‘Ghost Hosts’
Quantifying TB freedom in a multi-host maintenance-spillover wildlife system

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NZ aims to eradicate TB from wildlife

- From 2.5m ha (10% of NZ) during 2011-2026 period
  - A quarter of the area with a risk of wildlife TB
  - ~800,000 ha declared provisionally free since 2011
  - Mostly farmland areas with easy access and relatively few wildlife
  - Not yet from a large forested area

⇒ **Key NPMP aim: Determine feasibility of eradication from two such areas**

(Hauhungaroa and Hokonui)

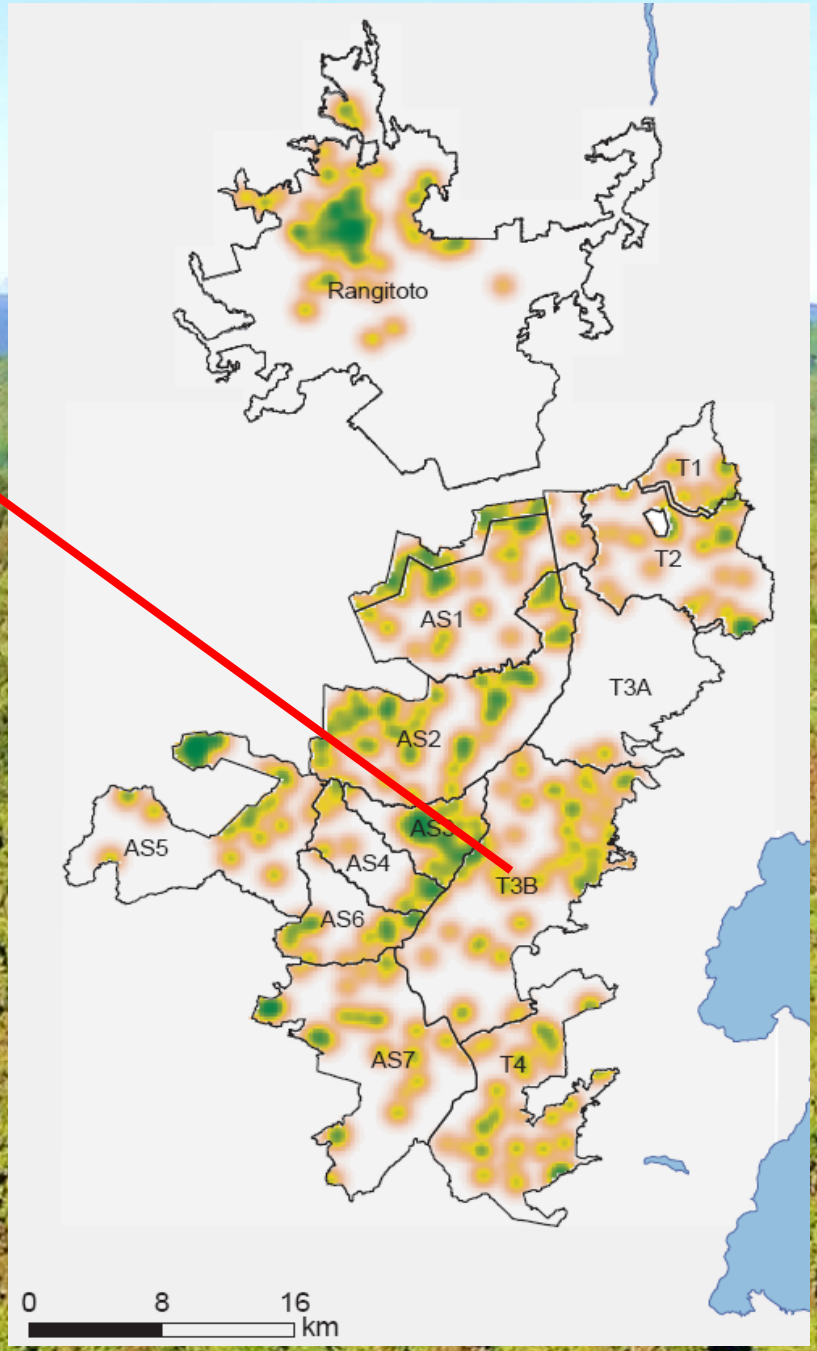
Can Tb be eradicated from a wildlife host?

- Only one country (Aust.) has ever eliminated TB from a wildlife maintenance host
  - Buffalo - big and easy to see, and muster or shoot – much the same as cattle
- In NZ, the main TB host is possums
  - Small, abundant (up to >10/ha), forest dwelling, nocturnal, widespread

=> Much much more difficult

Hauhungaroa and Rangitoto Ranges (HRR)

Tihoi 3B VCZ
13800 ha



- 122,000 ha
- TB present in possums, pigs, deer, since 1970s
- Dense tall rain forest, unroaded, difficult access

=> Possum control mostly by aerial 1080 poisoning

This project: Aims

- Assess 2011-2014 progress toward TB freedom in possum in HRR by;
  - Modelling likely effectiveness of possum control in eliminating TB from possums
  - Summarising outcomes of TB surveillance (in possums and other sentinel species (pigs and deer)
  - Quantifying current probabilities of TB freedom
  - Exploring epidemiological significance of continued TB detection in sentinel species

Modelling of effectiveness of possum control in eliminating TB from possums

- In 1981-83, TB widespread, 2-3% of possums infected, population 500,000?
- Possum control applied since 1994, but full coverage not till 2005
  - Last known TB possum in 2005
  - TB+ve deer and pigs found in late 2013.

Control History Examples

(estimated reductions from control operations)

VCZ	2005	2006	2007	2008	2009	2010	2011	2012	2013
AS2	97%						31%		89%
AS3	95%						91%		
AS4	97%						92%		99%
T3B	97%						92%		
T1	90%					50%		50%	50%
T3A	97*%					36%		58%	

Possum/Tb Spatial population model

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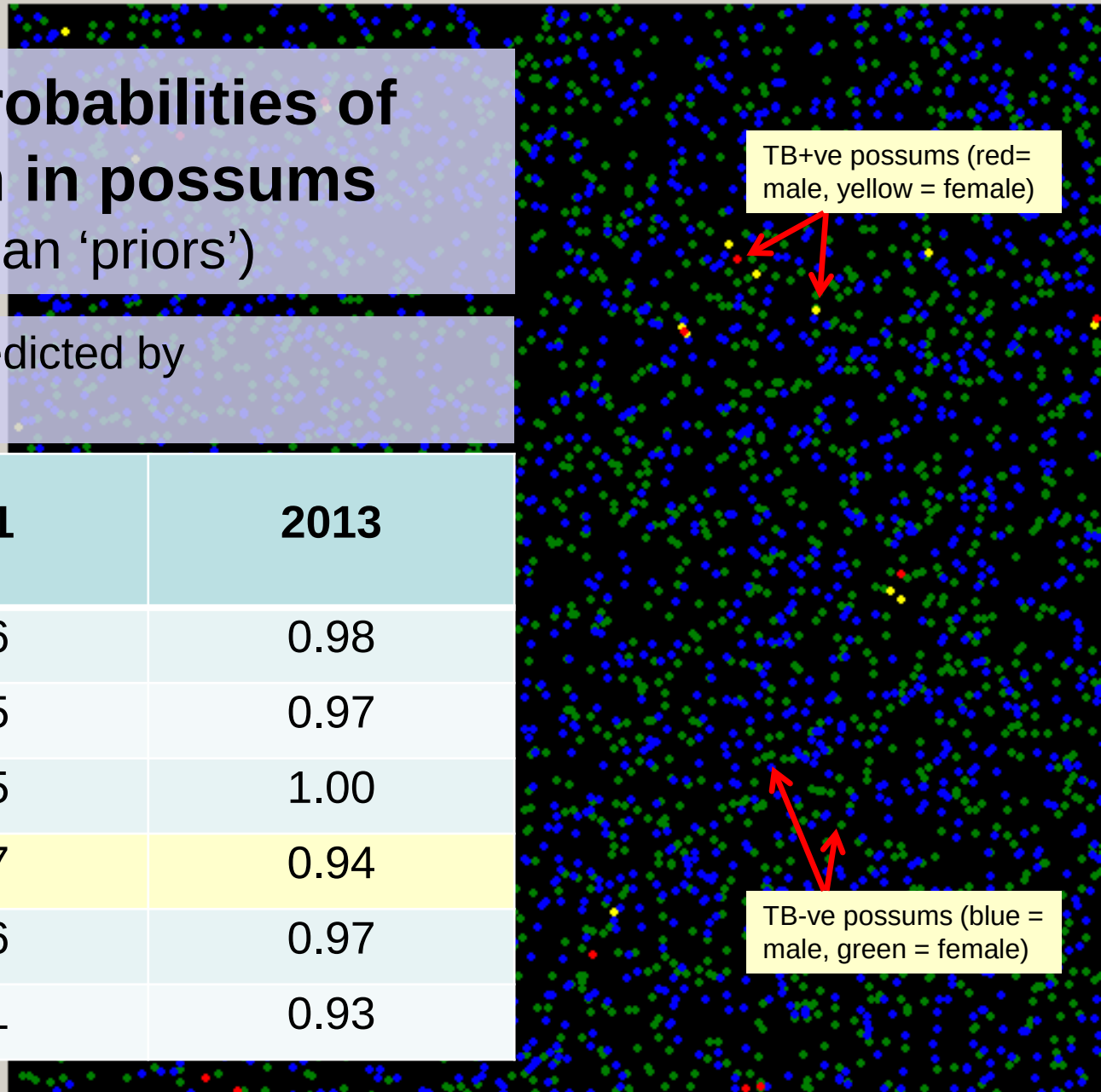
Predicted probabilities of TB freedom in possums

(= Bayesian 'priors')

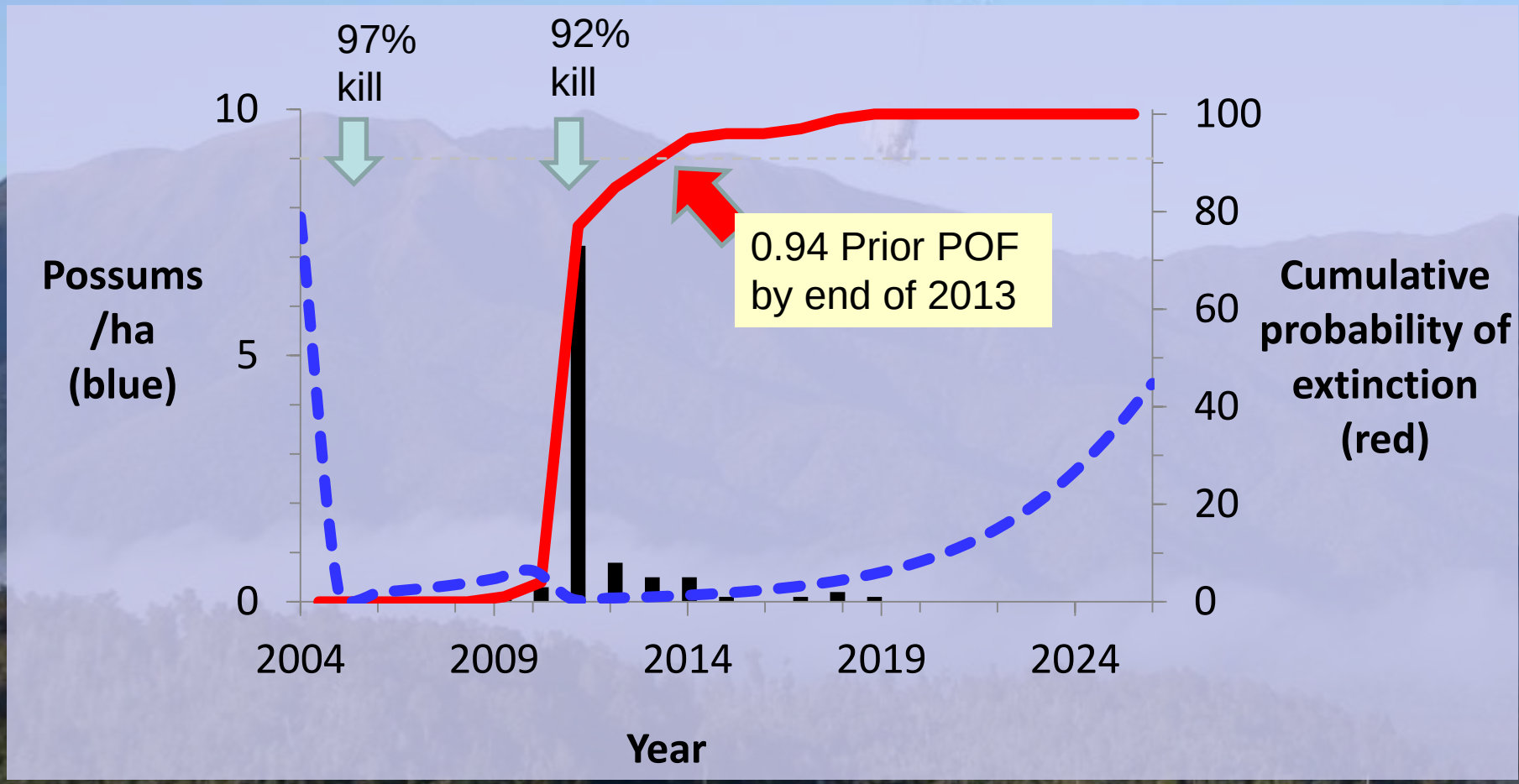
Output probabilities predicted by Spatial Possum Model

VCZ	2011	2013
AS2	0.56	0.98
AS3	0.95	0.97
AS4	0.95	1.00
T3B	0.87	0.94
T1	0.86	0.97
T3A	0.61	0.93



Simulating impact of control on TB persistence

Tihoi 3B (ignoring pre 2005)



Validation through empirical TB surveillance

Sentinel surveys

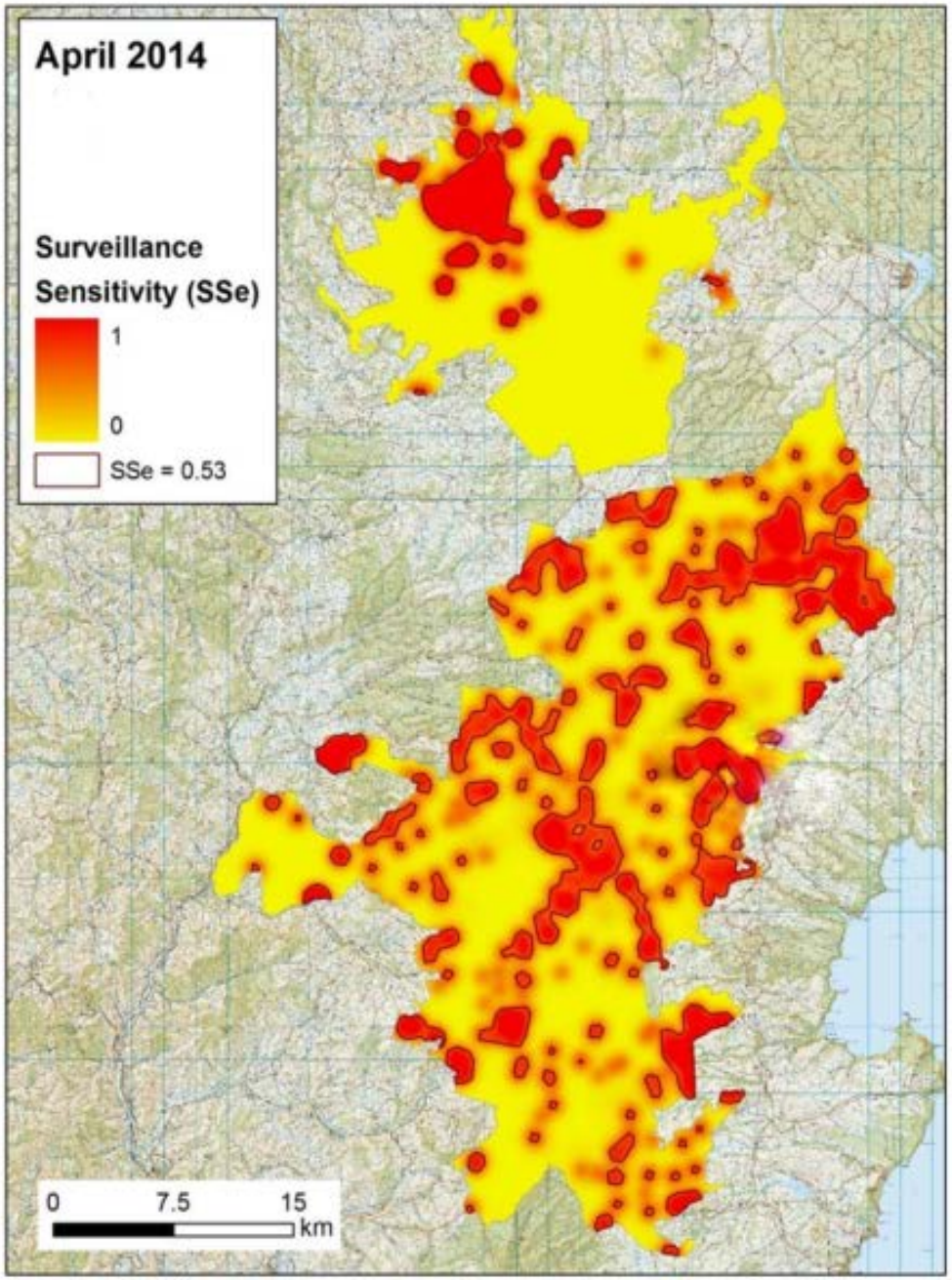
Number (N) and density (N/km^2) pigs and red deer obtained within each VCZ in 2012

VCZ	Area (km^2)	Pig		Red Deer	
		N	N/km^2	N	N/km^2
AS2	105.3	55	0.52	7	0.07
AS3	29.8	23	0.77	1	0.03
AS4	30.5	15	0.49	–	–
AS5	90.0	33	0.37	–	–
Tihoi 3B	138.1	61	0.44	24	0.17
Tihoi 3A	84.2	3	0.04	4	0.05

Quantifying current probabilities of TB freedom

Illustrative example 2011-2013

VCZ	Predicted prior Sep 2011	Adopted prior	Pigs	Deer	All sentinels	Possum only
AS2	56	0.56	55	7	0.642	-
AS3	95	0.90	23	1	0.952	0.932
AS4	95	0.90	15		0.909	-
AS5	91	0.90	33		0.910	-
Tihoi 3B	77	0.77	61	24	0.799	-
Tihoi 3A	61	0.61	3	4	0.609	0.619



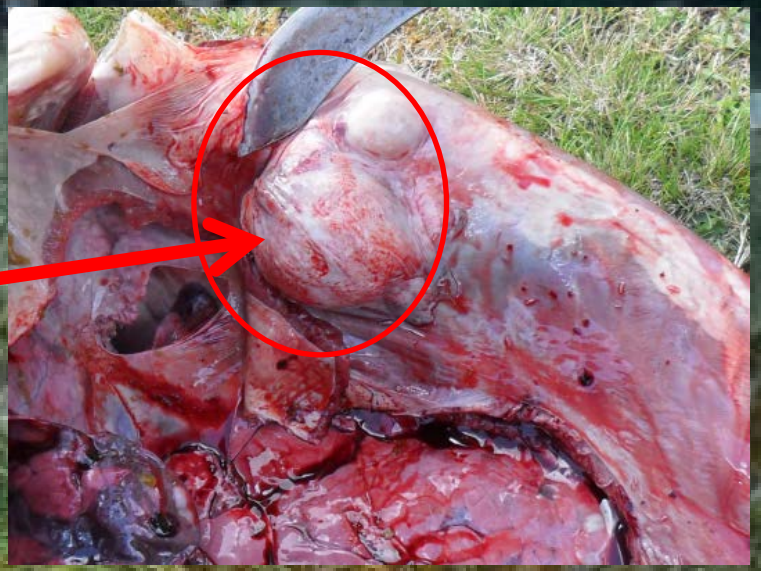
2013-2014 Sentinel Surveillance efficacy

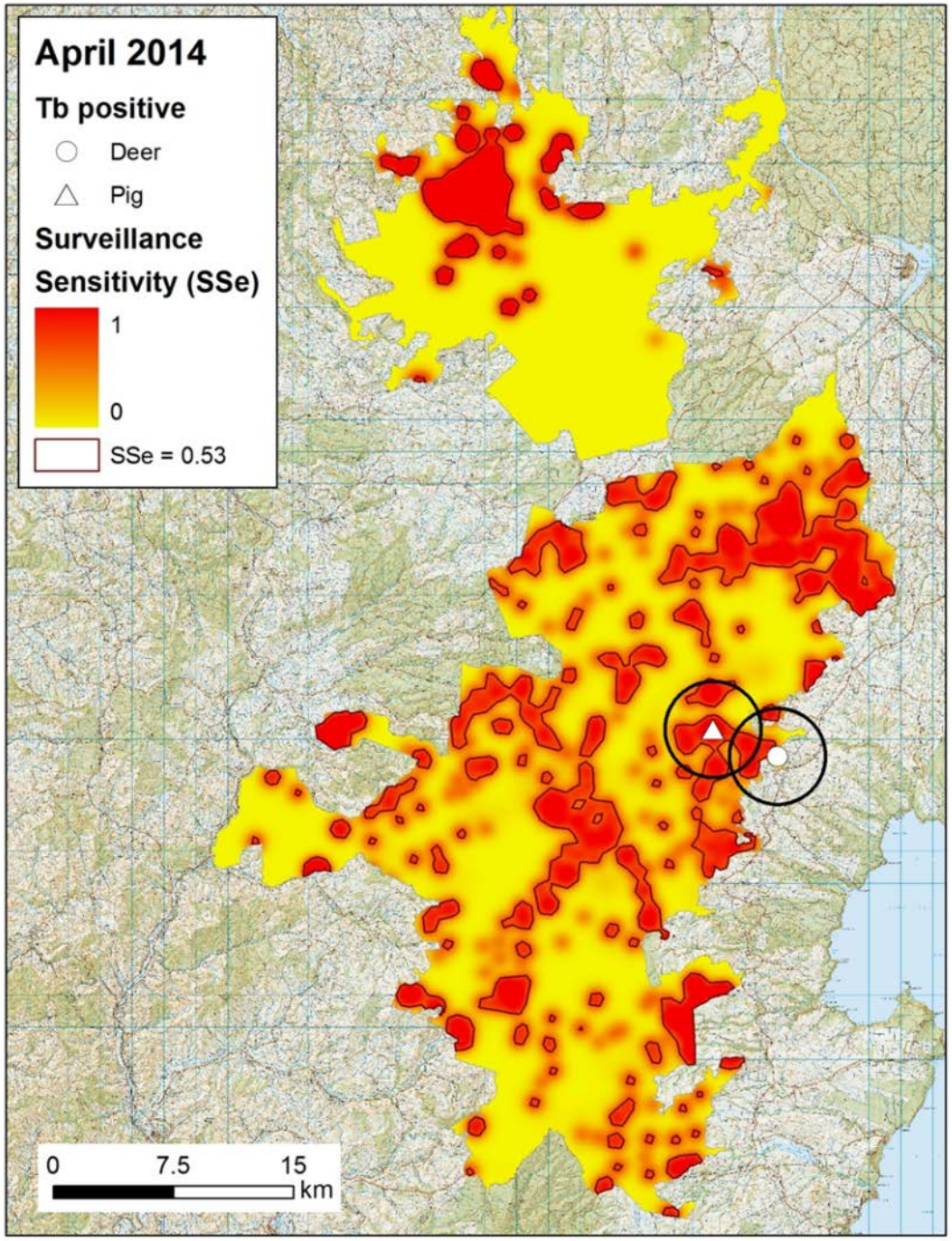
- Current low intensity sentinel surveys producing worthwhile data at low cost ($1/ha/yr)
- Already sufficient to confirm freedom over ~40% of HRR

- **BUT ONLY IF NO TB+ves FOUND**

Continued TB detection in sentinel species

- No TB+ves found in July 2012 – June 2013 samples (n = >400)
- But then Spring 2013 TB positive pig
- Followed by (Dec 2013) lesioned deer (5 y old)
- AND culture positive deer (1 y old).





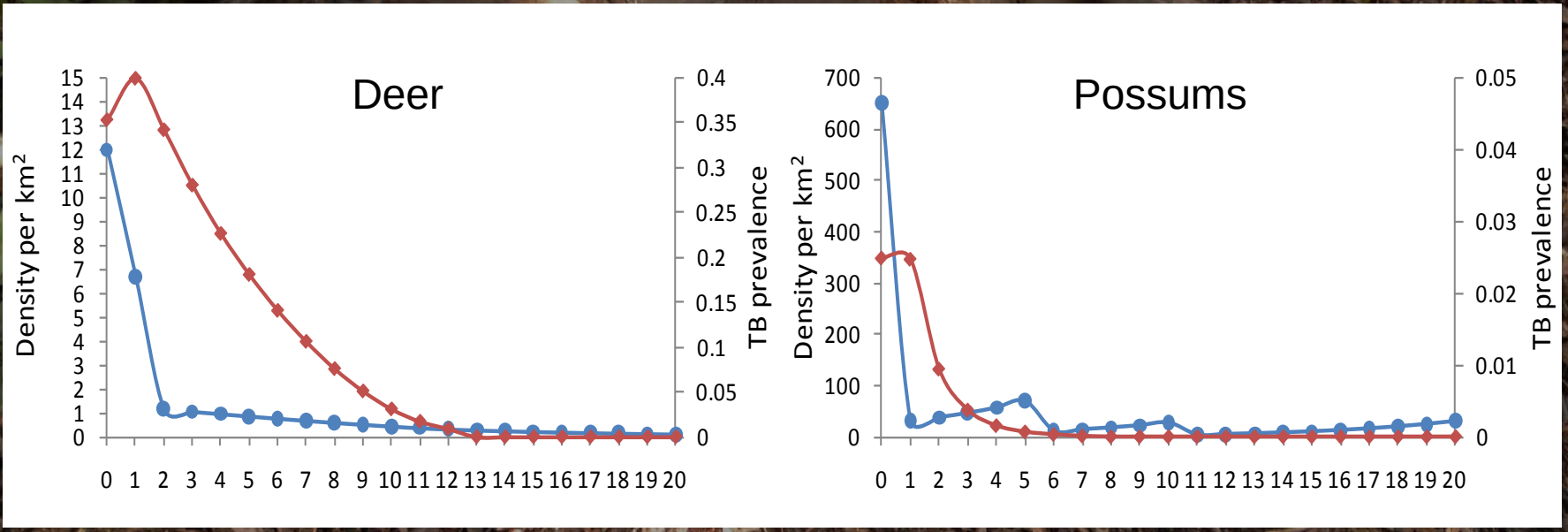
Consequences

- Survival of TB in deer long ago expected
- But TB+ve deer appears to indicate TB still present in possums until at least 2010, and possibly 2013
- Are the SPM predictions wrong? Maybe, Maybe not.
- But, certainly, all pig and deer data collected to date now redundant
  - At very least within 3-5km of TB deer

Modelling spillback risk

- Rate of spillback not known
- Simulated ‘probable-extreme’ parameters
- TB eradicated from possums with 7 years
- Spillback risk persists for 14 years

=> Possum density must be kept low for 15 years



Consequences II

- Further possum control still needed
  - despite SPM predictions of >90% chance TB will have been eradicated from possums in all VCZs by 2015
  - Such control already long planned – 'final' operations in 2015-2018 period.

- **IF** both 2013 TB deer remain confirmed, spill back risk until 2030 in those vicinities? (albeit negligibly small by then)

=> Revised surveillance strategy required?

Some surveillance options

- In VCZs **with no** TB+ve sentinels;
  - low-intensity sentinel surveillance – free by 2020-2025
  - post-control possum surveillance – free by 2018-2020
- In VCZs **with** TB+ve sentinels, could adopt either option with 5-10 year delay (depending on TB+ve sentinel age)
- Alternatively, **in all** VCZs, implement high cost possum surveillance coupled with high intensity control
  - i.e.; ensure that deer/pigs = ghost hosts of no epidemiological significance (possum density too low for reestablishment)
  - free by 2016-2020

Summary

- Eradication of TB from a large forested area is within reach
- High probability TB already gone from possums (or will be very soon)
- But declaration of freedom will be delayed by ghost hosts
- Strategic choice;
  - Either wait it out till 2020-2030
  - Or aim at 2016-2020 by (i) confirming TB absence in possums and (ii) keep possum density too low for re-establsih freedom by 2018-2020
  - ment until after 2020.

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Ghost hosts: Complexities in quantifying TB freedom in a multi-host wildlife system.

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Introduction: New Zealand aims to quantitatively demonstrate freedom from bovine tuberculosis in wildlife from 2.5 million ha by 2026. This paper outlines progress toward biological eradication of TB from all wildlife hosts in the ~80,000-ha Hauhungaroa Ranges, an unfarmed forested area of difficult terrain. It highlights the complexities in quantifying TB freedom when multiple wildlife hosts are involved

Methods: We show how progress toward achieving TB freedom in the main wildlife maintenance host (possums, *Trichosurus vulpecula*) is being quantified, and then explore the implications of ongoing detection of TB in long-lived sentinel species (wild pigs and deer) but not possums.

Results and discussion: TB was once widespread in possums at 2-6% prevalence, but has not been detected in possums since 2005, when effective possum population control was first achieved for the entire area. Modelling and limited direct survey indicates the likelihood of TB persisting in possums is very low, but TB is still being found occasionally in the sentinel species. The conundrum is that absence of TB in sentinels implies absence in possums, whereas TB presence in sentinels does not conversely imply presence in possums. TB in long-lived sentinels may simply reflect residual ‘ghost-host’ infection with epidemiological significance for TB freedom. The implications for decision making will be discussed.