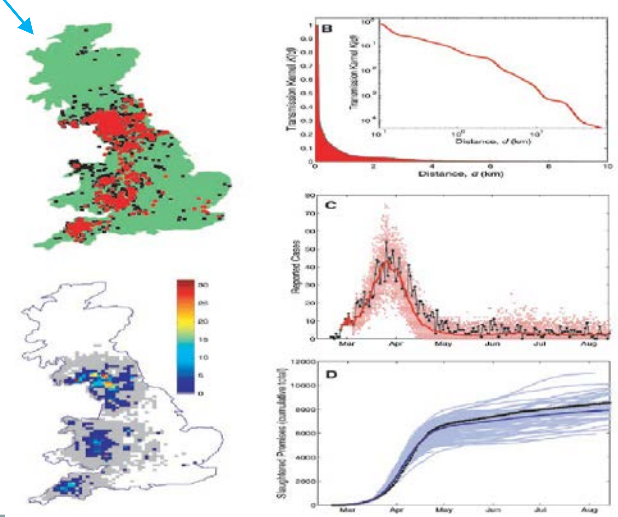
Global success Rinderpest (OIE)



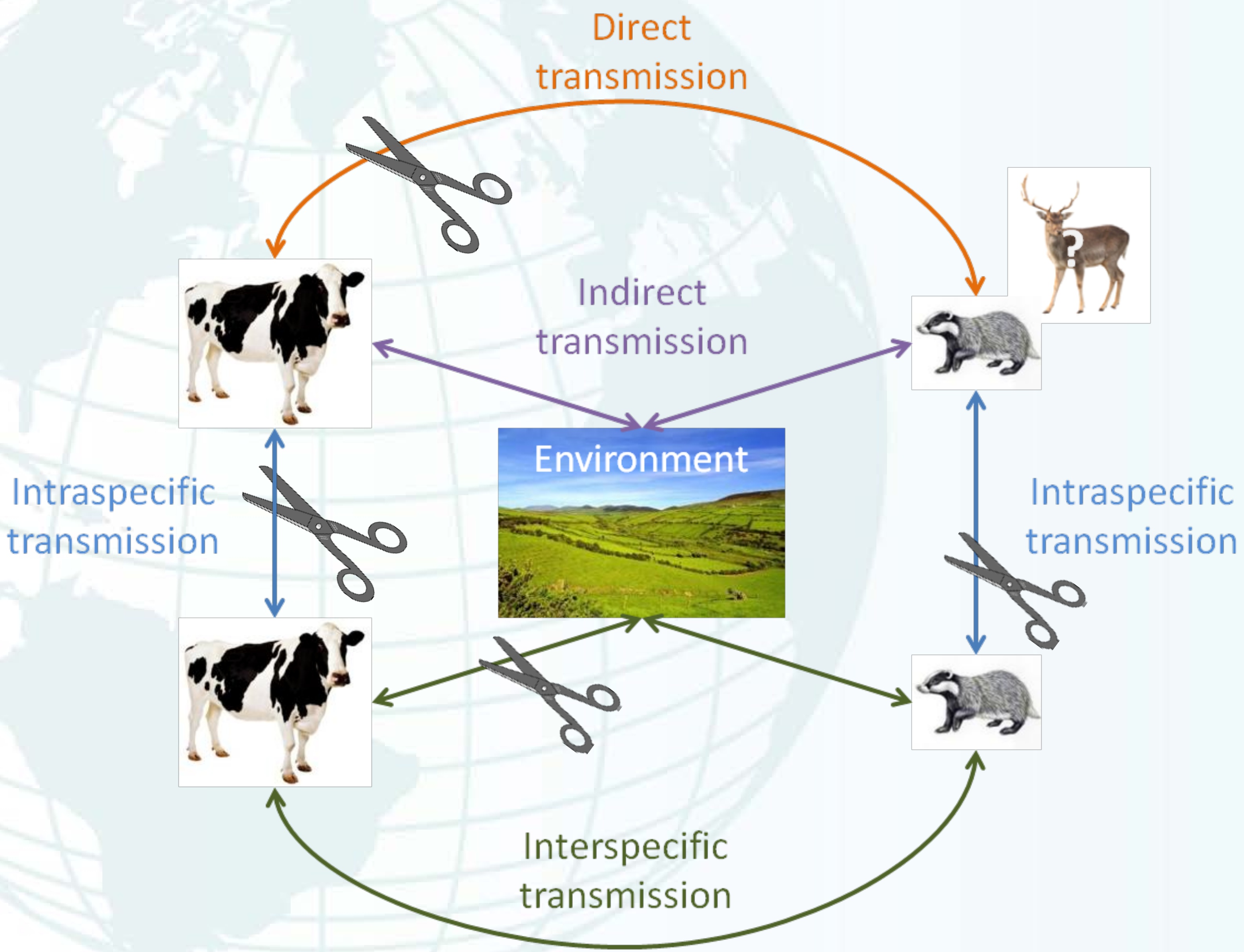


Local coordination

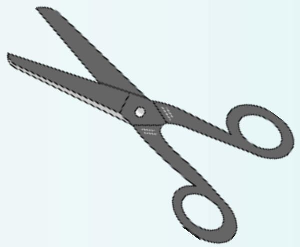
Designing interventions, tracking transmissions (Keeling et al. 2001)



Veterinary Epidemiology – Bovine TB



Cut transmission chains
– requires <u>evidence</u> and <u>tools</u>



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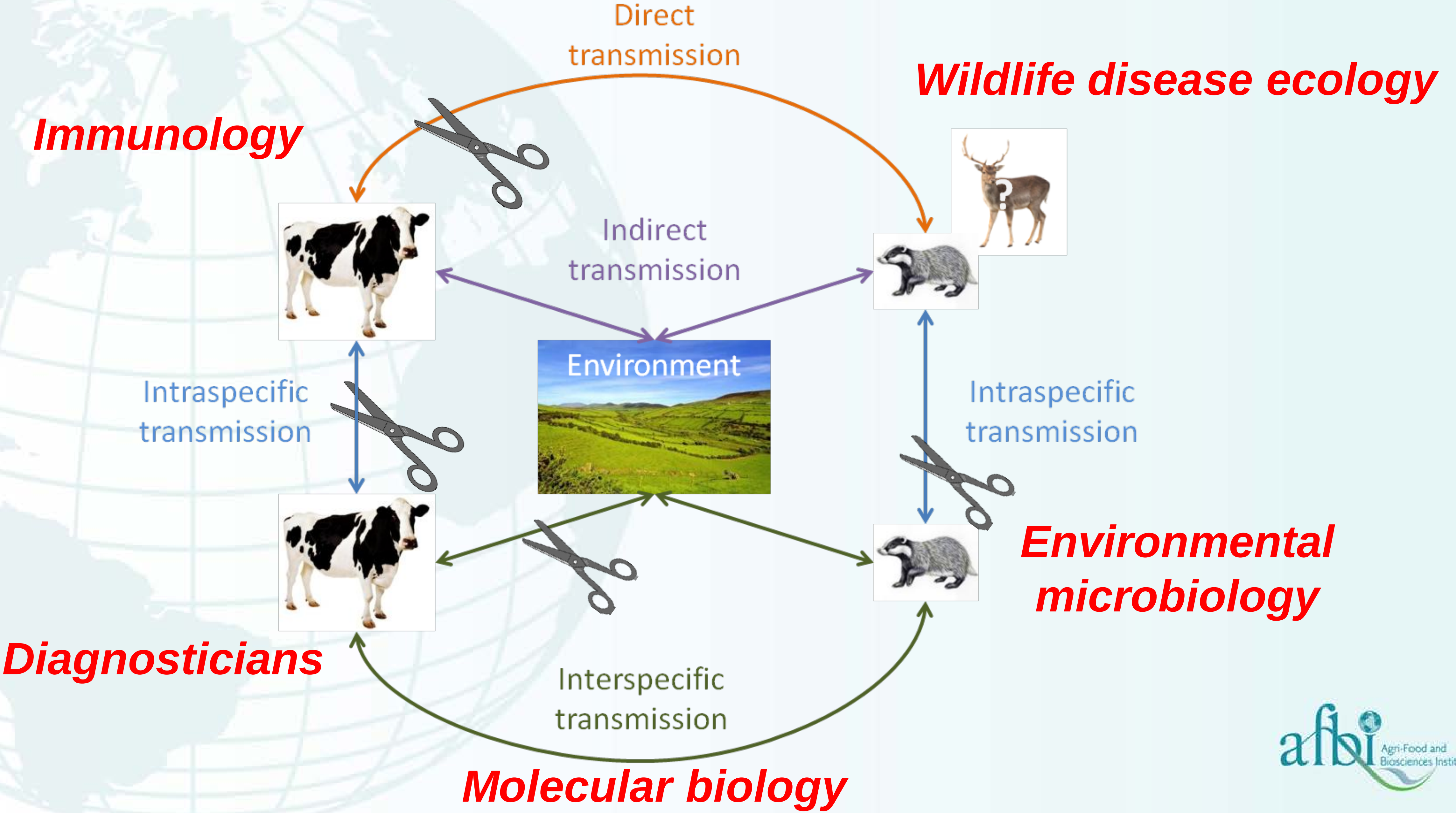
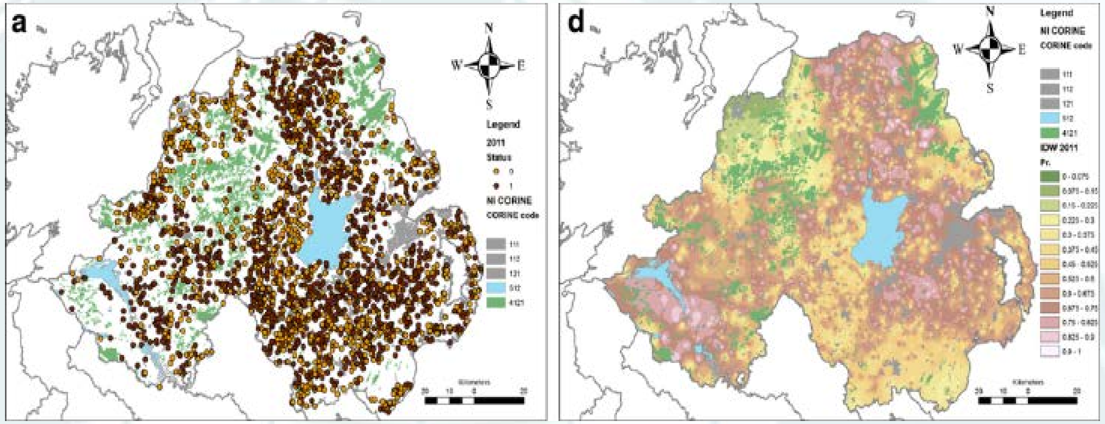
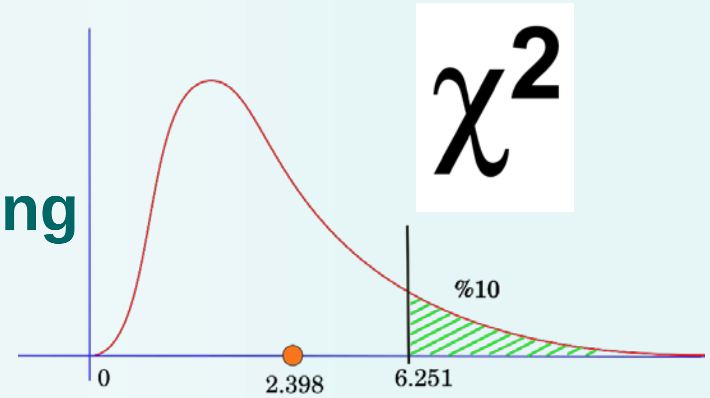
Veterinary Epidemiology – Bovine TB



Veterinary Epidemiology – Research base NI, the tools





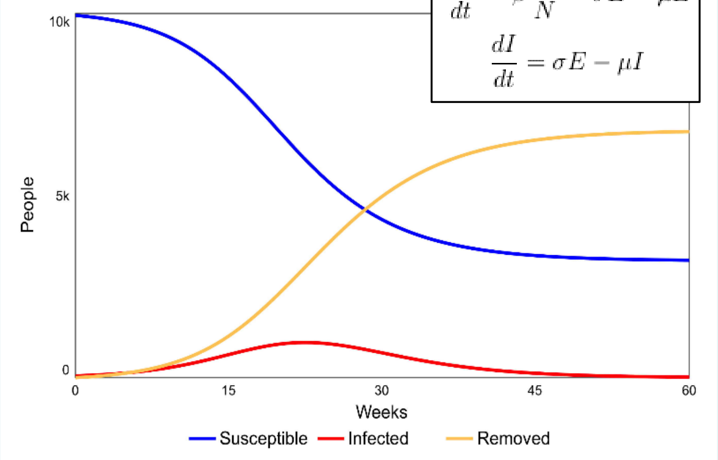
Statistical modelling

Mathematical modelling

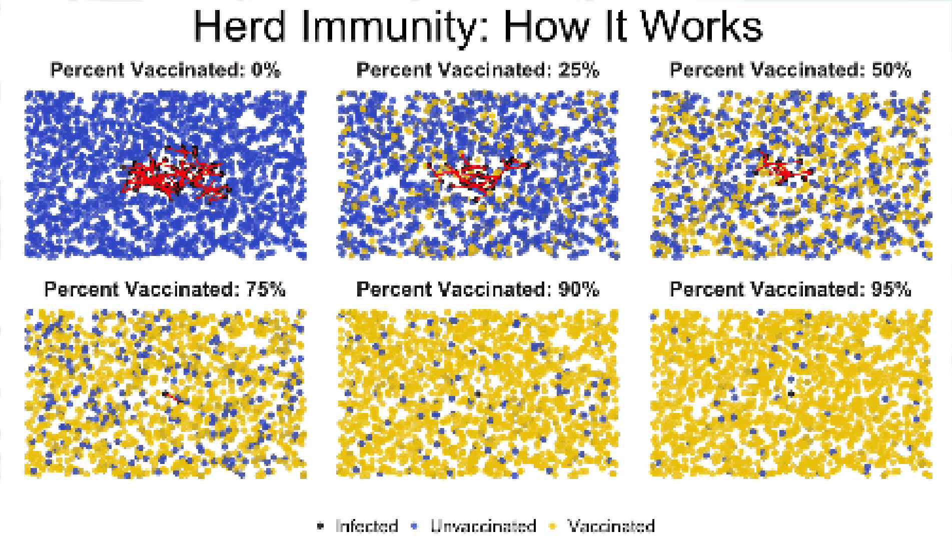
$$\frac{dS}{dt} = v - \beta\frac{SI}{N} - \mu S$$

$$\frac{dE}{dt} = \beta\frac{SI}{N} - \sigma E - \mu E$$

$$\frac{dI}{dt} = \sigma E - \mu I$$



GeoSpatial modelling



Simulation modelling

Qualitative epidemiology

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Veterinary Epidemiology – Research base NI, the tools
χ^2
Statistical modelling
Mathematical modelling
Geo-Spatial modelling
Simulation modelling
Herd Immunity: How It Works
Networks
Co-infection
Wildlife
Tools
Chronic herds
Test evaluation
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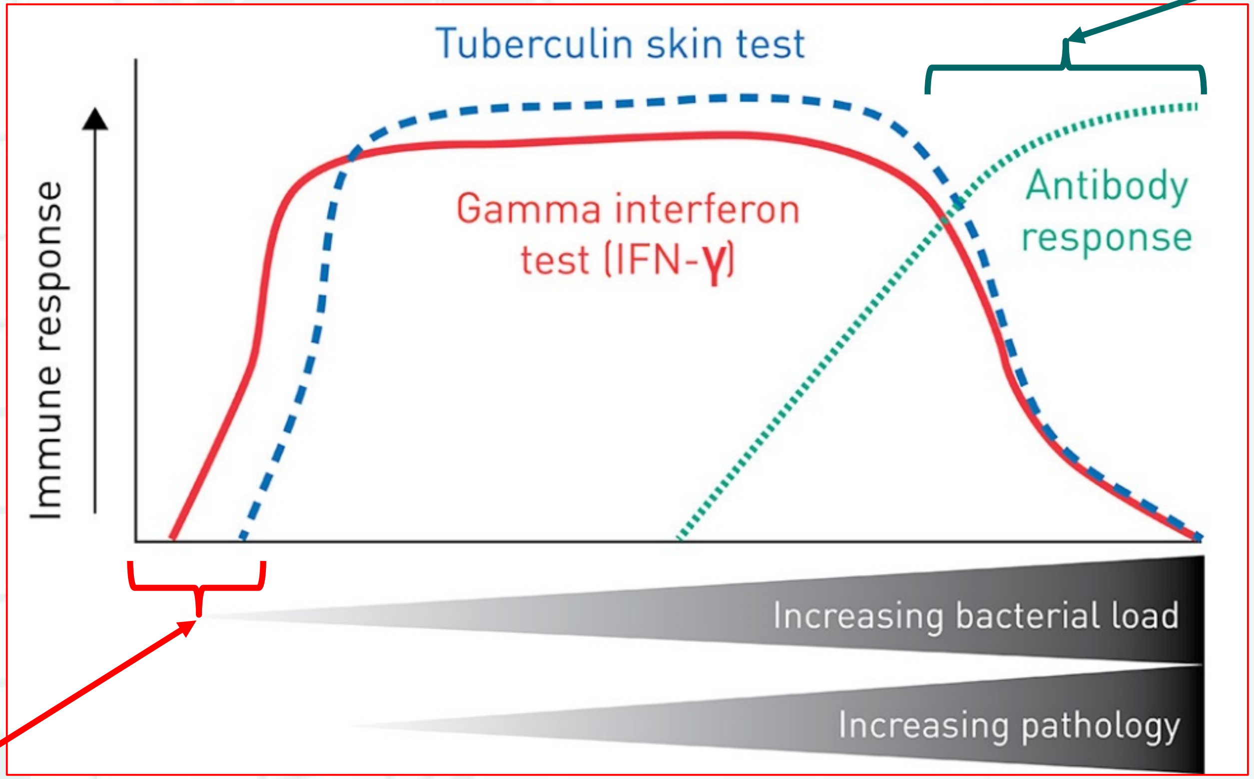
Veterinary Epidemiology – diagnosis

Anergic animals = serological (antibody) tests



Early responders

Time

Pollock and Neill 2002

McCallan et al. 2017a & 2017b
Lahuerta-Marin et al. 2015, 2016, 2018 (in review)

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Veterinary Epidemiology – diagnosis

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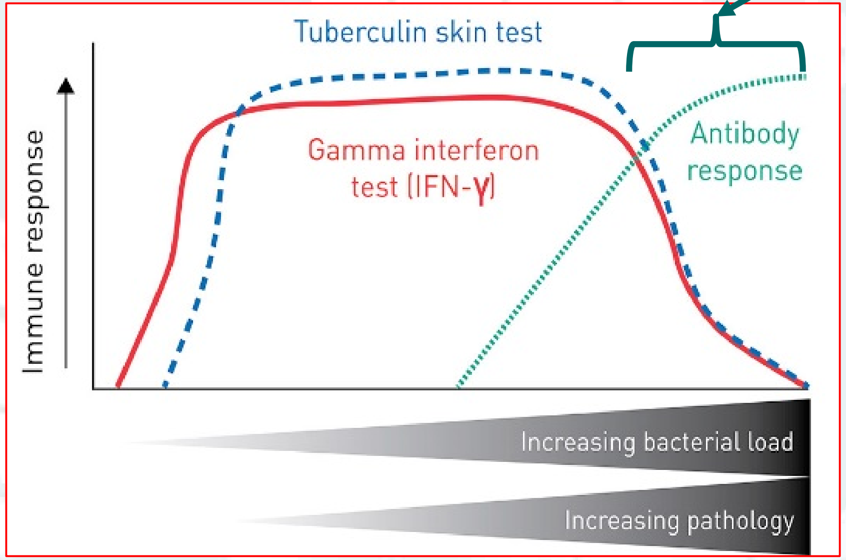
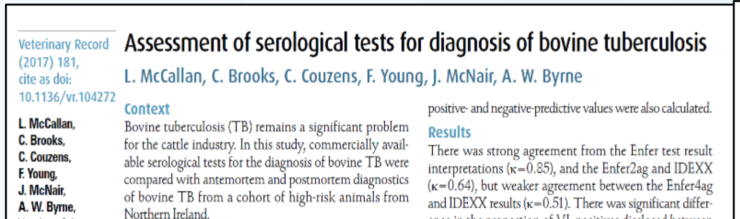


Time

- Two ‘flavours’ of **ENFER test** – undertaken blind in ENFER labs (ROI)
  - Enfer2ag (positive to either MPB70, MPB83 antigens) or
  - Enfer4ag (positive to two from four of the following antigens: MPB70, MPB83, Early secretory antigenic target-6 (ESAT-6), Culture filtrate protein-10 (CFP10))
- **IDEXX** – standalone kit, undertaken in-house: MPB70, MPB83 antigens

Assessment of “commercially available” **serological tests**

McCallan et al. 2017a & 2017b


Veterinary Record (2017) 181, cite as doi: 10.1136/vr.104272

Assessment of serological tests for diagnosis of bovine tuberculosis

L. McCallan, C. Brooks, C. Couzens, F. Young, J. McNair, A. W. Byrne

L. McCallan, C. Brooks, C. Couzens, F. Young, J. McNair, A. W. Byrne,

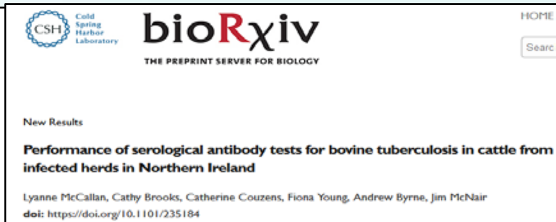
Context

Bovine tuberculosis (TB) remains a significant problem for the cattle industry. In this study, commercially available serological tests for the diagnosis of bovine TB were compared with antemortem and postmortem diagnostics of bovine TB from a cohort of high-risk animals from Northern Ireland.

positive- and negative-predictive values were also calculated.

Results

There was strong agreement from the Enfer test result interpretations (κ=0.85), and the Enfer2ag and IDEXX (κ=0.64), but weaker agreement between the Enfer4ag and IDEXX results (κ=0.51). There was significant differ-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New Results

Performance of serological antibody tests for bovine tuberculosis in cattle from infected herds in Northern Ireland

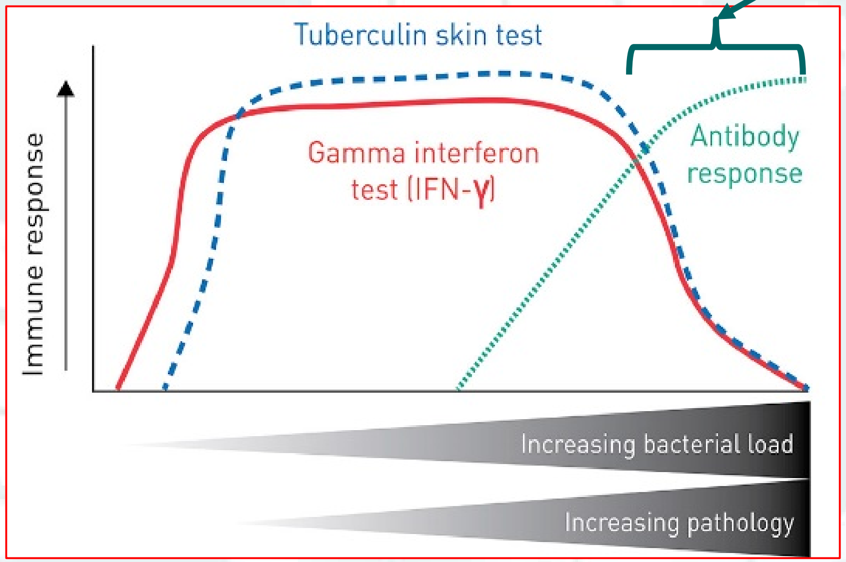
Lyanne McCallan, Cathy Brooks, Catherine Couzens, Fiona Young, Andrew Byrne, Jim McNair

doi: https://doi.org/10.1101/235184

Veterinary Epidemiology – diagnosis

Anergic animals = serological (antibody) tests

- *Results*
- High specificity, but **variable/low SE** – especially when blood samples taken prior to skin testing

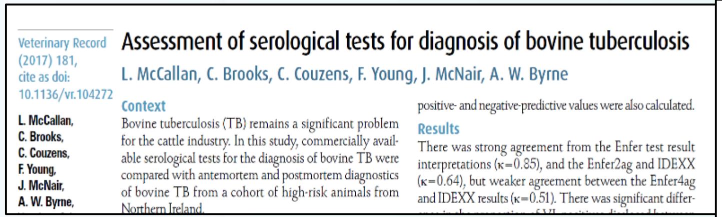


Time

*"When INF-g & skin test used together – serology testing was **not** disclosing additional infected animals"*

Assessment of "commercially available"
serological tests

McCallan et al. 2017a & 2017b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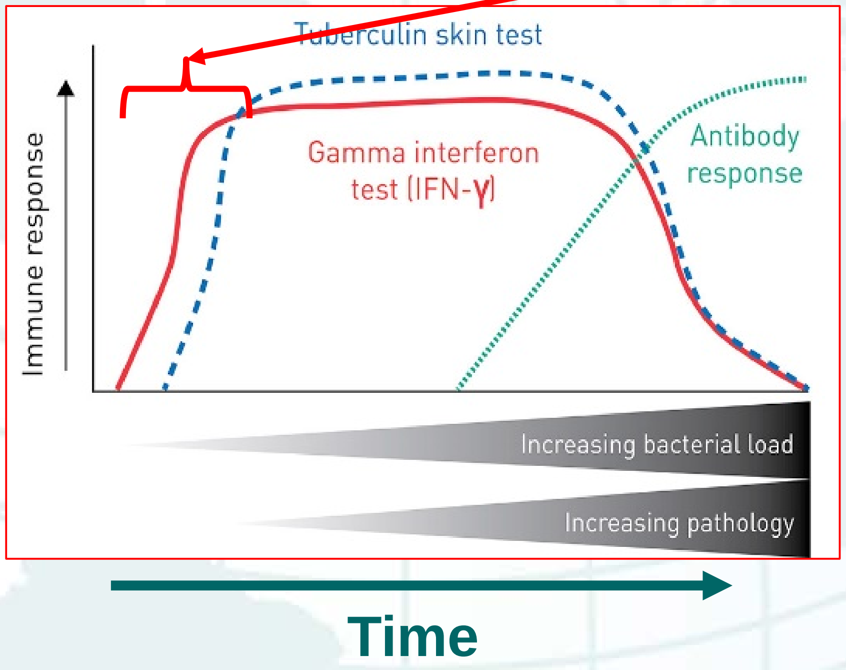
Veterinary Epidemiology – diagnosis

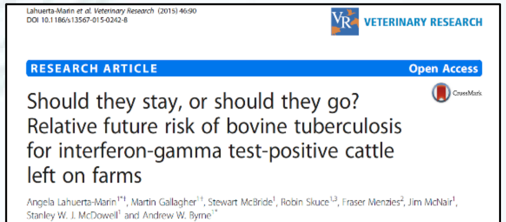
Early responders
= gamma+, SCITT-

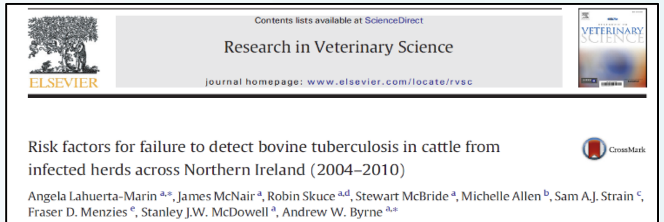


Assessment of INF-g to find early infection

- Followed herds which retained animals that were INF-g positive, but SCITT negative
- Survival model
- 1107 IFN-g positive animals from 239 herds

Lahuerta-Marin et al. 2015, 2016,


Lahuerta-Marin *et al. Veterinary Research* (2015) 46:90
DOI 10.1186/s13567-015-0242-8
VETERINARY RESEARCH
RESEARCH ARTICLE Open Access
Should they stay, or should they go? Relative future risk of bovine tuberculosis for interferon-gamma test-positive cattle left on farms
Angela Lahuerta-Marin[1*†], Martin Gallagher[1†], Stewart McBride[1], Robin Skuce[1,3], Fraser Menzies[2], Jim McNair[1], Stanley W. J. McDowell[1] and Andrew W. Byrne[1*]


Contents lists available at ScienceDirect
Research in Veterinary Science
journal homepage: www.elsevier.com/locate/rvsc
ELSEVIER
Risk factors for failure to detect bovine tuberculosis in cattle from infected herds across Northern Ireland (2004–2010)
Angela Lahuerta-Marin [a,*], James McNair [a], Robin Skuce [a,d], Stewart McBride [a], Michelle Allen [b], Sam A.J. Strain [c], Fraser D. Menzies [e], Stanley J.W. McDowell [a], Andrew W. Byrne [a,*]

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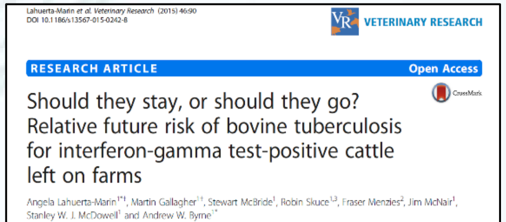
Veterinary Epidemiology – diagnosis

INF-g+ animals were **<u>2.3 times</u>** more likely to fail a future TB test ($p<0.05$), than IFN-g negative herd-mates

- @ 18 months **22.6% for IFN-g positive animals versus 6.1% for IFN-g negative animals had failed the SICCT**
- **Parallel use of SCITT and IFN-g tests together resulted in the least missed infections**

Lahuerta-Marin et al. 2015, 2016,



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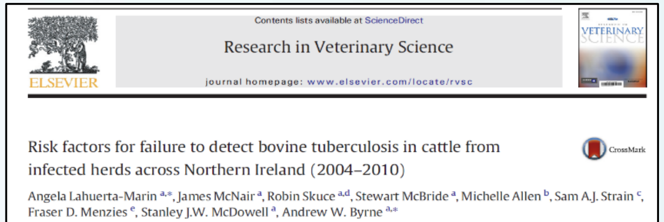

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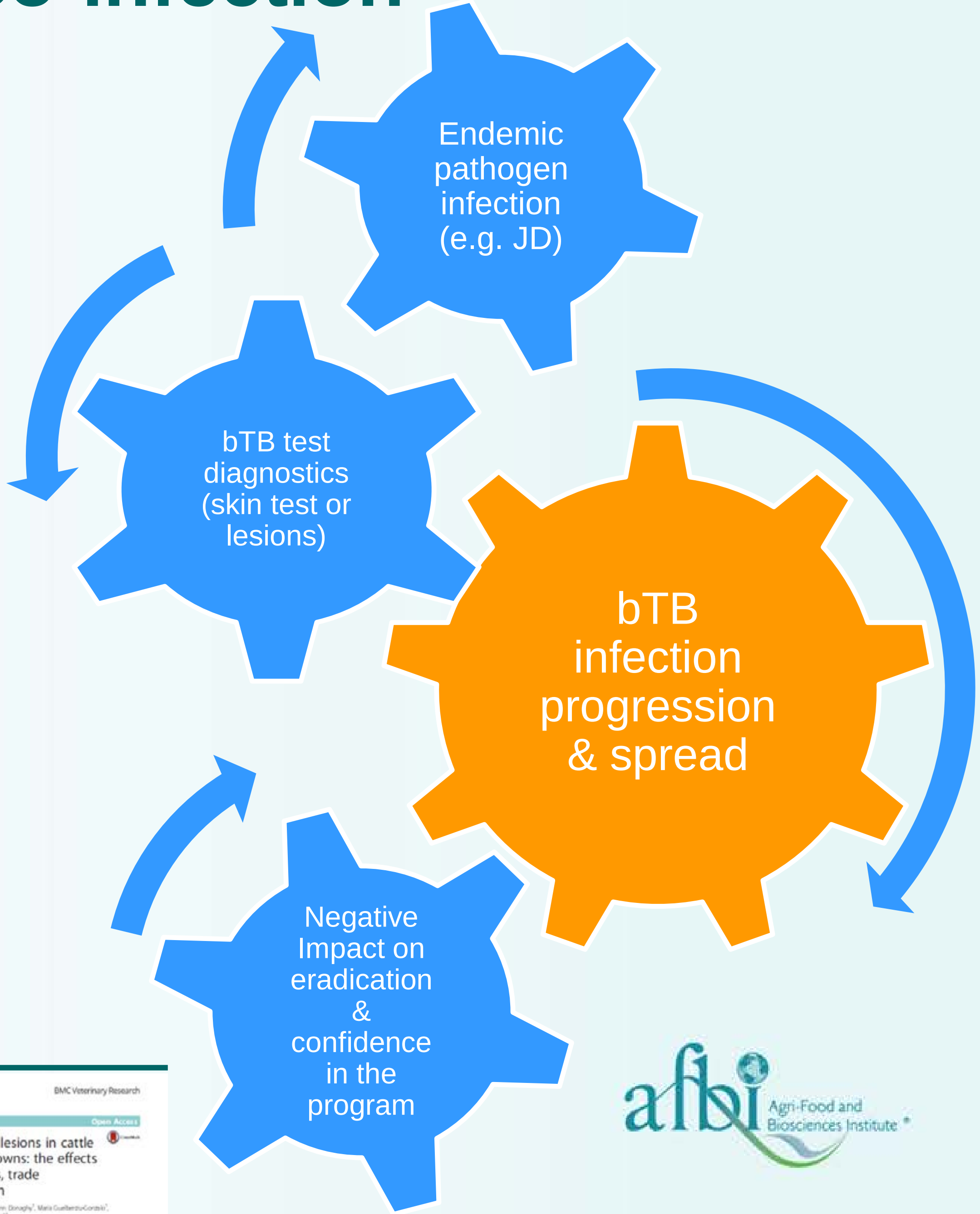
Veterinary Epidemiology – co-infection

- Co-infection can modulate immunological responses
  - Impact on diagnostics
  - Exacerbate infection
- Some data on the potential impacts in bTB in all three pathogens of interest
  - BVDV
    - Liver fluke
      - Johne's Disease




Byrne et al. Parasites & Vectors (2016) 9:209
DOI 10.1186/s13071-016-1489-2

Parasites & Vectors

RESEARCH Open Access

Liver fluke (*Fasciola hepatica*) infection in cattle in Northern Ireland: a large-scale epidemiological investigation utilising surveillance data

Andrew W. Byrne*, Stewart McBride, Angela Lahuerta-Marin, Maria Guelbenzu, Jim McNair, Robin A. Skuce and Stanley W.J. McDowell

Preventive Veterinary Medicine

Assessment of concurrent infection with bovine viral diarrhoea virus (BVDV) and *Mycobacterium bovis*: A herd-level risk factor analysis from Northern Ireland

A.W. Byrne, M. Guelbenzu-Gonzalo, S.A.J. Strain, S. McBride, J. Graham, A. Lahuerta-Marin, R. Harwood, D.A. Graham, S. McDowell

Received: 9 August 2017
DOI: 10.1111/tbed.12814

ORIGINAL ARTICLE WILEY

Modelling the variation in skin-test tuberculin reactions, post-mortem lesion counts and case pathology in tuberculosis-exposed cattle: Effects of animal characteristics, histories and co-infection

A. W. Byrne[1,2] | J. Graham[1] | C. Brown[1] | A. Donaghy[1] | M. Guelbenzu-Gonzalo[1] | J. McNair[1] | R. A. Skuce[1,2] | A. Allen[1] | S. W. McDowell[1]

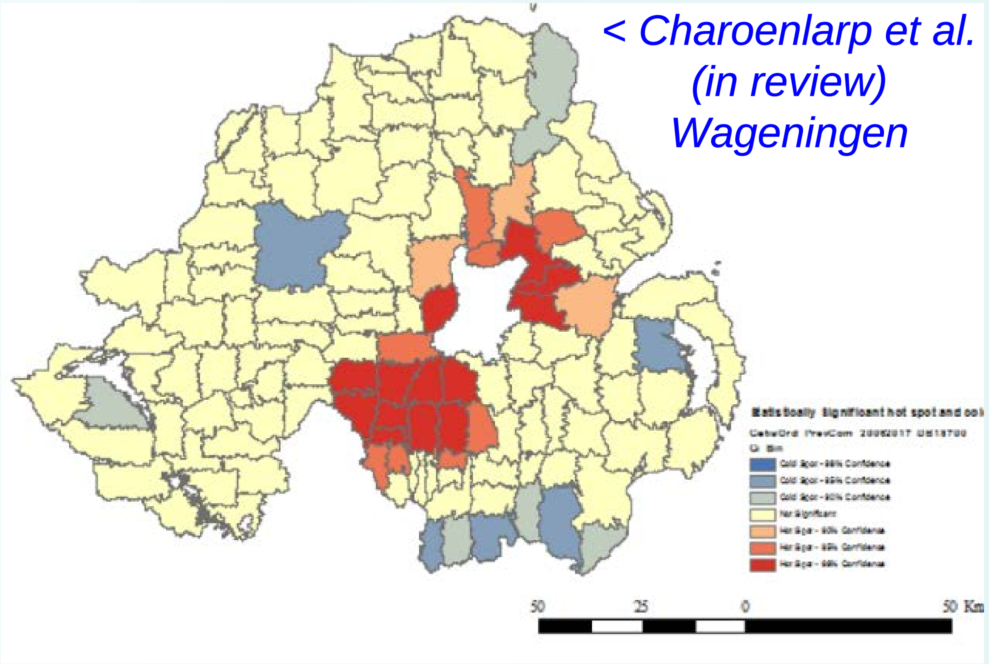
BMC Veterinary Research

RESEARCH ARTICLE Open Access

Bovine tuberculosis visible lesions in cattle culled during herd breakdowns: the effects of individual characteristics, trade movement and co-infection

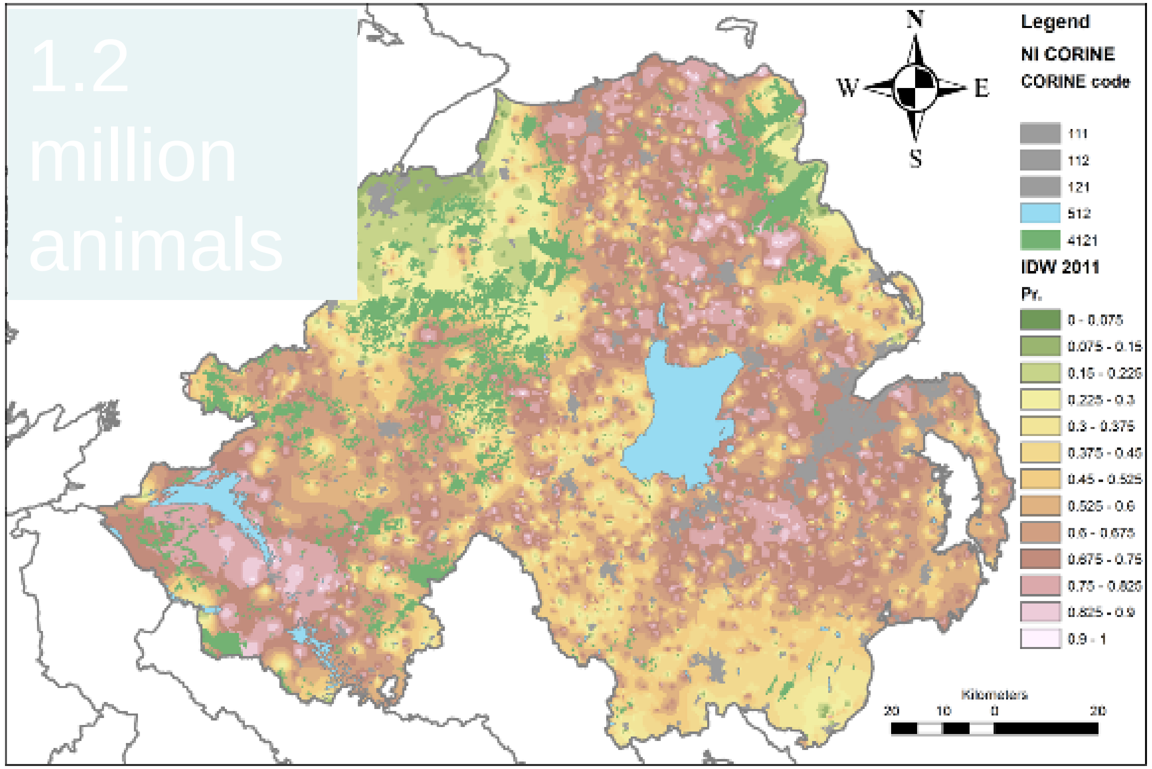
Co-infection

Veterinary Epidemiology – co-infection



< *Charoenlarp et al. (in review) Wageningen*

- Highlight spatial epidemiology of **BVD** and **Liver fluke**



- Fluke – co-infection (N=6242) associated with **smaller TB lesions size and lower lesion counts**
- Co-infection reducing confirmation probability? Undermining skin test interpretation?

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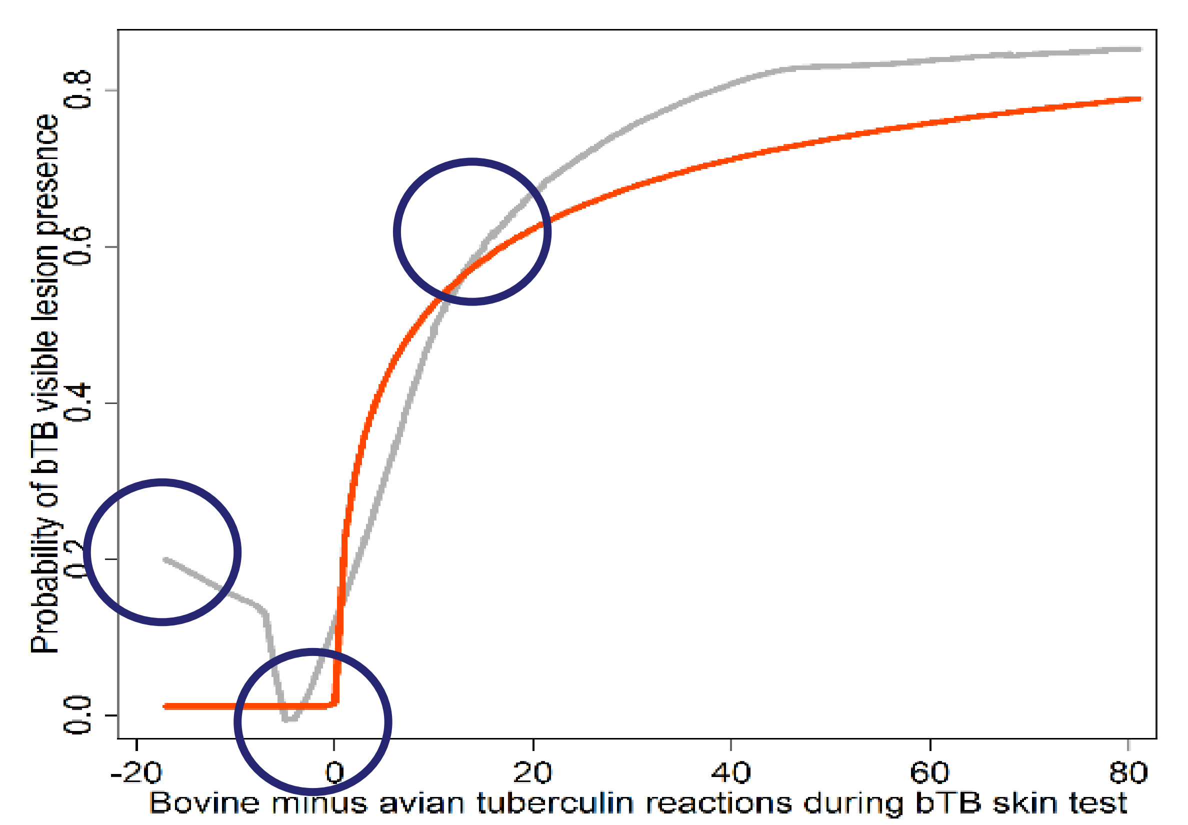
Co-infection

Veterinary Epidemiology – co-infection

- Retrospective animal-level assessment Johne's disease co-infection
  - "Avian reactors" – negative B-A tuberculin
  - Confirmation (VL) probability vs non-reactors (b-a=0)



- **Avian reactors higher risk of being missed** when infected (n=6,242) reactors/NICs

Byrne et al. BMC Veterinary Research (2017) 13:400
DOI 10.1186/s12917-017-1321-z
BMC Veterinary Research
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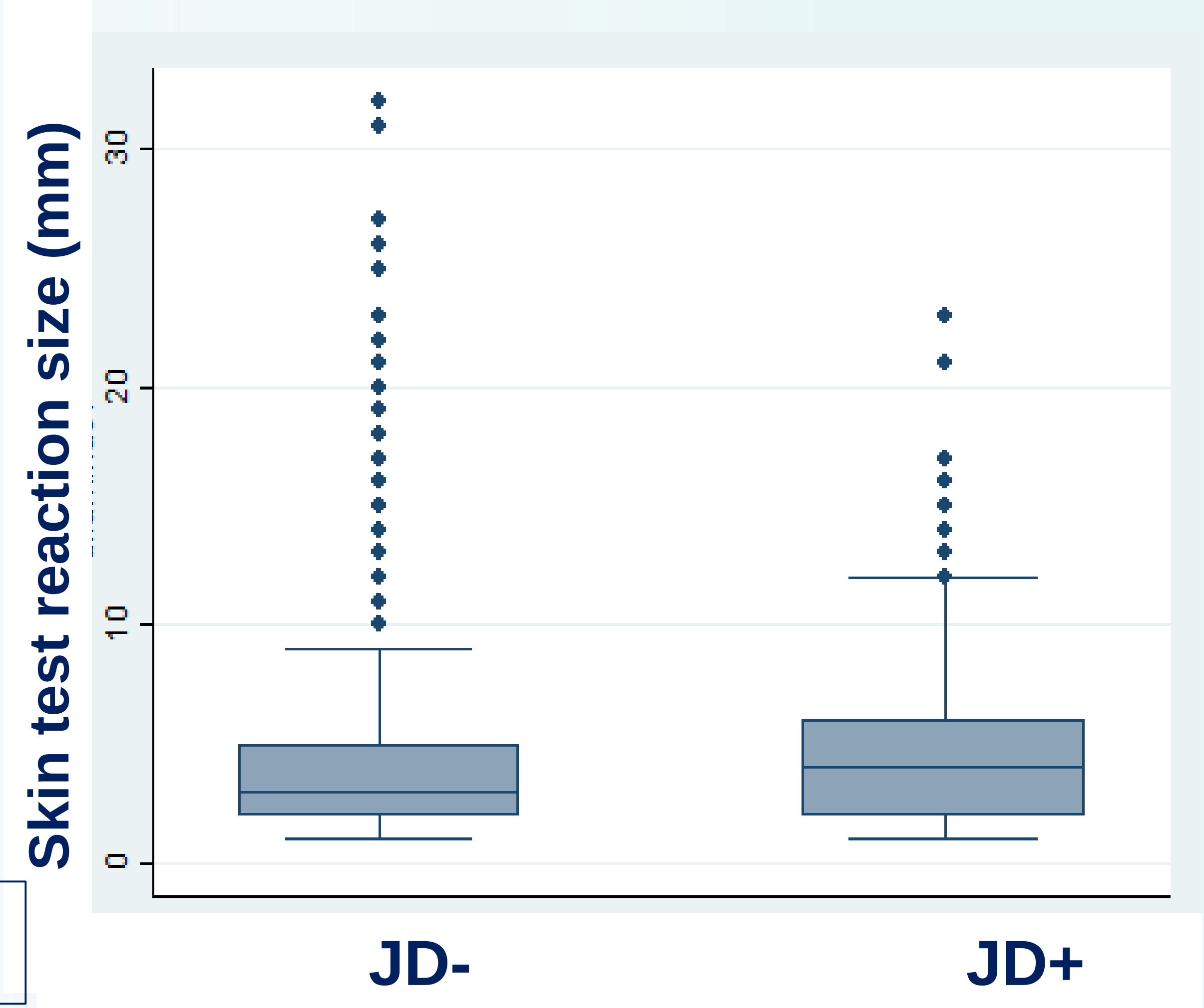
Veterinary Epidemiology – co-infection

Co-infection

- **Avium reactions were also higher for Johnes Disease ELISA+** (p<0.001)



MAP effects bTB diagnosis

Lahuerta-Marin et al. unpublished

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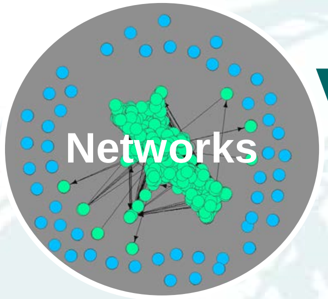
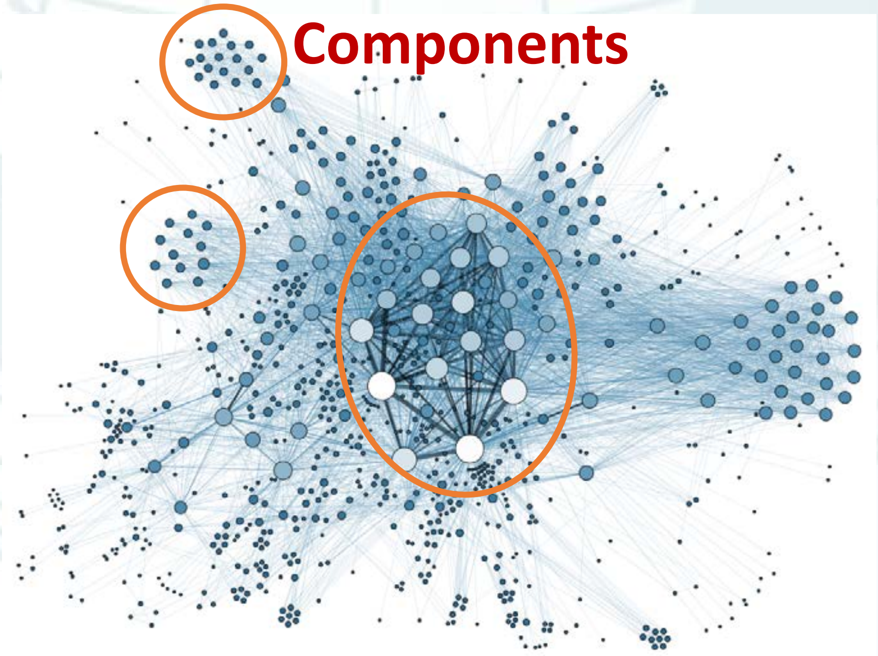
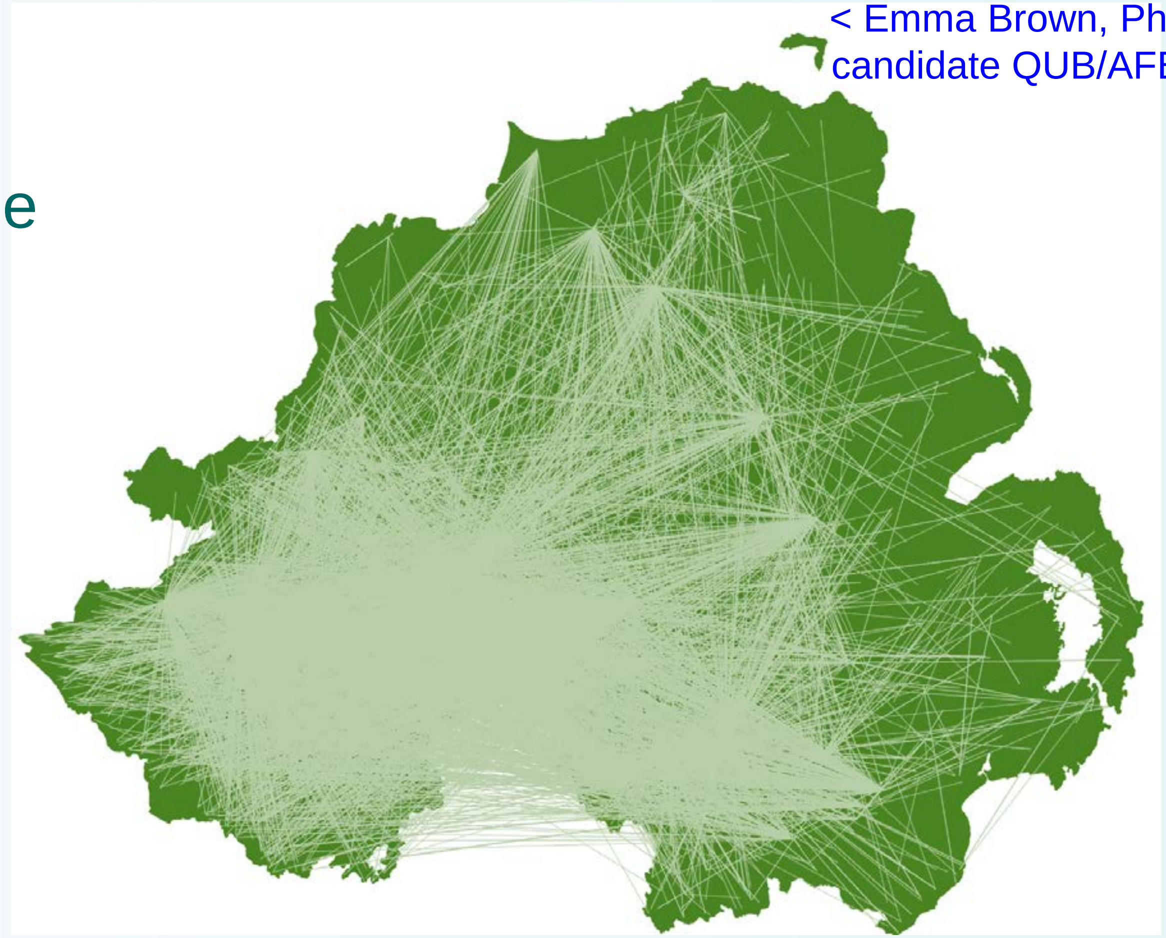


Veterinary Epidemiology – Movement networks

- Movement of animals is important for disease spread
- Movement can be modelled using **social network analysis** – farms are "nodes", trade/moves are "edges" connecting nodes





< Emma Brown, PhD candidate QUB/AFBI

AFBI working on visualising network & mapping

QUEEN'S UNIVERSITY BELFAST

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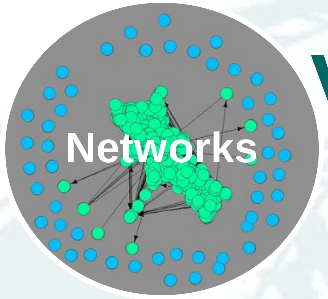
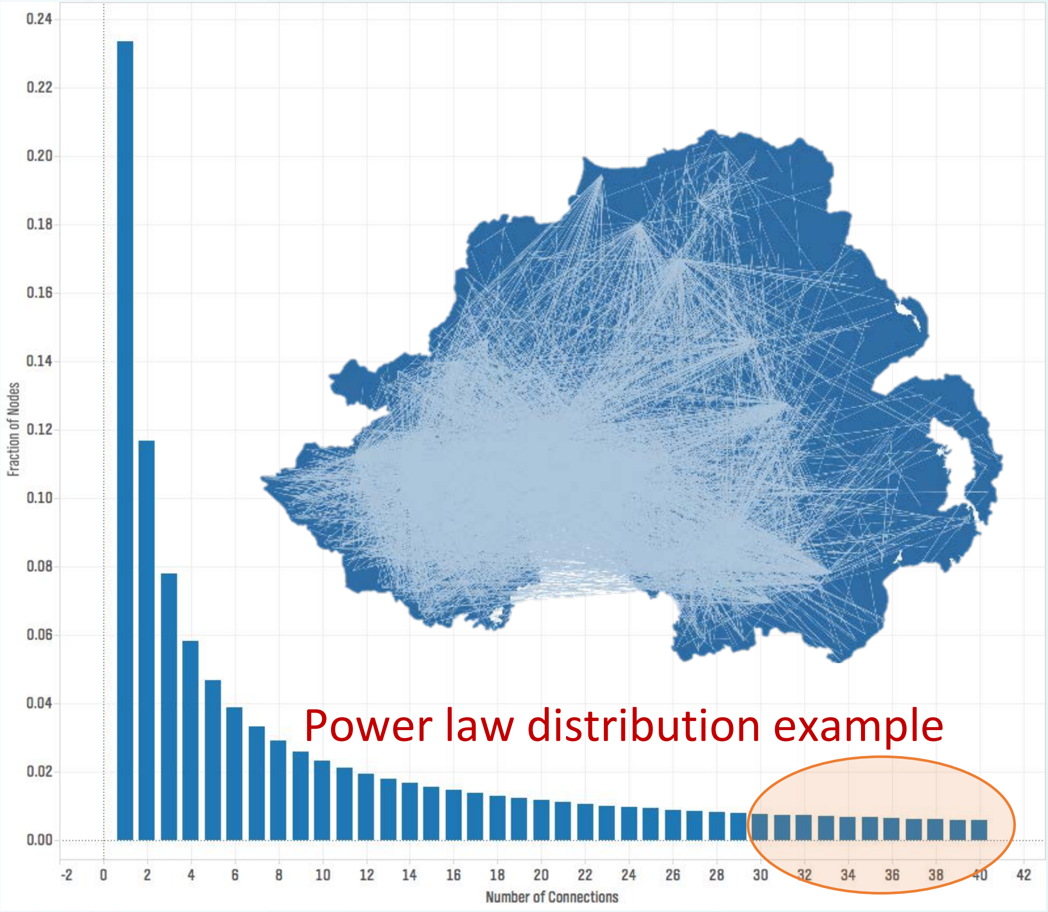


Veterinary Epidemiology – Movement networks

- Network modelling constitute a ***<u>‘big data’</u>*** challenge

- For example, **21,963,941 movements** in the database for **6,154,451 cattle** over the 10 year period



“Not all nodes are equal!”

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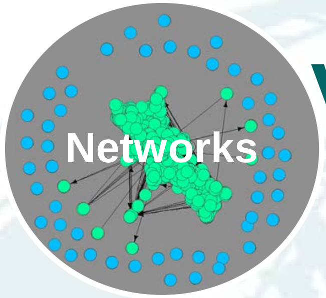
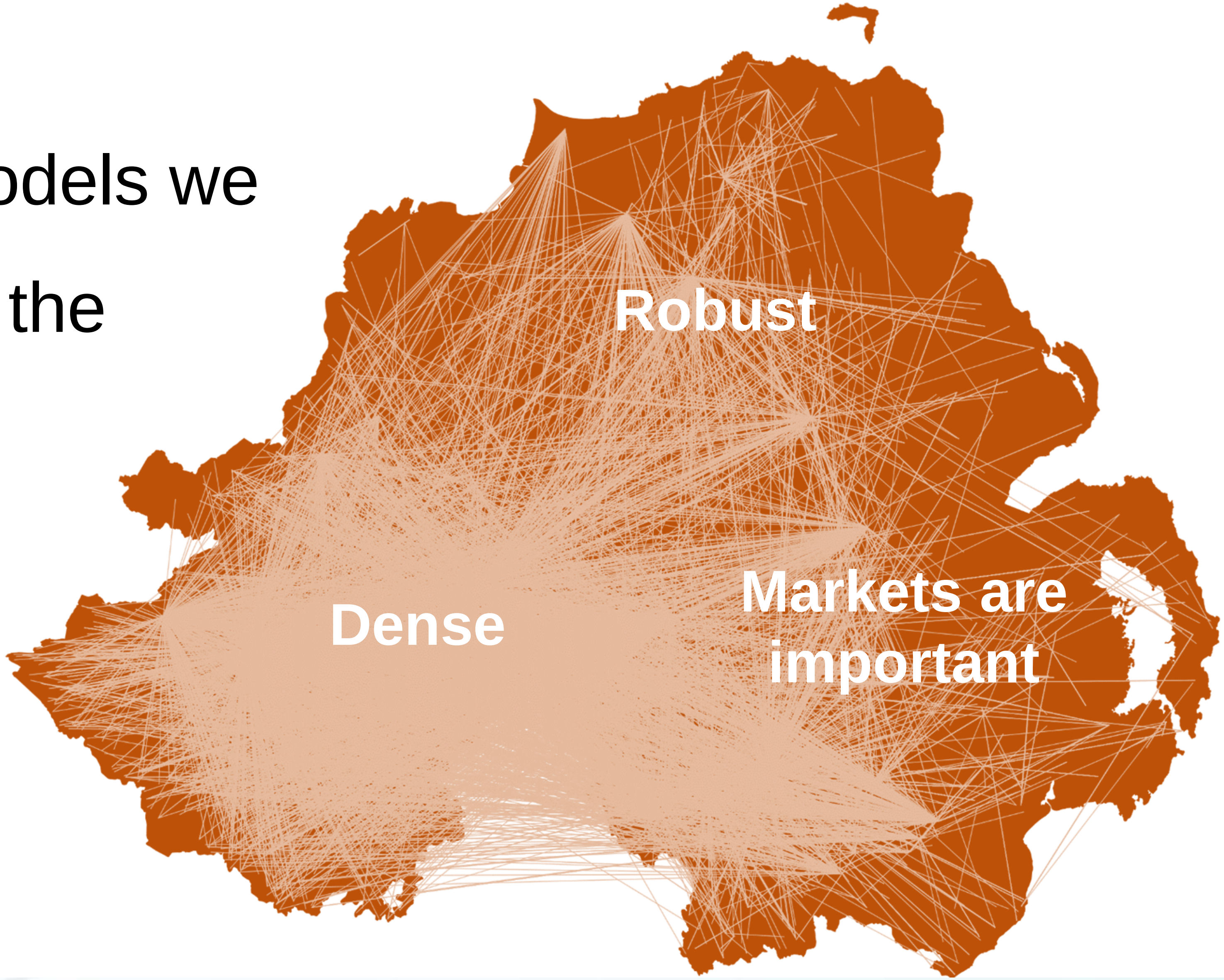


Veterinary Epidemiology – Movement networks

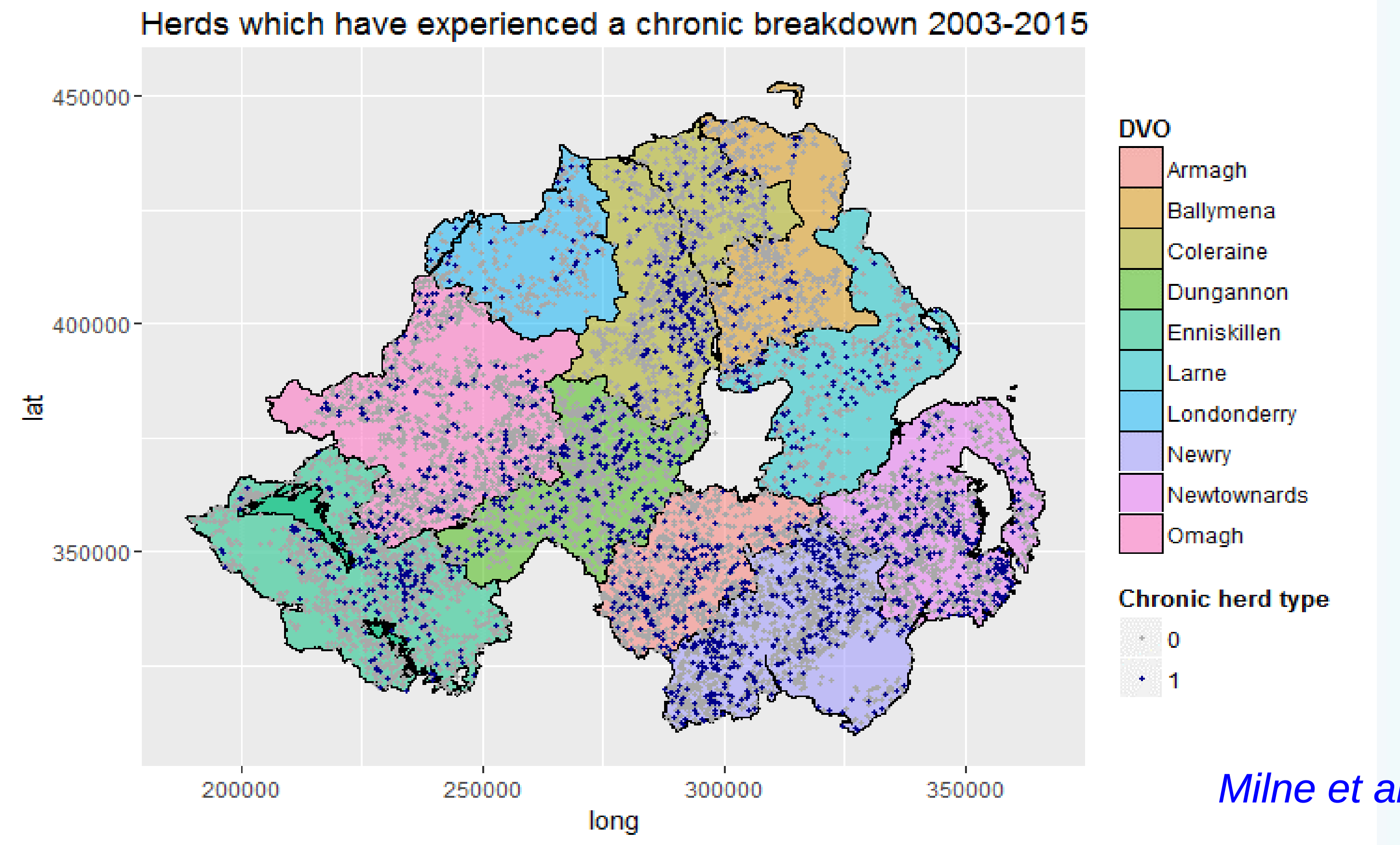
From our models we learned that the network is…



Veterinary Epidemiology – Chronic herds

"The majority of reactors in Northern Ireland come from a small amount of herd"

These herds are characterised as having long or recurrent breakdowns - ***chronic herds***



We addressed two questions?

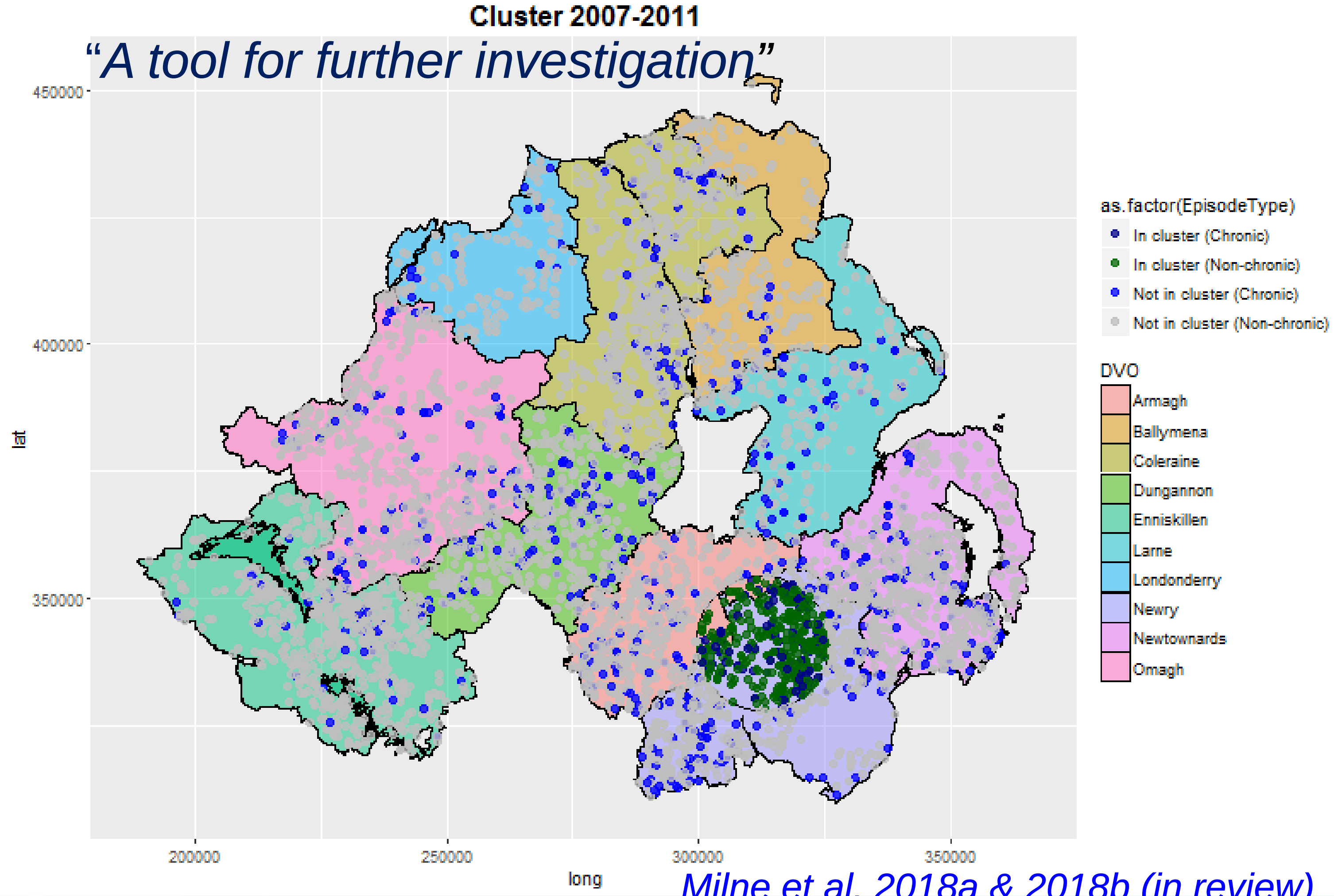
What risk factors are associated with "chronicity"?

Are there spatial clusters in space and time?

Milne et al. 2018a & 2018b (in review)

Veterinary Epidemiology – Chronic herds

“A tool for further investigation”



Milne et al. 2018a & 2018b (in review)

<u>We addressed two questions?</u>

1. Are there spatial clusters in space and time?

Answer: Yes!

Mapping of genotypic strains of *M. bovis* suggested movement from outside “home range” may be important

Purchasing strategy is important for managing risk

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Veterinary Epidemiology – Chronic herds

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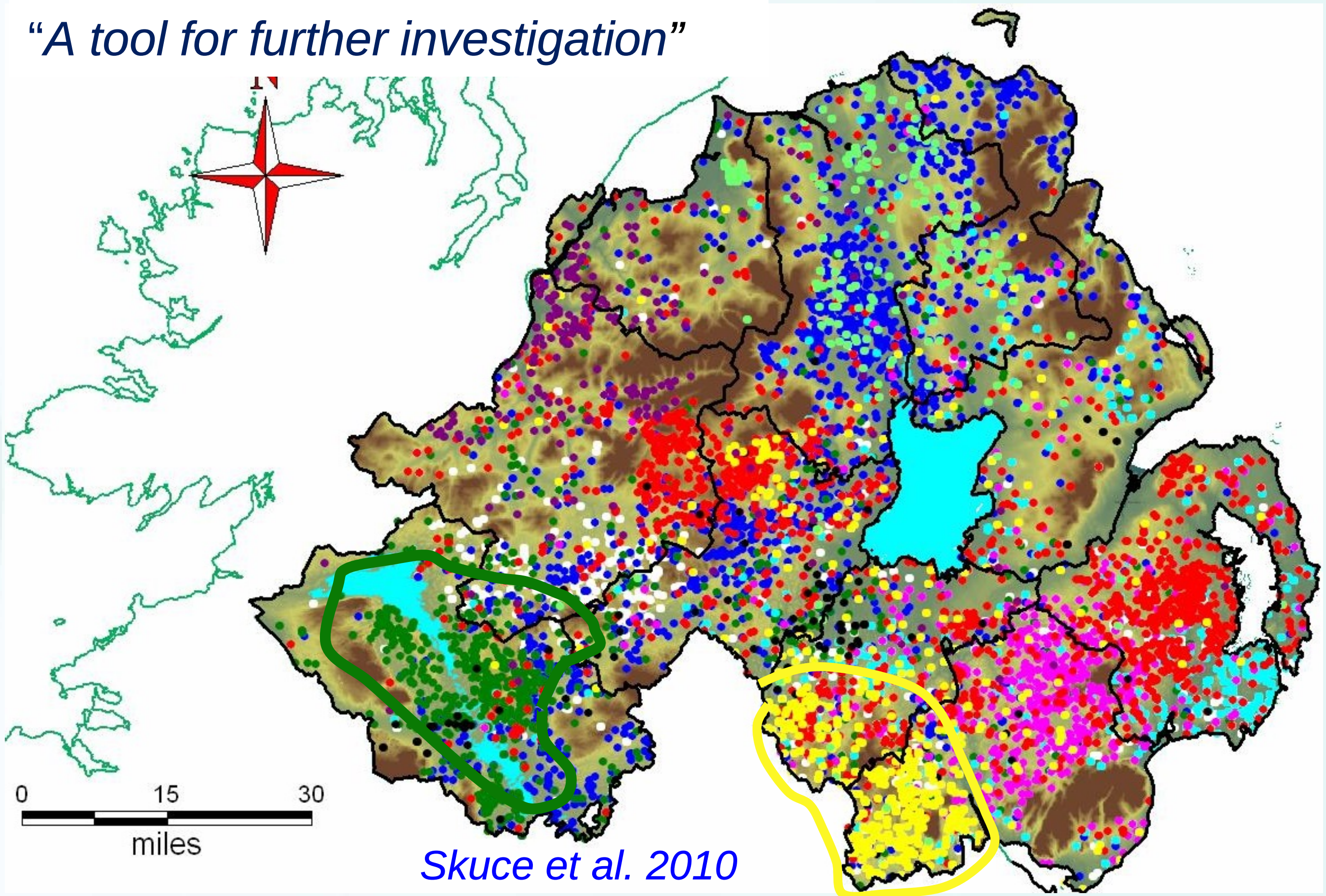
"A tool for further investigation"



Skuce et al. 2010

Milne et al. 2018a & 2018b (in review)

Purchasing strategy is important for managing risk

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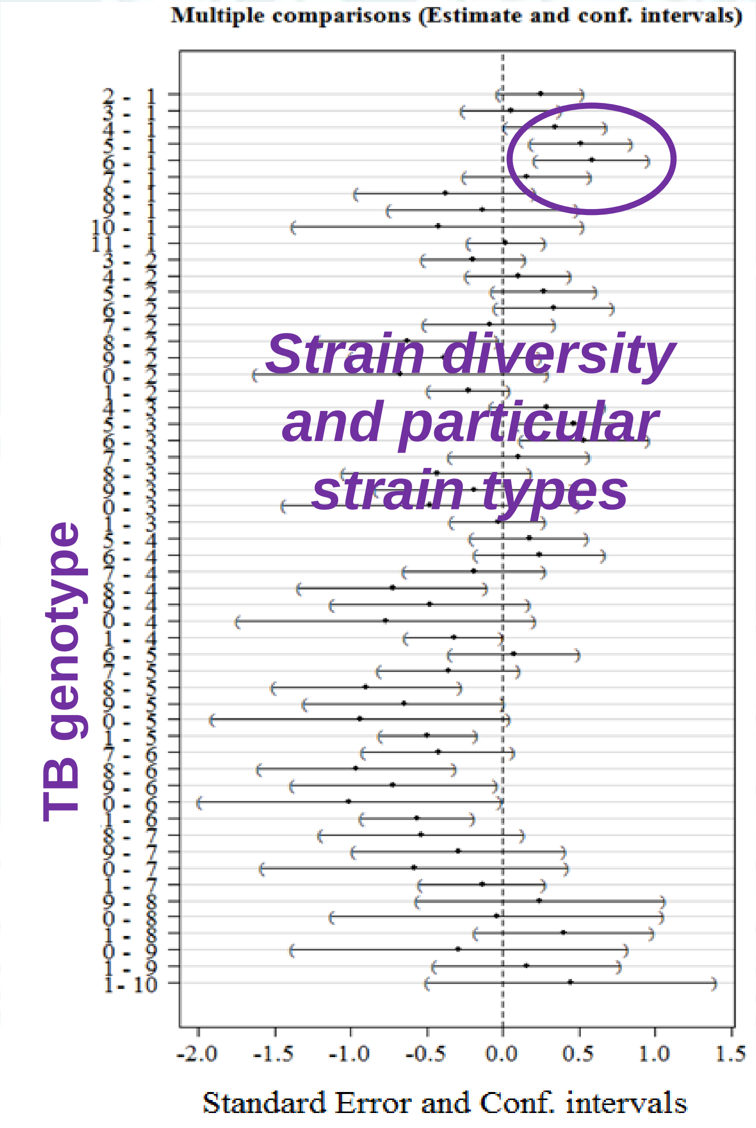
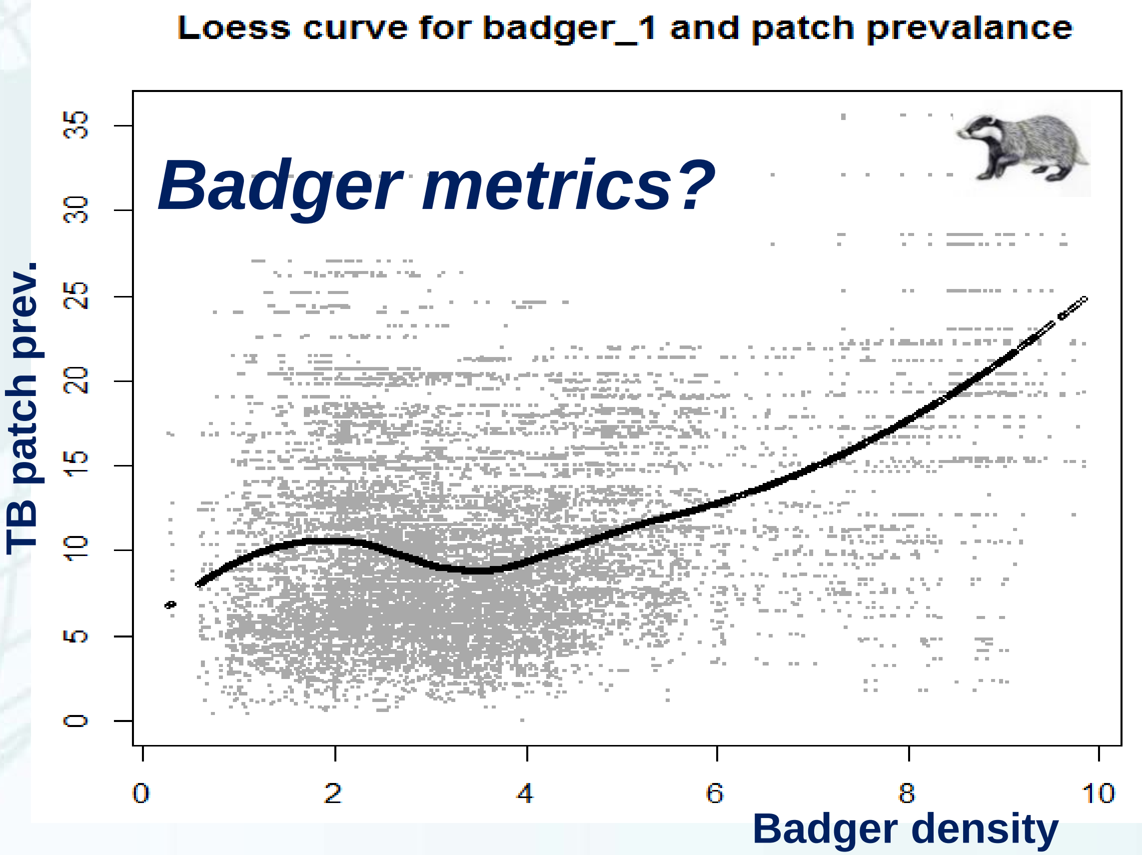
Veterinary Epidemiology – Chronic herds

2. **What risk factors are associated with "chronicity"?**

Herd-size, buying-in, local prevalence, associated herds





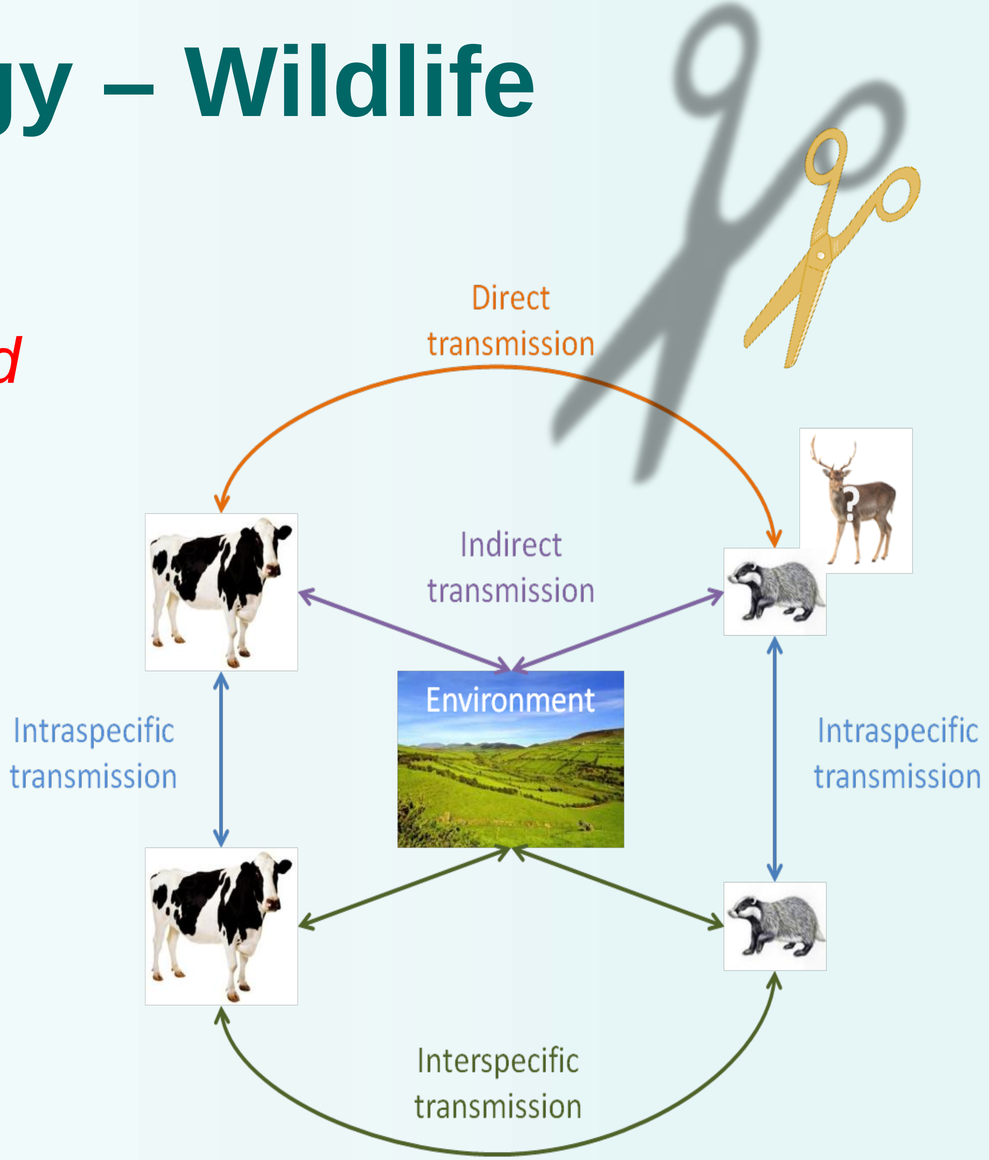
Milne et al. 2018a & 2018b (in review)

Veterinary Epidemiology – Wildlife

A research basis is fundamental to understanding and potentially mitigating the wildlife risk

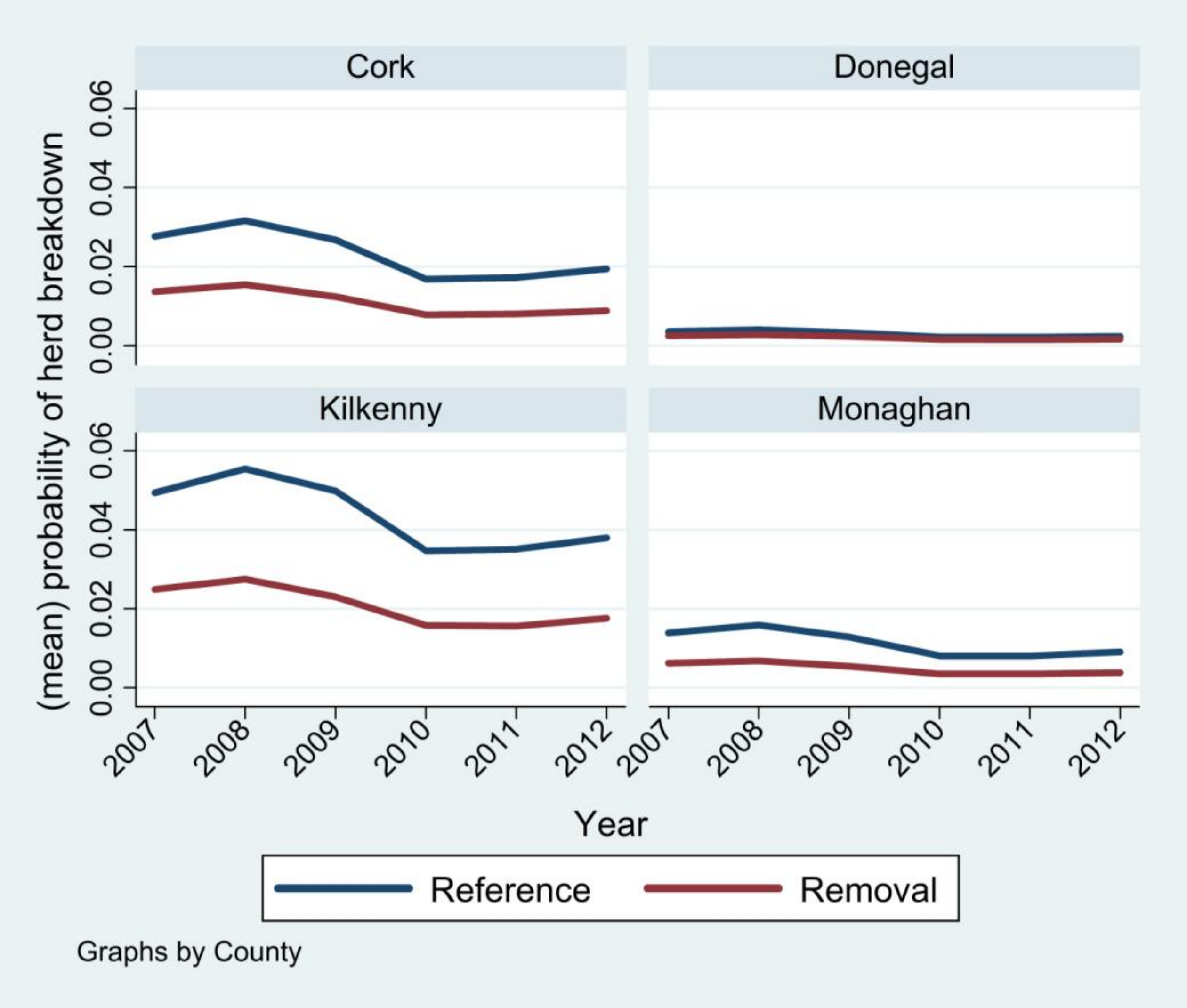
1. Establish effects of historic badger interventions
2. Spatial and temporal variation in badger TB prevalence
3. Fundamental ecological studies to understand risk – density and movement

- Ultimately, research can feed into mathematical and simulation models to test "what if" scenarios?



Veterinary Epidemiology – Wildlife

1. Establish effects of historic badger interventions



- Large-scale intensive interventions can have measurable effects 10 years on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NEWS

Badger culling a decade ago 'still reducing risk of bovine TB'


Byrne et al. Veterinary Research 2014, 45:109
http://www.veterinaryresearch.org/content/45/1/109

VETERINARY RESEARCH

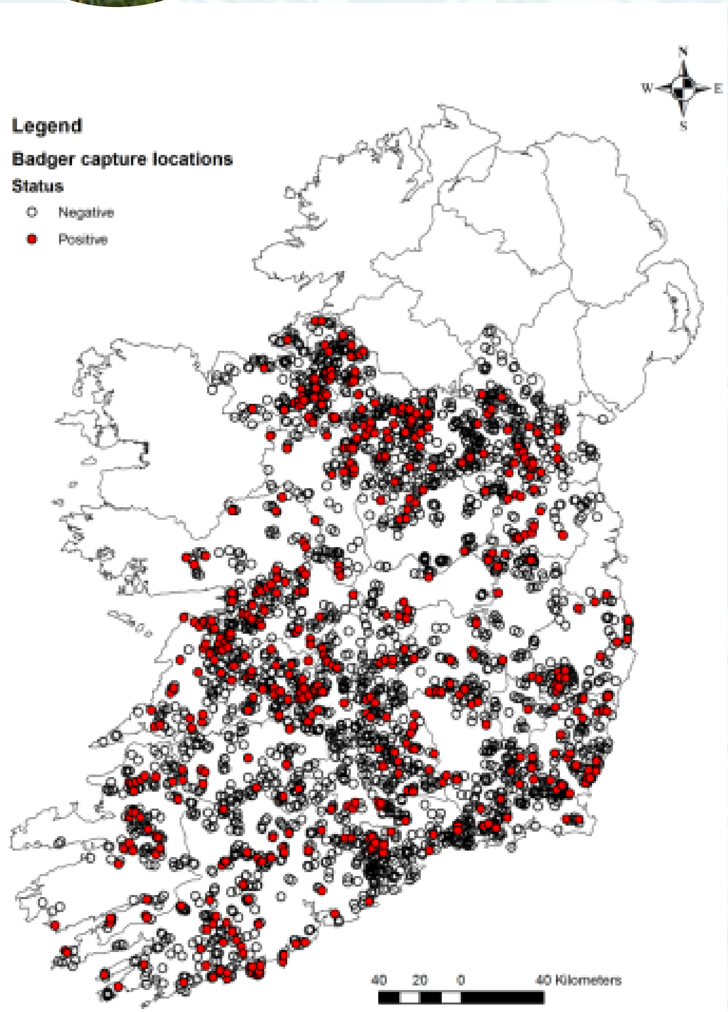
RESEARCH | Open Access

Risk of tuberculosis cattle herd breakdowns in Ireland: effects of badger culling effort, density and historic large-scale interventions

Andrew W Byrne[1,2*], Paul W White[1,3], Guy McGrath[1], James O'Keeffe[1,3] and S Wayne Martin[4]

Veterinary Epidemiology – Wildlife

2. Spatial and temporal variation in badger TB prevalence



Large spatial variation in local badger prevalence

- Significant correlation between cattle and badger risk


Contents lists available at ScienceDirect

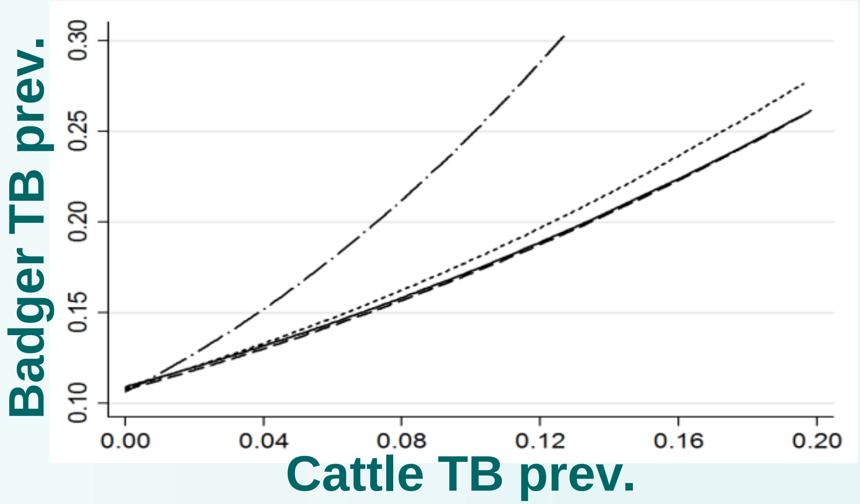
Preventive Veterinary Medicine

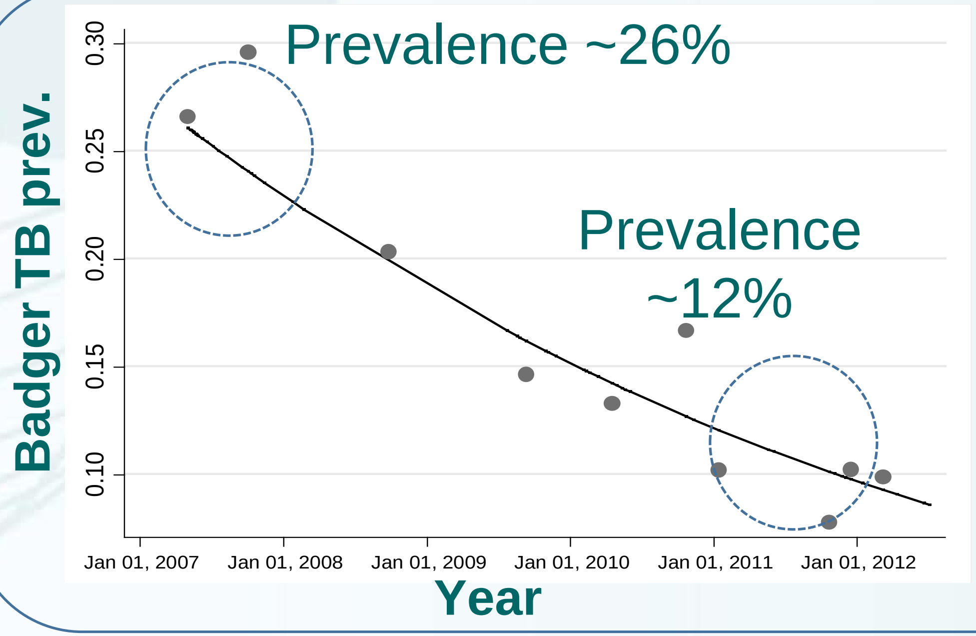
journal homepage: www.elsevier.com/locate/prevetmed

ELSEVIER

Spatial and temporal analyses of metrics of tuberculosis infection in badgers (*Meles meles*) from the Republic of Ireland: Trends in apparent prevalence

A.W. Byrne, K. Kenny, U. Fogarty, J.J. O'Keeffe, S.J. More, G. McGrath, M. Teeling, S.W. Martin, I.R. Dohoo

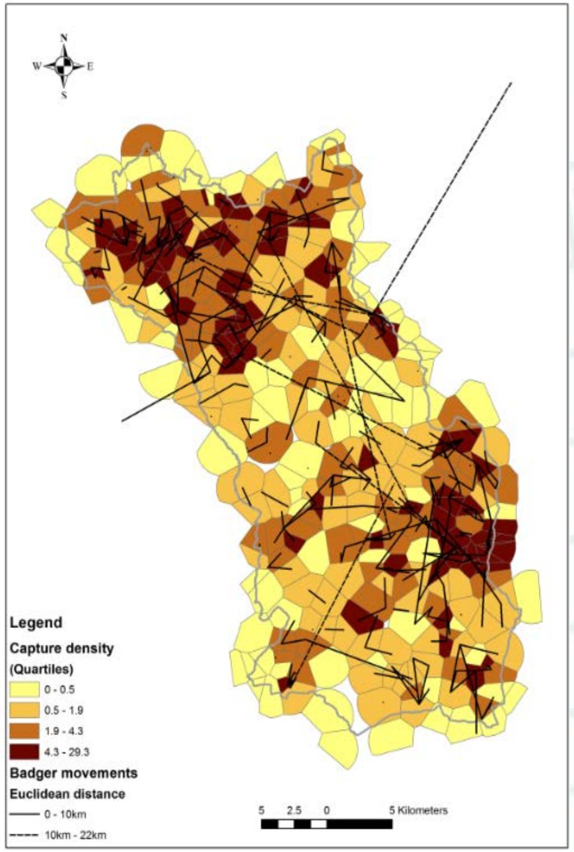




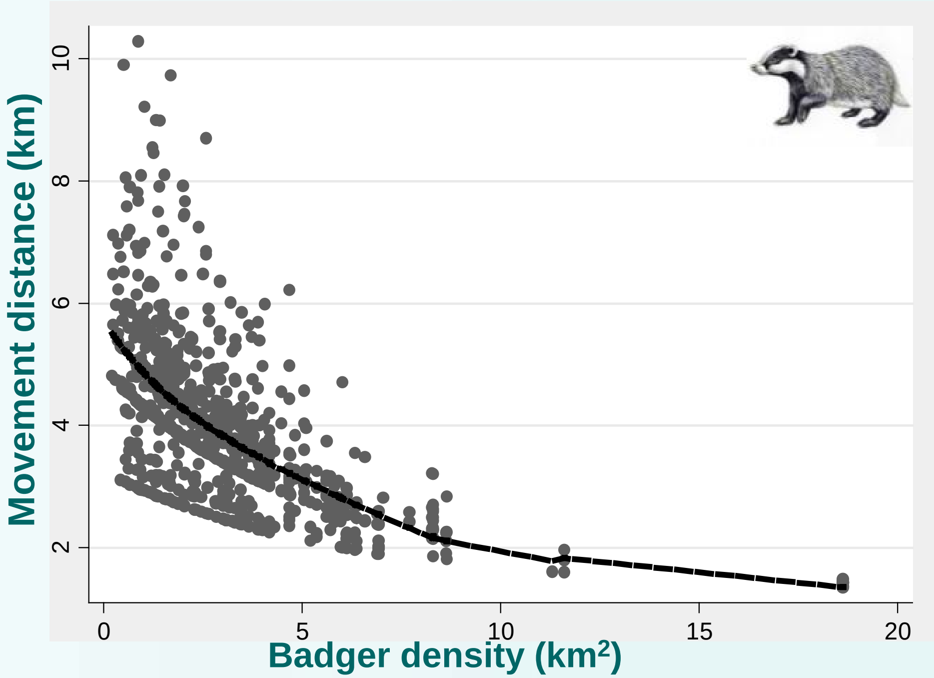
- Tracked the changing dynamics of the epidemic

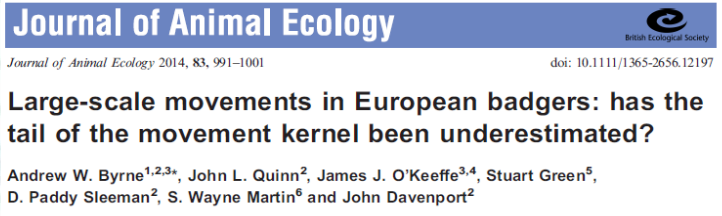
Veterinary Epidemiology – Wildlife

3. Fundamental ecological studies to understand risk – density and movement



- Badgers move over longer distances than previously thought
- Movements were significantly affected by density
- Future NI work essential – TVR & TBSPG




Journal of Animal Ecology

British Ecological Society

Journal of Animal Ecology 2014, 83, 991–1001 doi: 10.1111/1365-2656.12197

Large-scale movements in European badgers: has the tail of the movement kernel been underestimated?

Andrew W. Byrne[1,2,3*], John L. Quinn[2], James J. O'Keeffe[3,4], Stuart Green[5], D. Paddy Sleeman[2], S. Wayne Martin[6] and John Davenport[2]

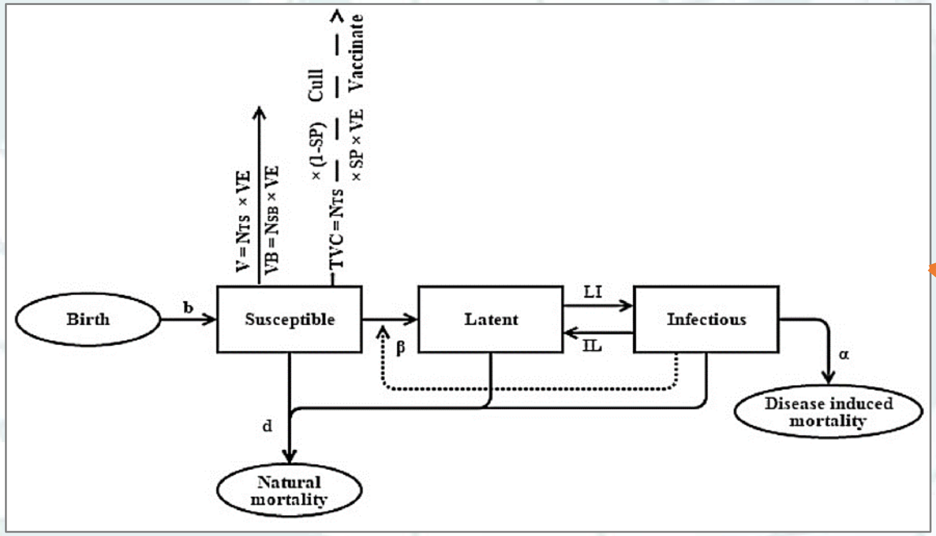
Coláiste na hOllscoile Corcaigh, Éire
University College Cork, Ireland

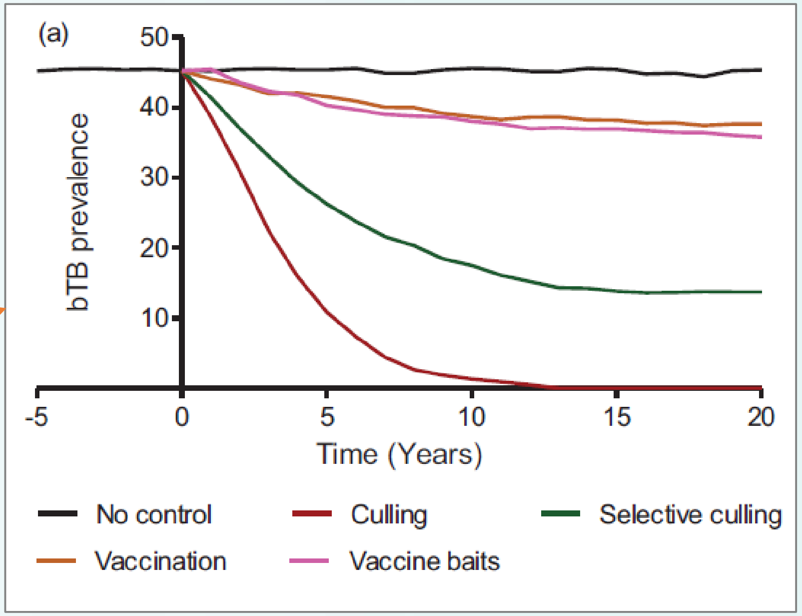
Agri-Food and Biosciences Institute

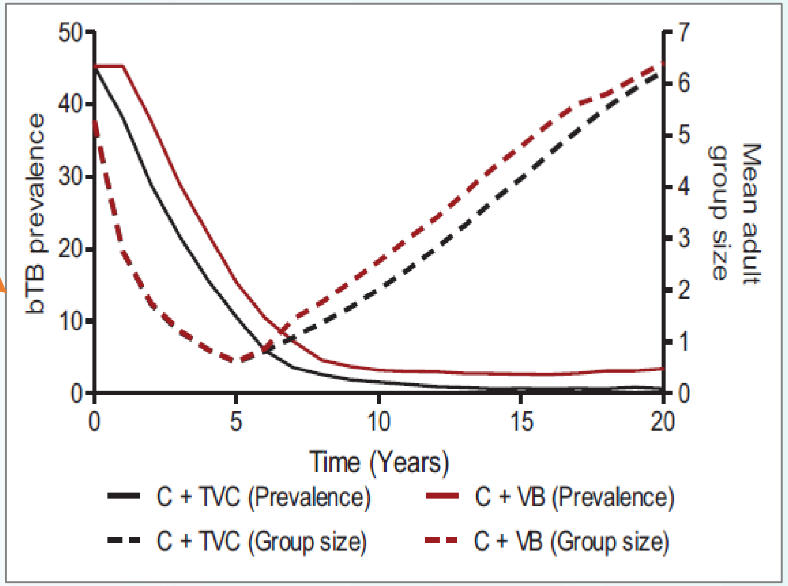
Veterinary Epidemiology – Wildlife

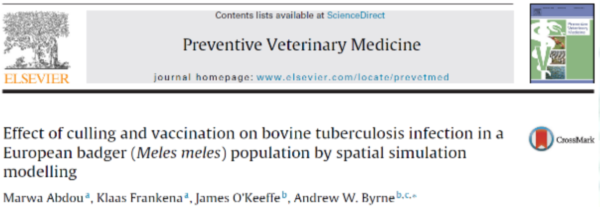
Simulation modelling

- Using fundamental parameters, create a *in silico* model to test 'what if' scenarios





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journal homepage: www.elsevier.com/locate/prevetmed

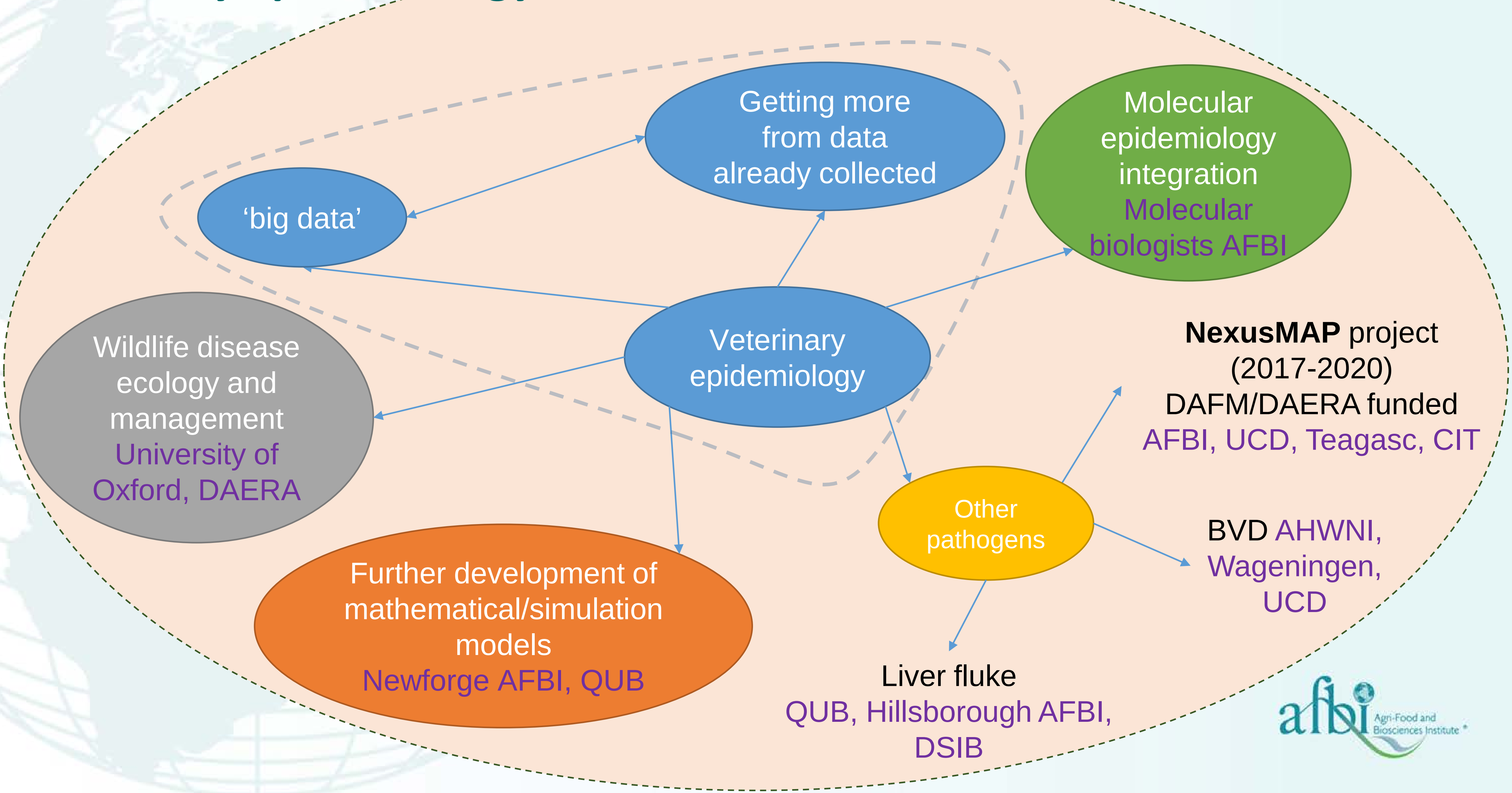
Effect of culling and vaccination on bovine tuberculosis infection in a European badger (*Meles meles*) population by spatial simulation modelling

Marwa Abdou[a], Klaas Frankena[a], James O'Keeffe[b], Andrew W. Byrne[b,c,*]

WAGENINGEN UNIVERSITY & RESEARCH

afbi Agri-Food and Biosciences Institute

Veterinary Epidemiology – the future vision?



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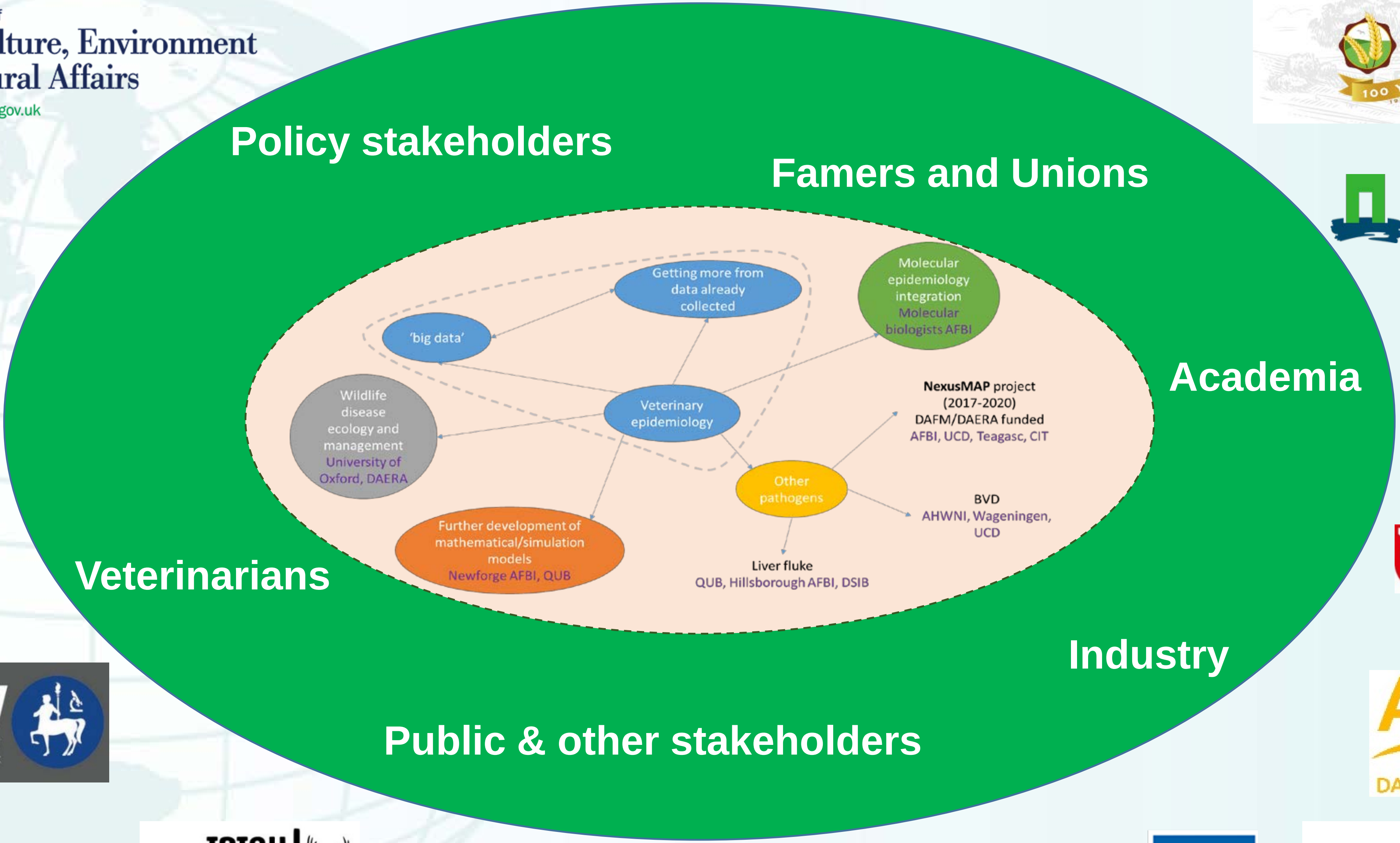

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The Association for Veterinary Teaching and Research Work

AHDB
Dairy

Irish Wildlife Trust

Northern Ireland Badger Group

Ulster Wildlife

Dale Farm

Fane Valley

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Prof. David Macdonald (ecology, Oxon)

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Emma Campbell (wildlife disease ecology; QUB)

Laura Rosen (wildlife disease ecology; Colorado State University)

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