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Bovine TB: Epidemiology and Ecology of a Multi-Host Disease

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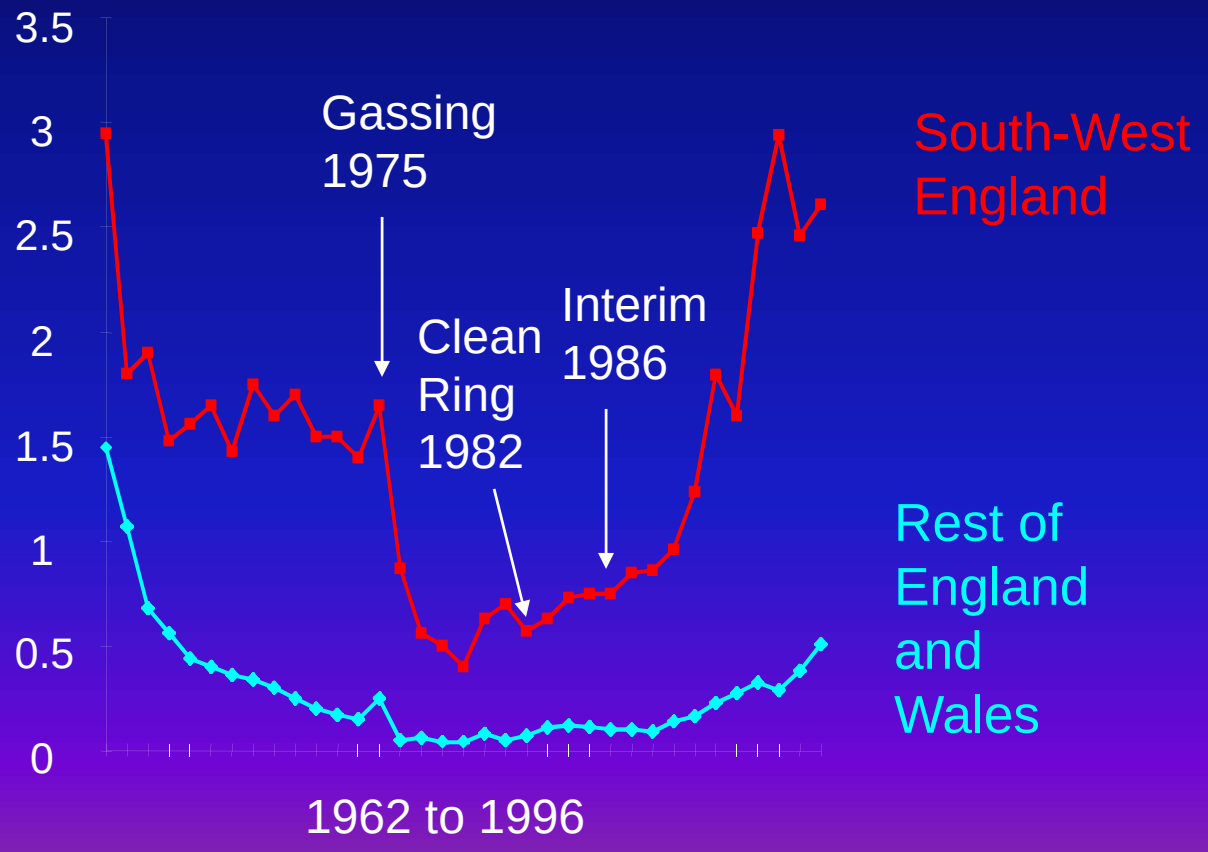
(and in spirit… Rosie Woodroffe,
Institute of Zoology London)

Percentage of total herds with reactor cattle (confirmed and unconfirmed)



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The Krebs Report

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In 1997, the government commissioned an Independent review chaired by Sir (now Lord) John Krebs.

Concluded that the evidence of a link between badgers and cattle TB is compelling but not conclusive

and that a field trial is required to test and quantify the impact of badger culling on disease in cattle

(with no culling outside trial areas)


Devastated by TB's bolt from the blue
Badgers escape the death penalty
Farmers hit out at more delays in TB fight
Badger culling to be restricted
Farm dismay on heels of badger culling decision
Culling halt stuns farmers
"Huge areas will be left without any control of badger TB"
Badger culling all but ended - Krebs report
Badger boom wreaks havoc
KREBS REPORT SERVES TO DELAY REAL ANSWERS TO BADGER TB DESTRUCTION

Farmers furious at TB risk in five-year experiment

Thousands of badgers to die

Is the badger an innocent scapegoat?

Outrag
MPs sup
massive c
of badgers

Latest badger cull is another Ministry gaff

TB or not TB? Don't blame our badgers

Badger cull dismays animal campaigners

10,000 badgers face death in five-year TB cull experiment

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That was then… this is now!

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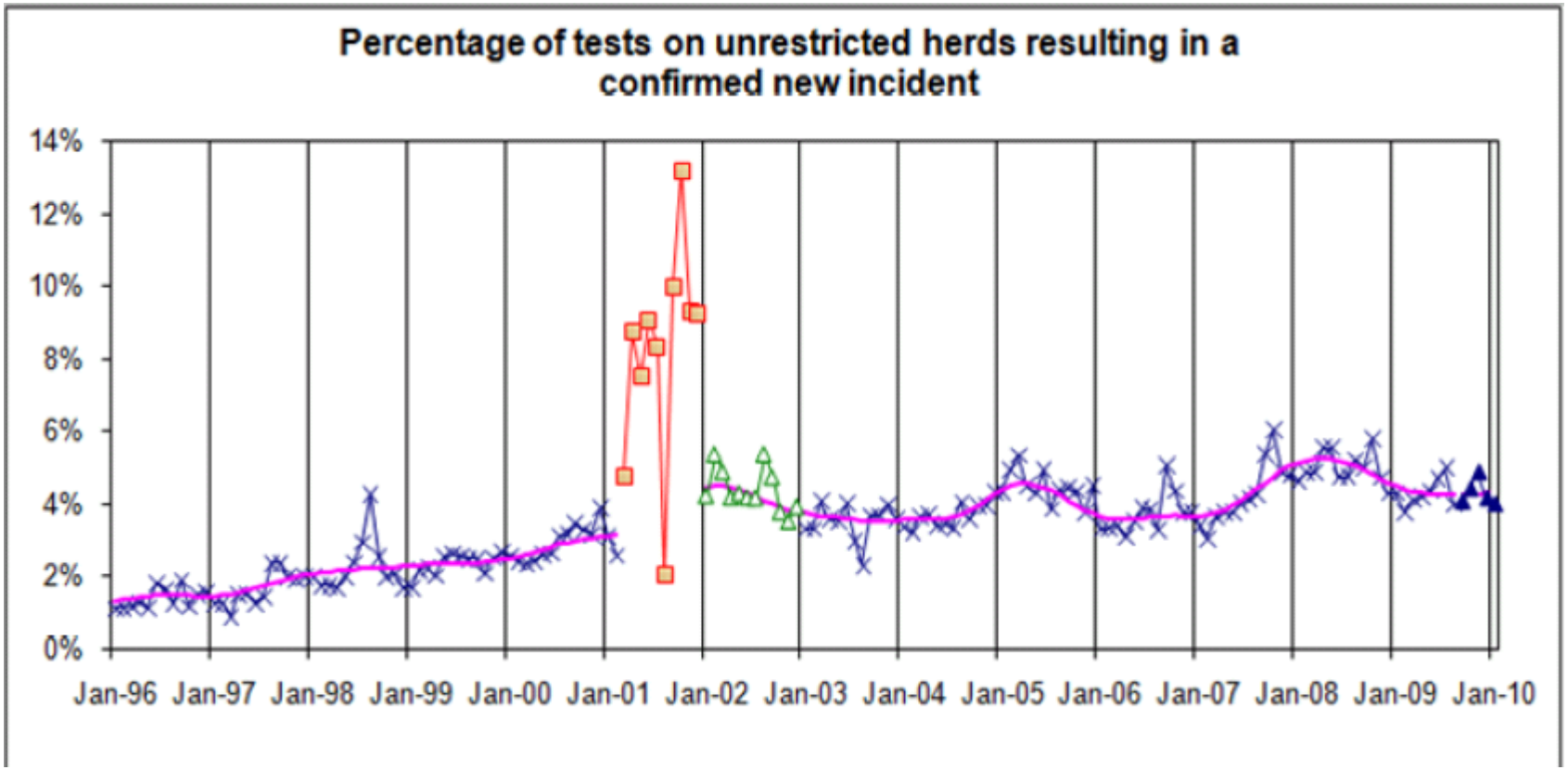

Data as of 21 April 2010 – as published by Defra.

http://www.defra.gov.uk/evidence/statistics/foodfarm/landuselivestock/cattletb/documents/tbpn.pdf

The Independent Scientific Group on Cattle TB

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Randomised Badger Culling Trial

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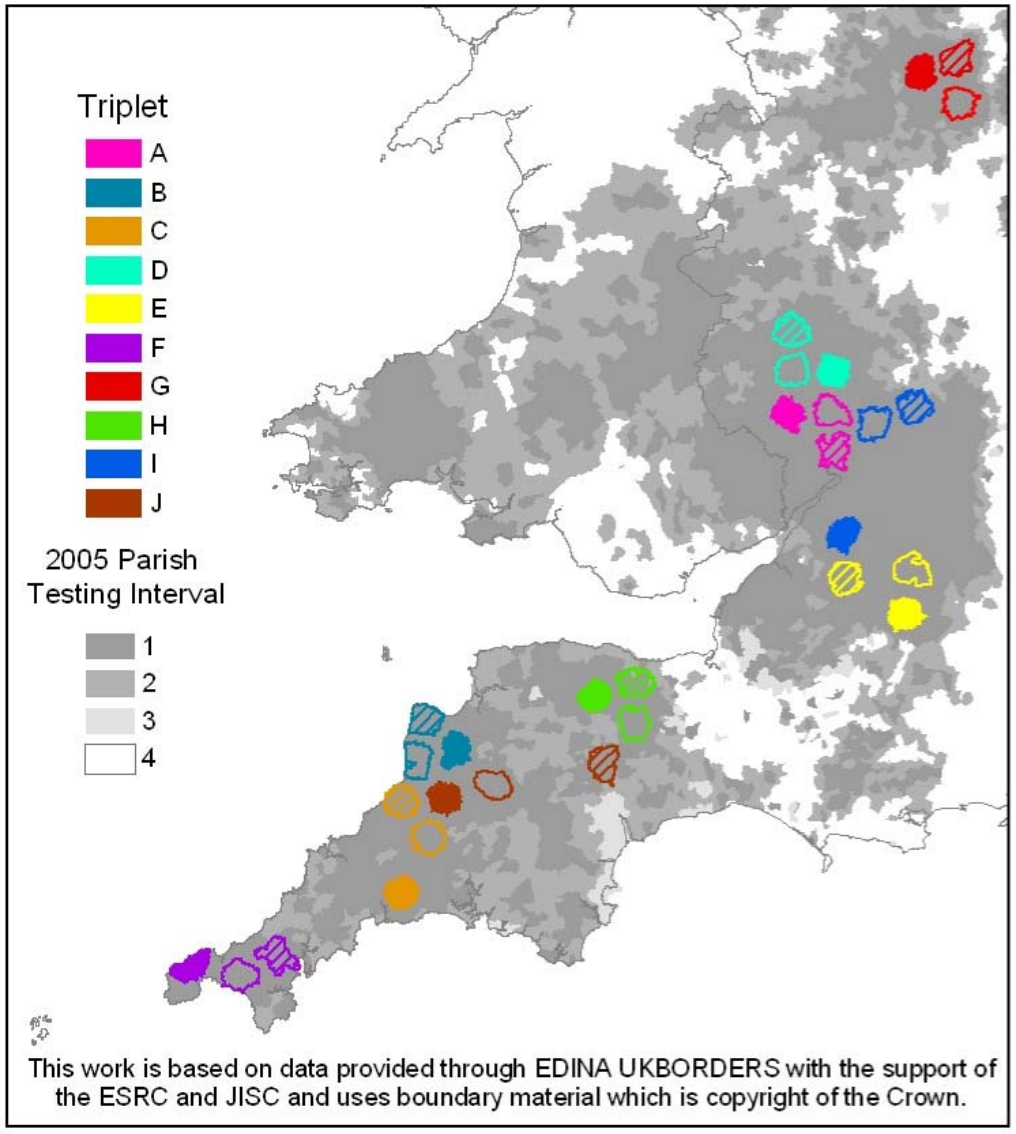

Randomised to 30 roughly 100km^2 areas where the incidence of confirmed TB breakdowns was greatest

- No culling
- Reactive culling
- Proactive culling

No culling outside the field trial areas

Donnelly *et al. Nature* 2006.

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RBCT Proactive Culls

Triplet	1	2	3	4	5	6	7
A	Jan ’00	May ‘02	Nov ’03	May ‘04	Oct ’05		
B	Dec ’98	Nov-Dec ’99	Aug ‘00 - Jan ‘01*	Nov-Dec ‘02*	Jun ’03	Jul-Aug ’04	Oct ‘05
C	Oct ’99	Jan ’01	Aug-Nov ‘02*	Oct ’03	Jun ’04	Sep ’05	
D	Dec ’02	May ’03	Sep ’04	May ’05			
E	May ’00	Jan ’01	Jun ‘02 - Jan ‘03*	Jun ’03	Jul ’04	Sep ‘05	
F	Jul ’00	May ’02	Dec ’03	Sep ’04	Jun ’05		
G	Oct-Nov ’00	Jul ’02	Jul ’03	Jun ’04	Jun ’05		
H	Dec ’00	Jun-Jul ’02	Sep ’03	May ’04	Jul-Aug ‘05		
I	Sept-Oct ’02	Sep-Oct ’03	Oct-Nov ’04	Jul ’05			
J	Oct ‘02	Jul-Aug ’03	Oct-Nov ‘04	May ’05			

Cattle Herds and Badger Prevalence

U (uninfected)

$$\frac{dU}{dt} = \frac{M}{p} - U\left(\beta\frac{I}{N} + k\right)$$

I (infected, and equivalently infectious, but undiagnosed)

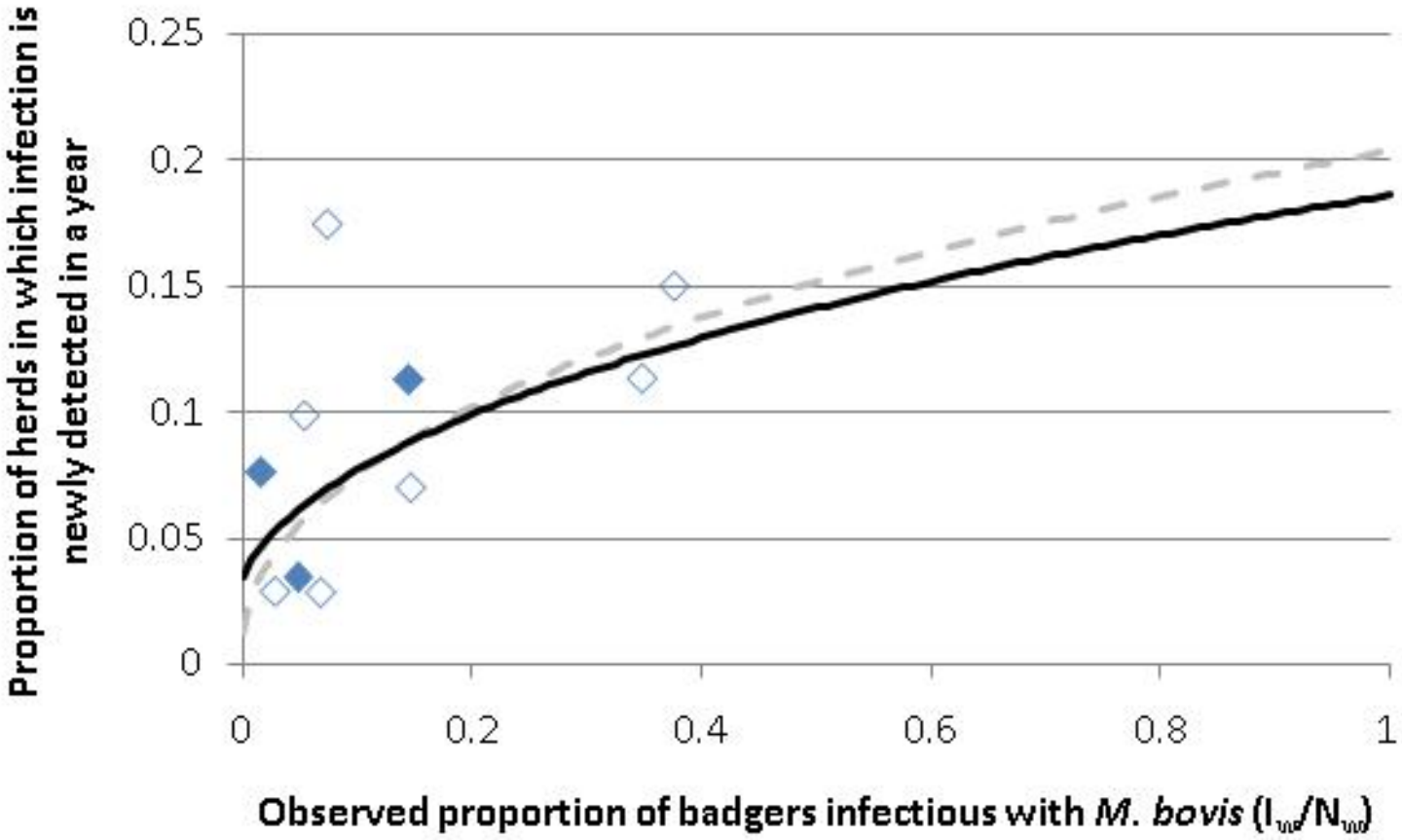
$$\frac{dI}{dt} = U\left(\beta\frac{I}{N} + k\right) - Ic$$

M (under movement controls and thus not infectious to other herds).

$$\frac{dM}{dt} = Ic - \frac{M}{p}$$

Donnelly & Hone. Is there an association between levels of bovine tuberculosis in cattle herds and badgers? *Statistical Communications in Infectious Diseases* 2 (1): article 3, 2010.

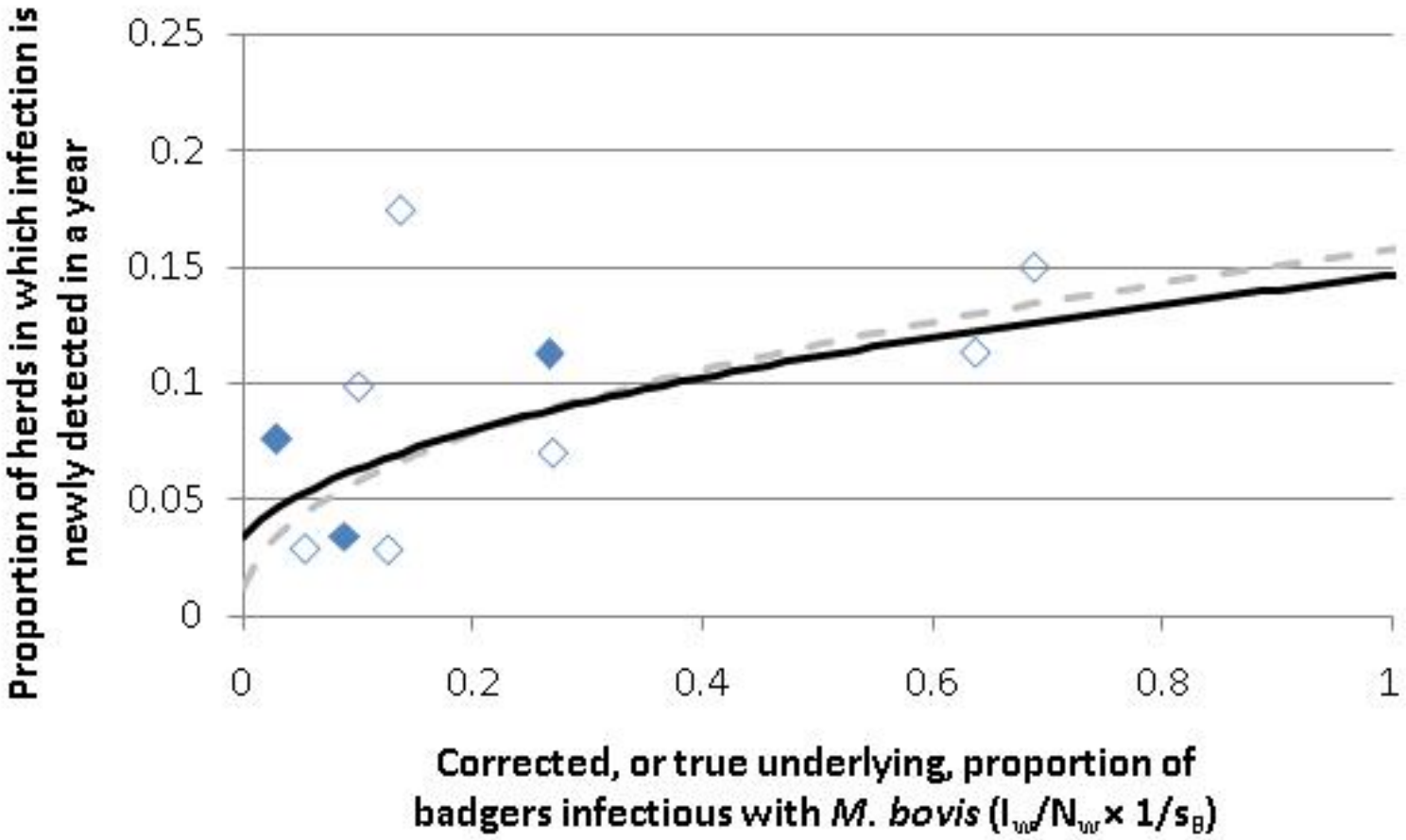
Cattle Herds and Badger Prevalence



But… Crawshaw *et al.* (2008) estimated that the overall sensitivity of the standard protocol, to which RBCT badgers were subjected, was only 54·6% (95% CI: 44·9 – 69·8%) relative to the more detailed protocol.

Donnelly & Hone. Is there an association between levels of bovine tuberculosis in cattle herds and badgers? *Statistical Communications in Infectious Diseases* 2 (1): article 3, 2010.

Cattle Herds and Badger Prevalence



Donnelly & Hone. Is there an association between levels of bovine tuberculosis in cattle herds and badgers? *Statistical Communications in Infectious Diseases* 2 (1): article 3, 2010.

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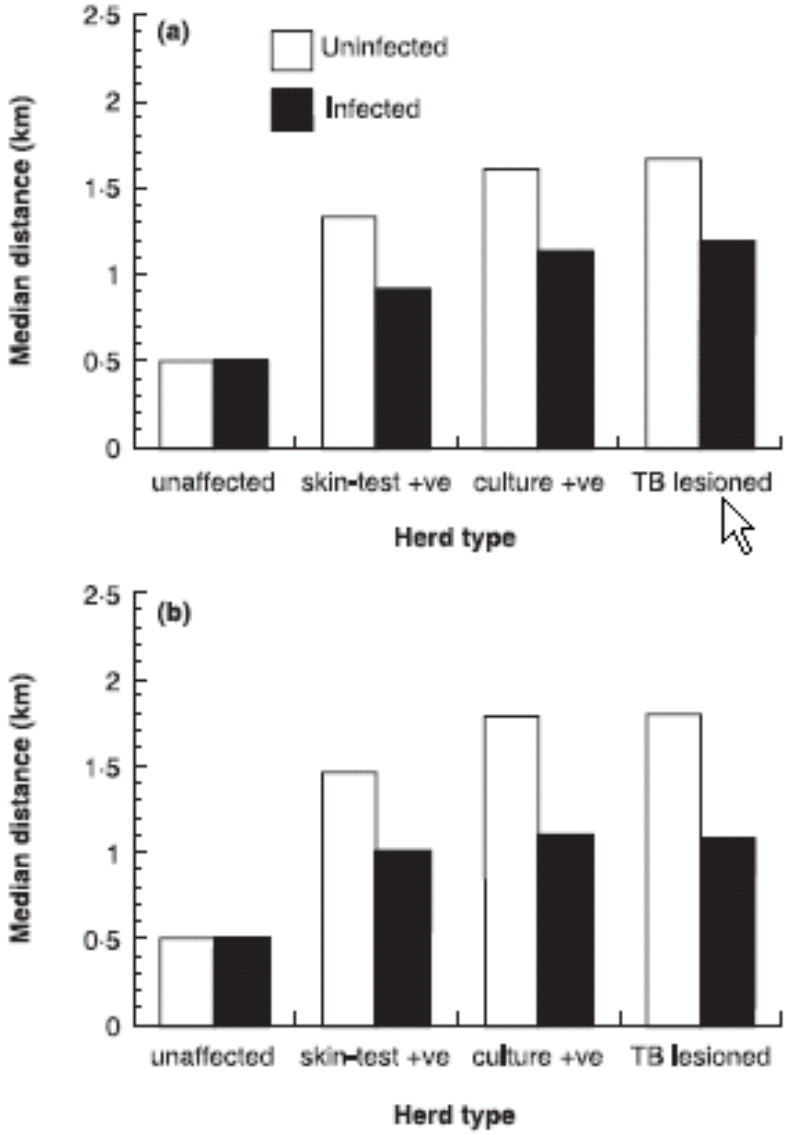
Spatial associations in badgers and cattle



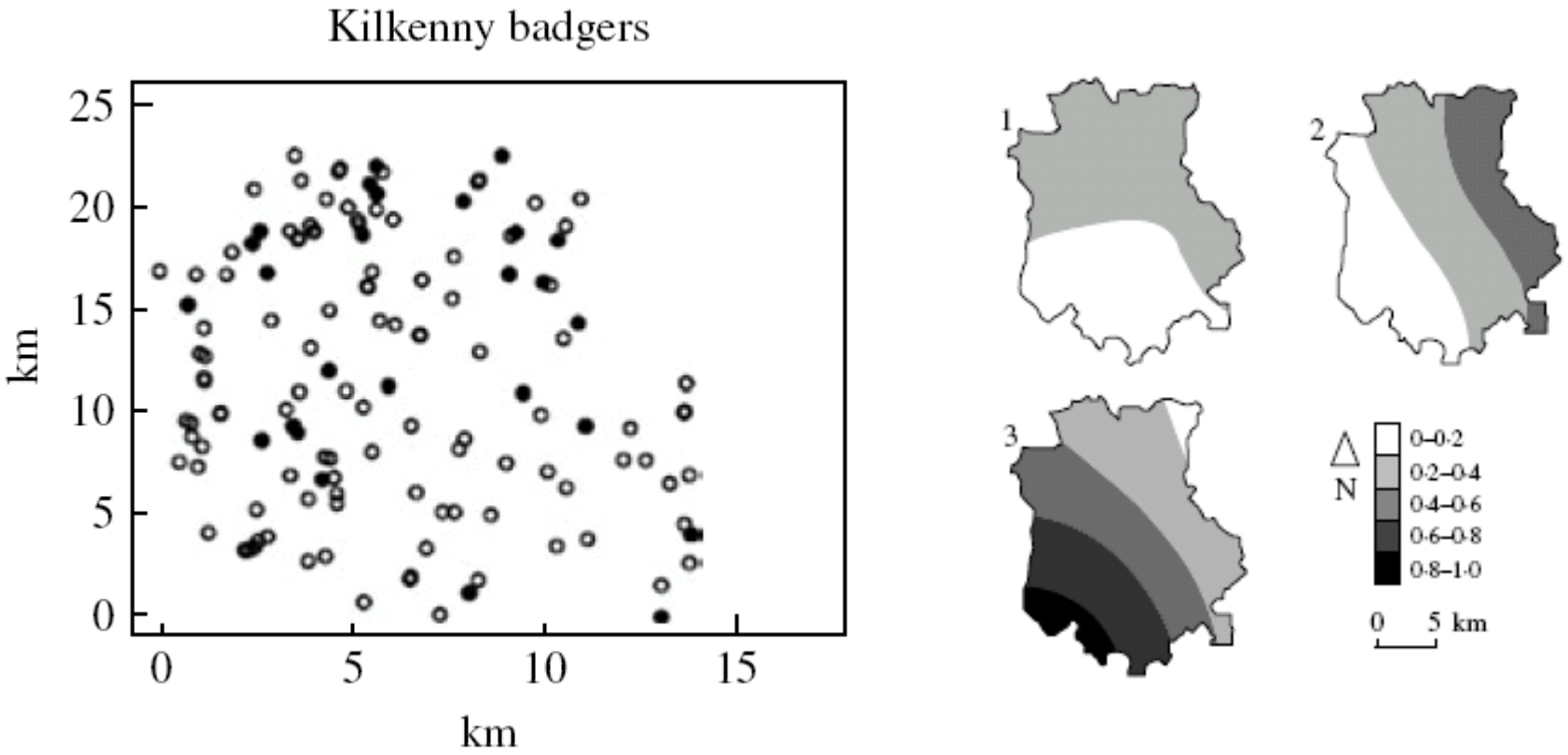
The median distances from capture locations of infected (solid bars) and uninfected (open bars) badgers to the nearest cattle herds of various types.

(a) shows the median distances from **adult badgers** to herds containing cattle that were either unaffected by TB, skin test-positive, culture-positive or TB-lesioned in the 12 months prior to the badger culls;

(b) has the same, but for **cubs**.

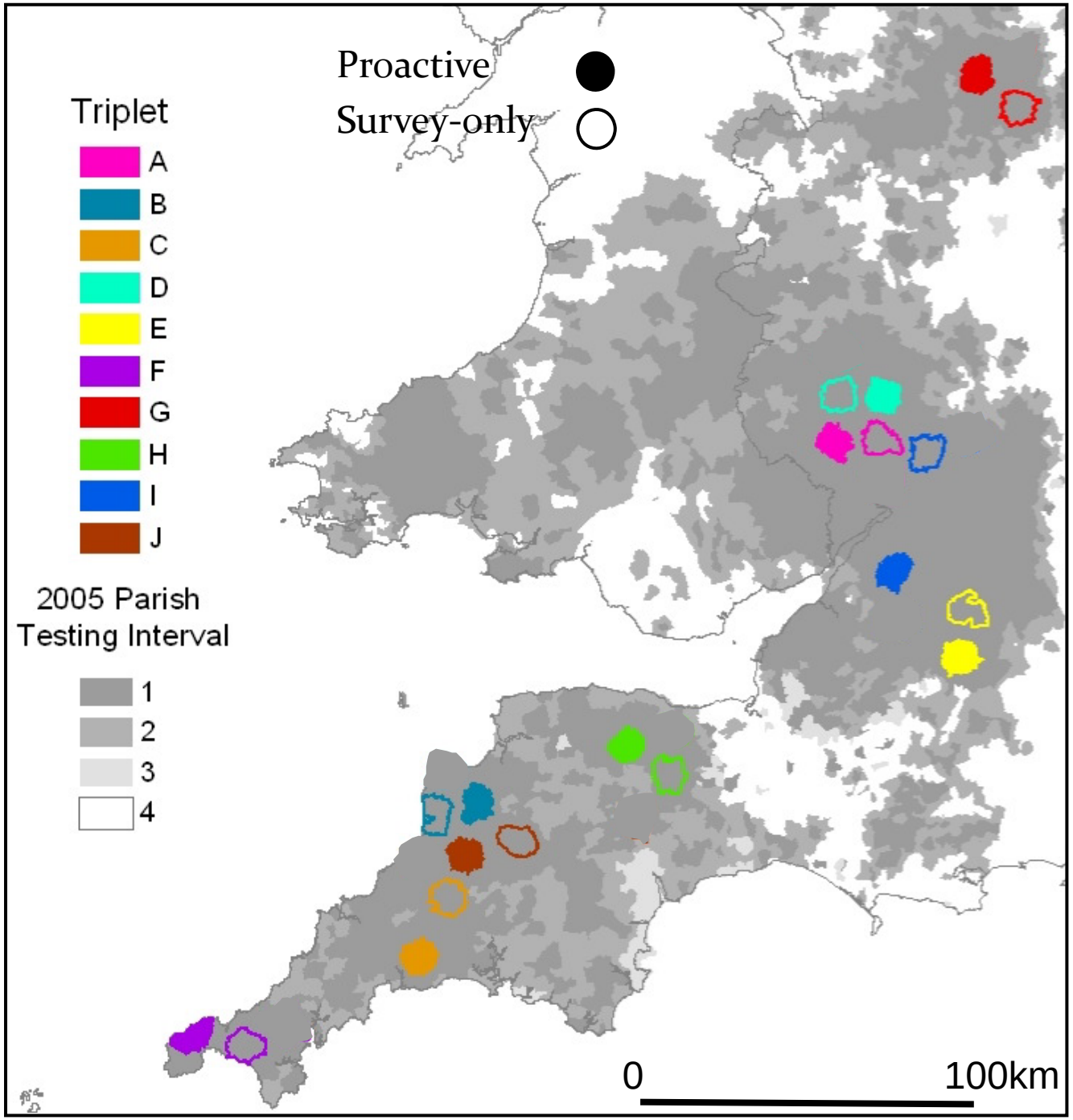
Woodroffe *et al. Journal of Applied Ecology* 2005

Spatial clustering of infection in Ireland



Kernel estimates of badger strain-specific probability surfaces in the Kilkenny area of the Irish Four Area study. 1: A1A1A, 2: A4A1H, 3: C1H1J strain-specific probability surfaces (P<0.001 indicating spatial segregation).

Kelly *et al.* Estimating the extent of spatial association of *Mycobacterium bovis* infection in badgers in Ireland. *Epidemiol. Infect.* (2010), 138, 270–279.



Results from inside **proactive** culling areas

TB incidence <u>inside</u> proactive culling areas was **23.2% lower** than that inside no-culling areas (95% CI: 12 to 33% lower)

Based on 55.8 triplet-years

Donnelly *et al. IJID* 2007

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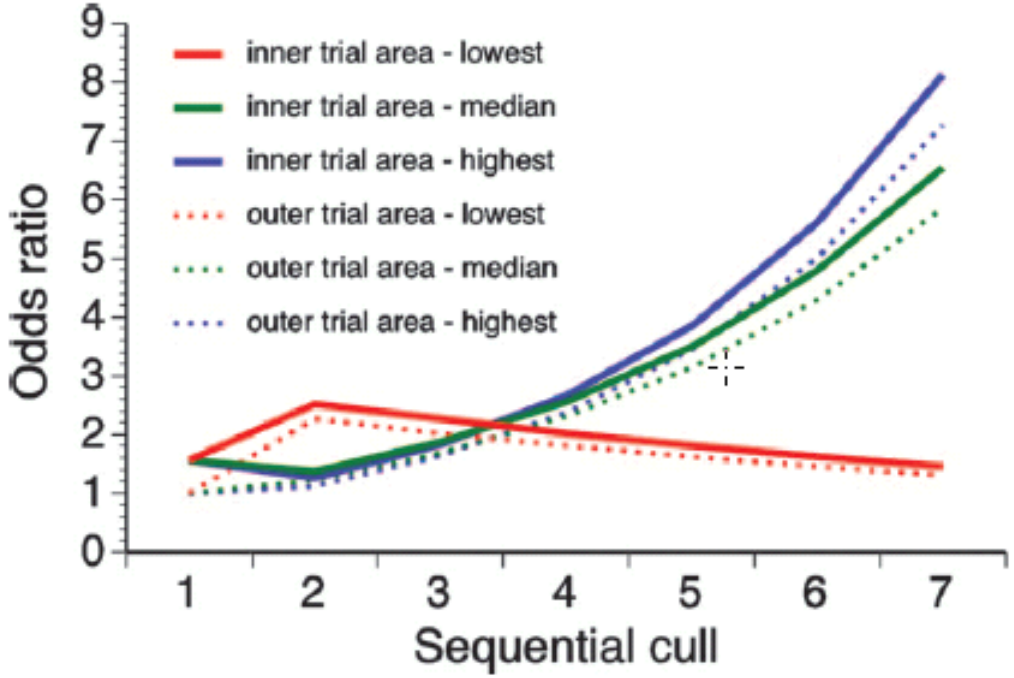
Impact of culling on Badger Prevalence

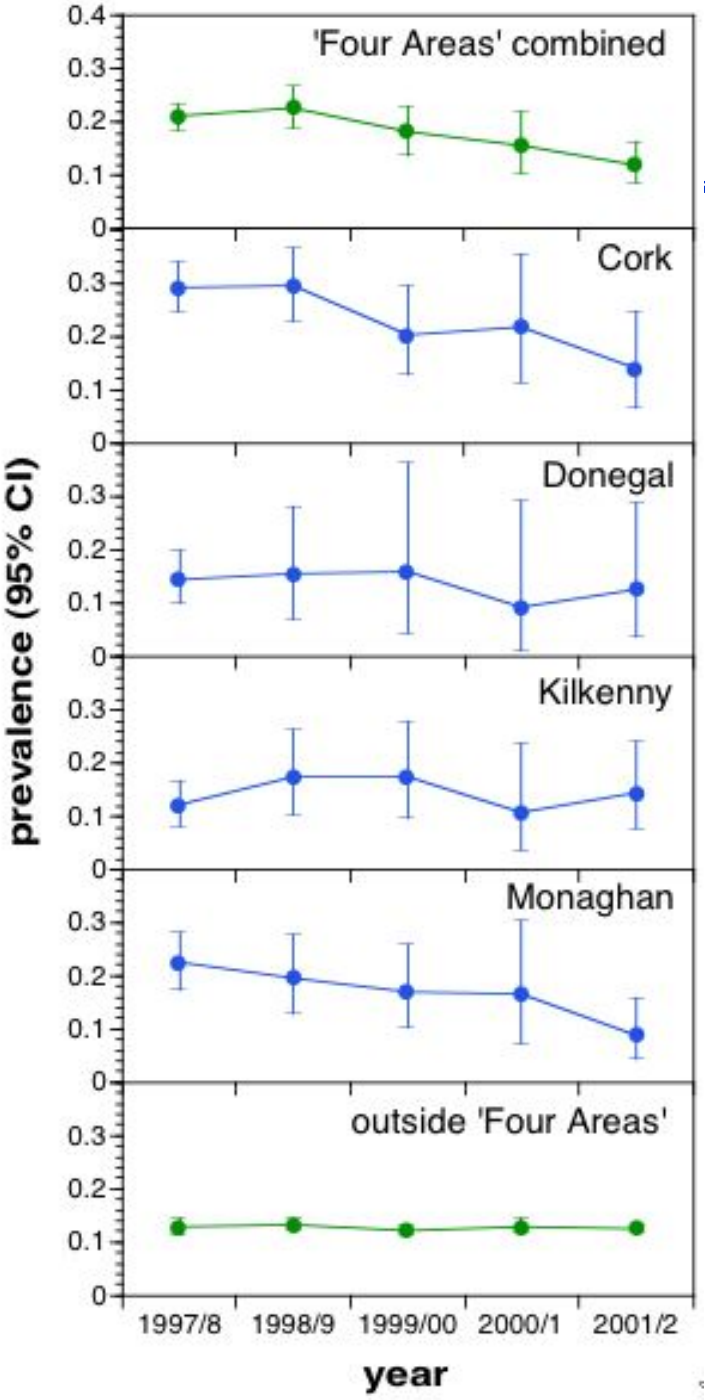


Boundary permeability

- lowest observed (0.55)
- median observed (0.94)
- highest observed (1.0)

A logistic regression model for badger M. bovis infection status had a significant interaction between repeated culls and the permeability of trial area boundaries, showing that successive culls led to increased prevalence only in less geographically isolated areas. We also detected a significant interaction between badger capture location and the variable describing initial vs. follow-up culls.

Woodroffe *et al. PNAS* 2006.



… and in the Republic of Ireland

Prevalence rise observed on successive RBCT proactive culls was not detected among badgers culled in the Irish "Four Areas Trial"; indeed, overall prevalence appeared, if anything, to decline.

Because all of the "Four Areas" received their initial culls in the same 12-month period, it is not possible for the Irish prevalence data to be analysed with both inter-annual and cull sequence effects simultaneously.

Griffin *et al.* (2003) in *Selected Papers 2002-2003.* (Veterinary Epidemiology and TB Investigation Unit, University College Dublin),1-12.

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Bait marking

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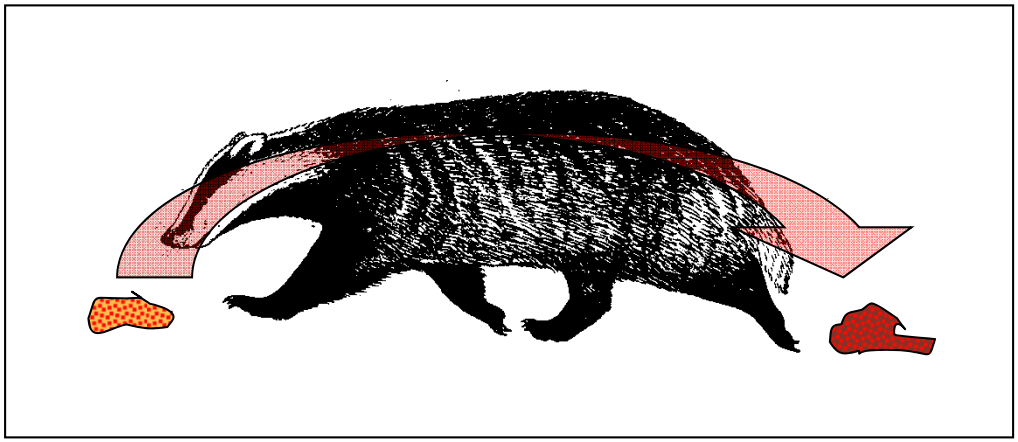
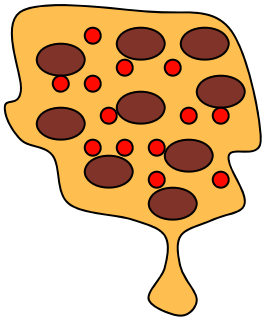
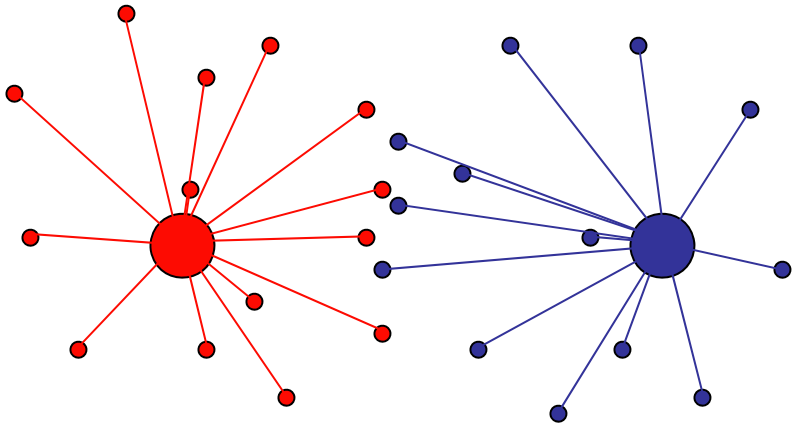
Standard technique for mapping badger home ranges





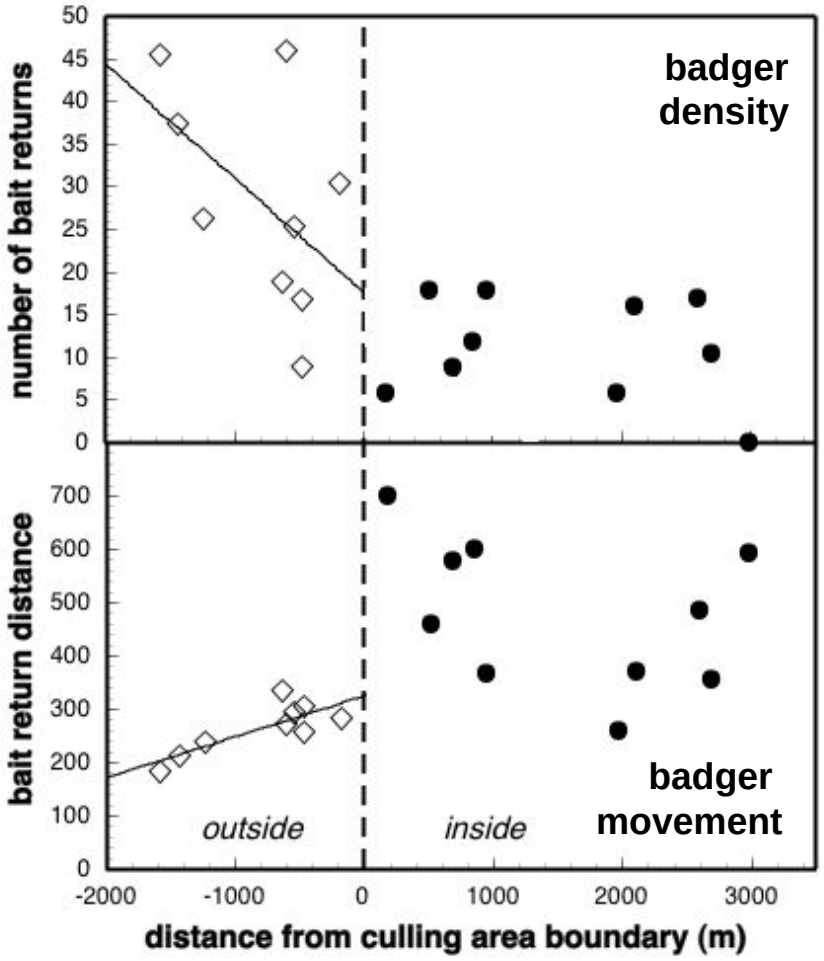
colour marked bait



matching bait returns to setts

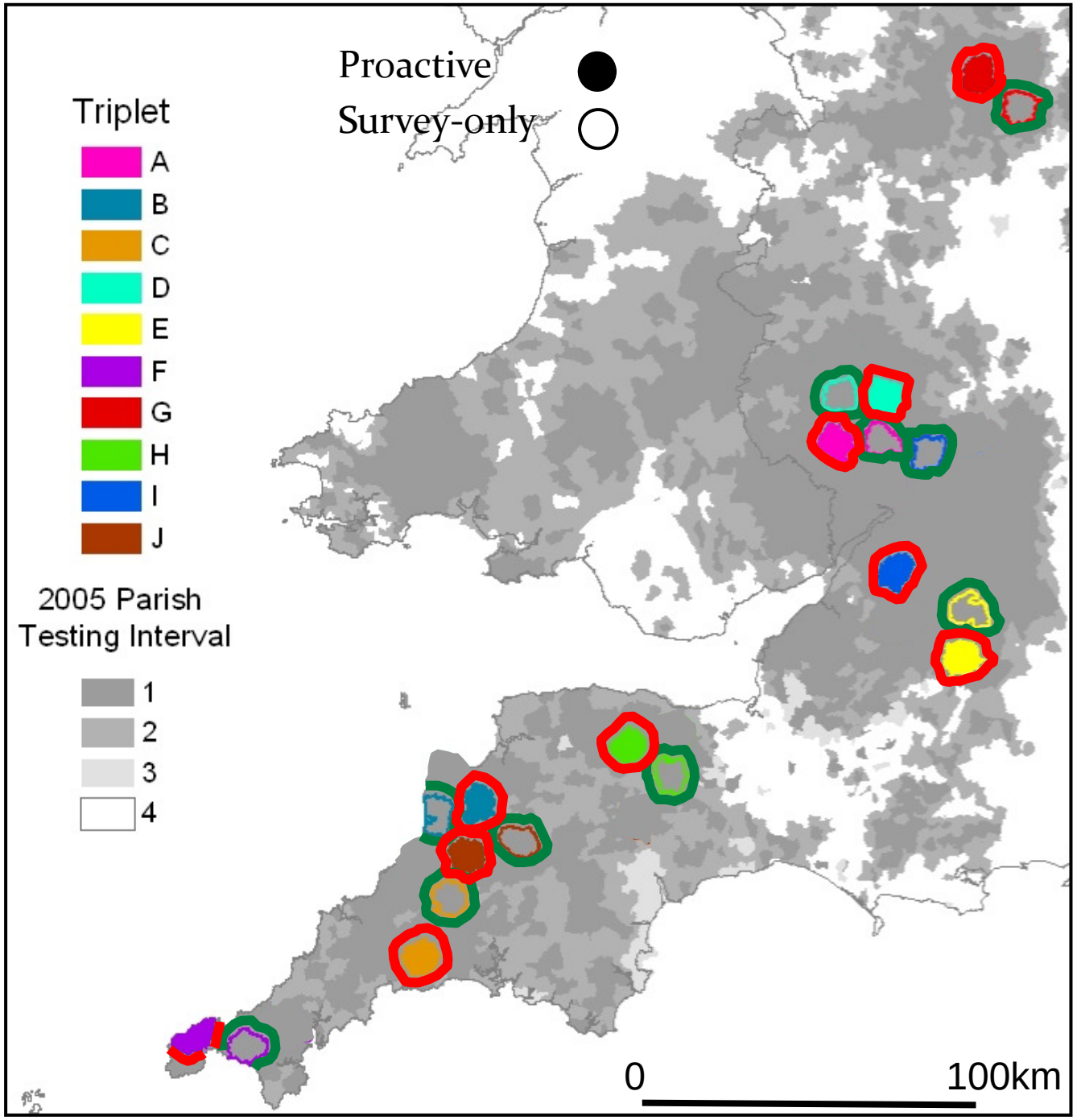
Impacts outside culling areas

Badger densities were slightly reduced, and badger movements expanded, on land immediately outside proactive culling areas



If disruption of badger spatial organization caused the increased cattle TB incidence in localized (reactive) culling areas, ***the same effect might be observed on farms on land adjoining proactive culling areas.***

Woodroffe *et al. Journal of Applied Ecology* 2006



Results from just outside **proactive** culling areas

TB incidence up to 2km outside proactive culling areas was **24.5% higher** than that up to 2km outside no-culling areas (95% CI: 0.6 lower to 56% higher)

Based on 55.8 triplet-years

Donnelly *et al. IJID* 2007

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After culling stopped

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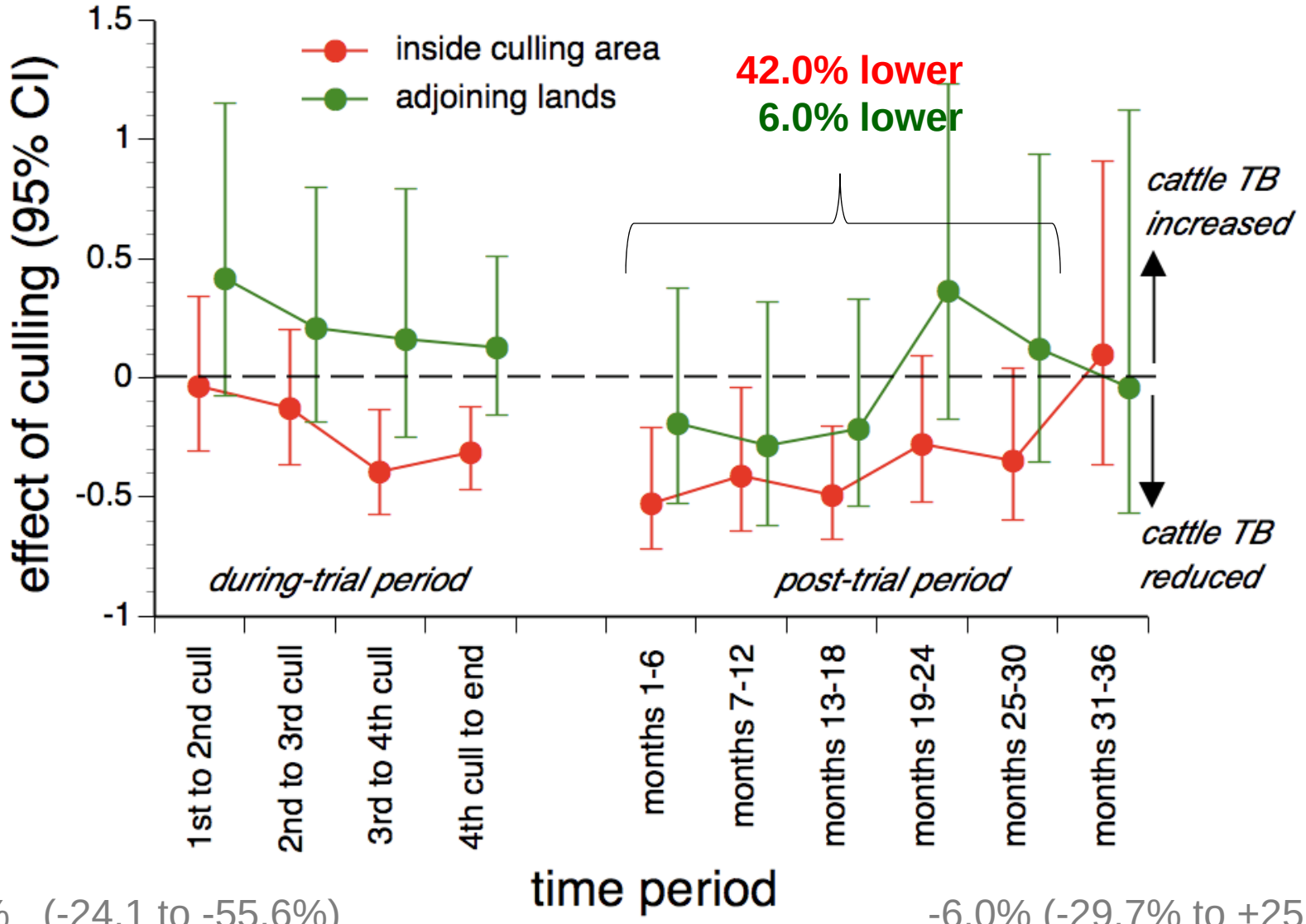

-42.0% (-24.1 to -55.6%)

-6.0% (-29.7% to +25.7%)

Jenkins, Woodroffe and Donnelly, *PLoS ONE* 2010

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Key findings

In high cattle incidence areas, there is a clear association between cattle disease and badger prevalence – both between and within trial areas.

Repeated widespread badger culling reduces cattle TB inside culled areas

- by 23% during culling
- by 42% between 1 and 3½ yrs after the last cull

[no detectable effect thereafter]

Culling affects badger density and ranging up to 2km outside culled areas. It also increases *M. bovis* prevalence among remaining badgers.

Cattle herds up to 2km outside culled areas have TB risks

- 24.5% higher during culling
- 6% lower between 1 and 3½ yrs after the last cull

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With heartfelt thanks to other ISG members:

John Bourne, University of Bristol
(former Director of the Institute for Animal Health)

Sir David Cox, Nuffield College Oxford

George Gettinby, Strathclyde University

John McInerney, University of Exeter

Ivan Morrison, University of Edinburgh

Rosie Woodroffe, Institute of Zoology London

and RAs: Gao Wei, Peter Gilks, Helen Jenkins, Tom Johnston and Andrea Le Fevre

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Thanks also to Defra and agencies:

The Randomised Badger Culling Trial was implemented by the staff of Defra and its associated agencies.

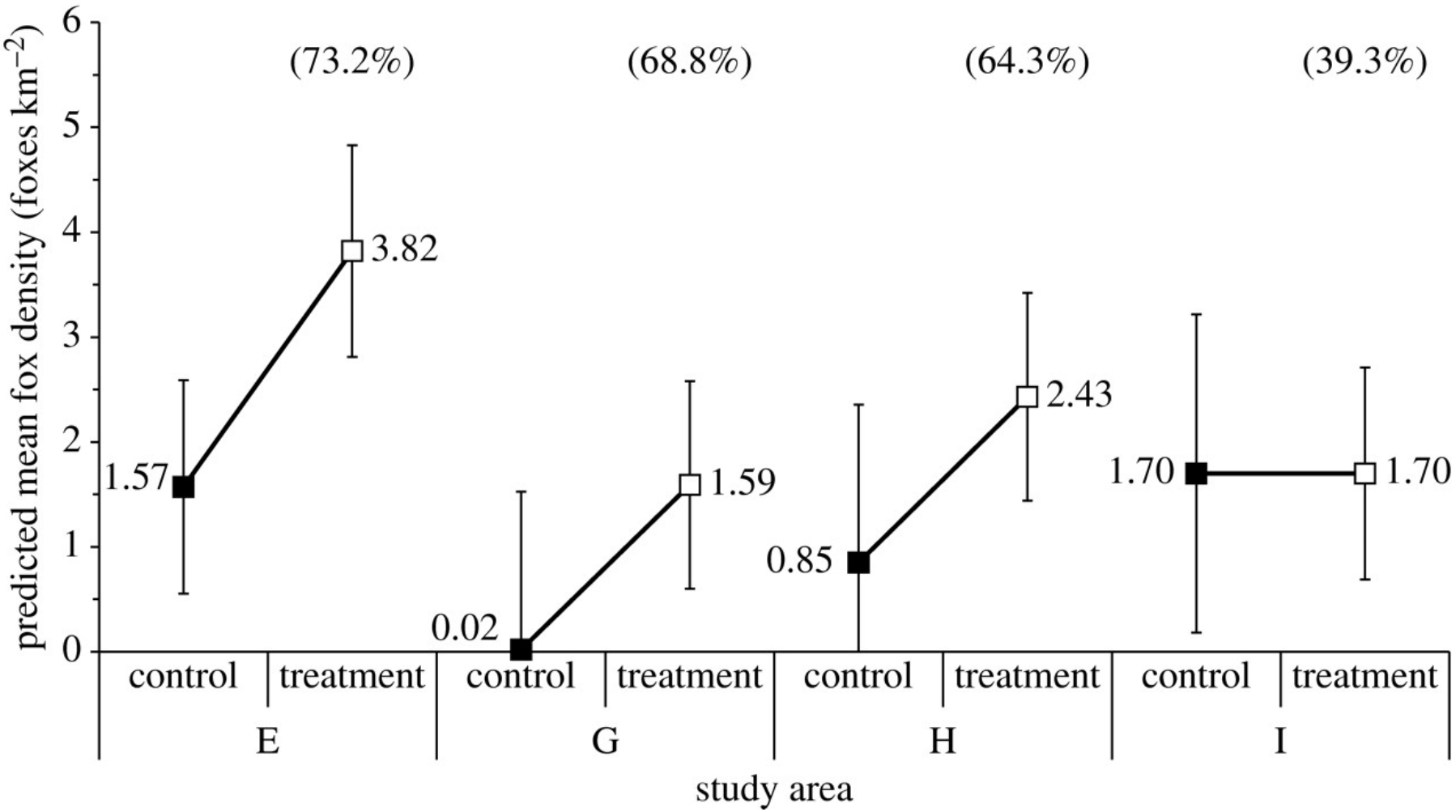
Defra funds the ongoing collection and storage of routine surveillance data, which were utilized in this study.

Defra funded the secretarial and research assistant support for the ISG.

Defra also funds an ongoing project at Imperial College London to undertake further analysis of data from RBCT trial areas.

biology letters

Predicted mean fox densities (and SEs) in response to experimental badger culling



Trewby I D *et al. Biol. Lett.* 2008;4:170-172

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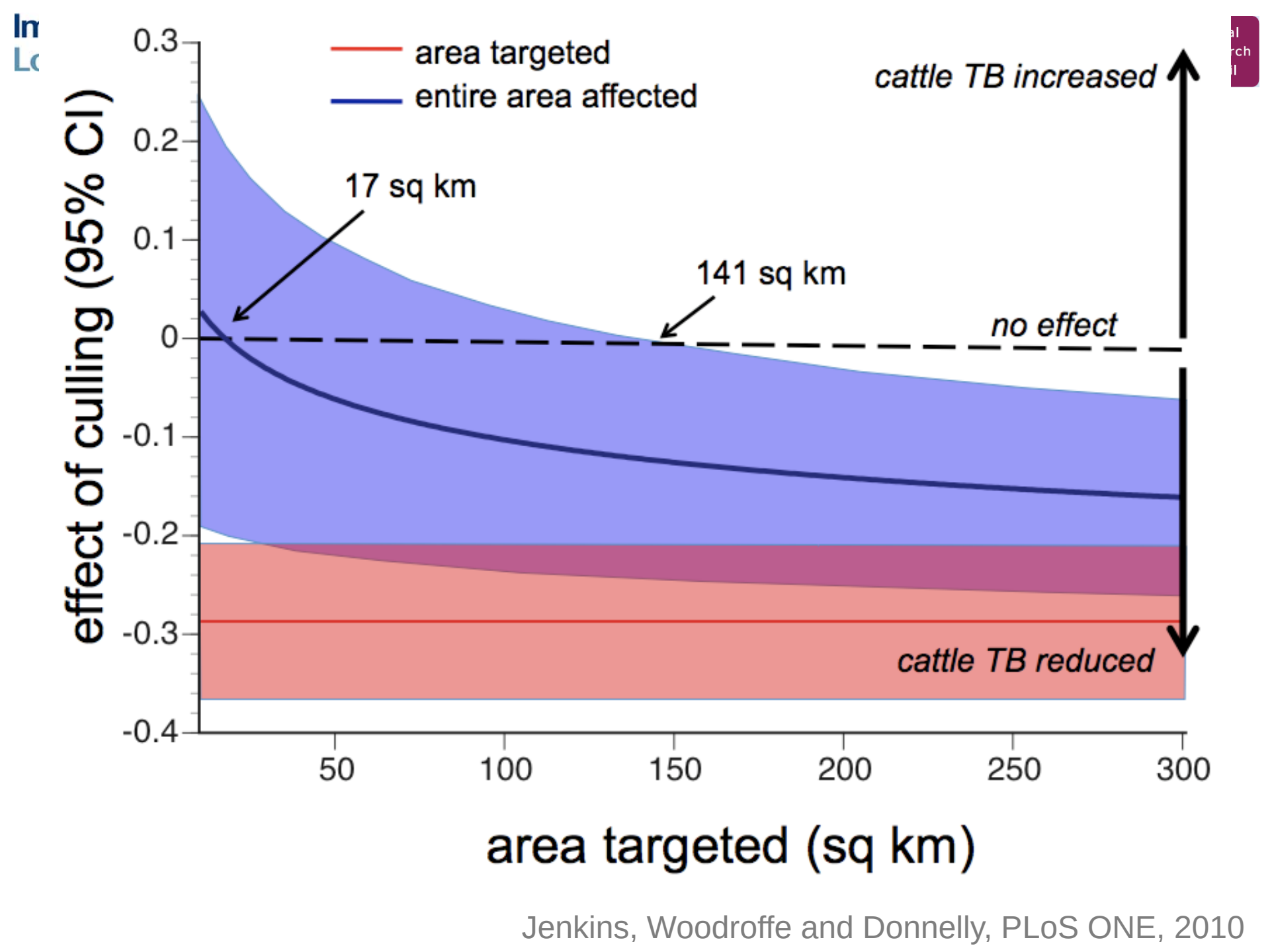

Jenkins, Woodroffe and Donnelly, PLoS ONE, 2010