ENDEMIC DISEASE MANAGEMENT MEETS THE INTERNET-OF-THINGS

A marriage made in heaven……literally

Kevin Crews, Richard Curtis: OSPRI NZ Ltd

TBfree is an OSPRI programme

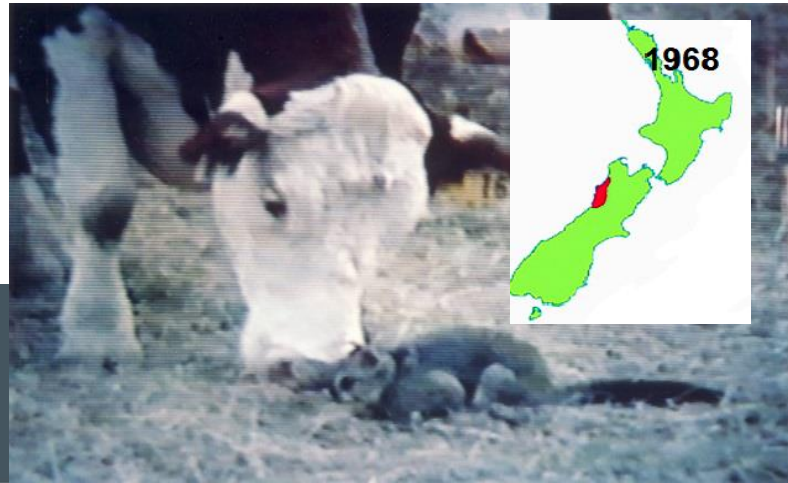
ORIGINS OF BOVINE TB IN NEW ZEALAND

- Introduced via cattle brought in with European colonisation in 1830s-1840s
- Still present nearly 200 years later

OSPRI

1960s-1970s: "THE OPTIMISTIC START"

- 79% of 40,000 herds under test "accredited" by August 1976
  - Additional 5,500 herds on verge of accreditation
- **TB eradication** expected to be achieved soon after
- Area on West Coast with TB persistence in cattle herds
- Identification of cattle-TB-possum link
- Discovered in other areas subsequently



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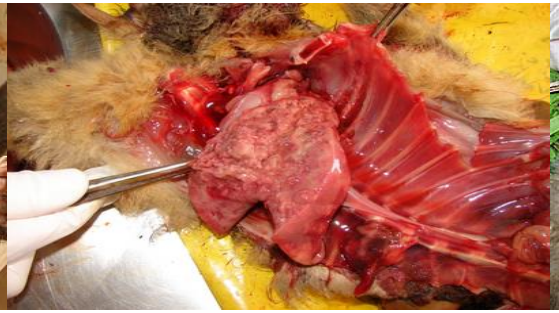
POSSUM-TB-CATTLE LINK



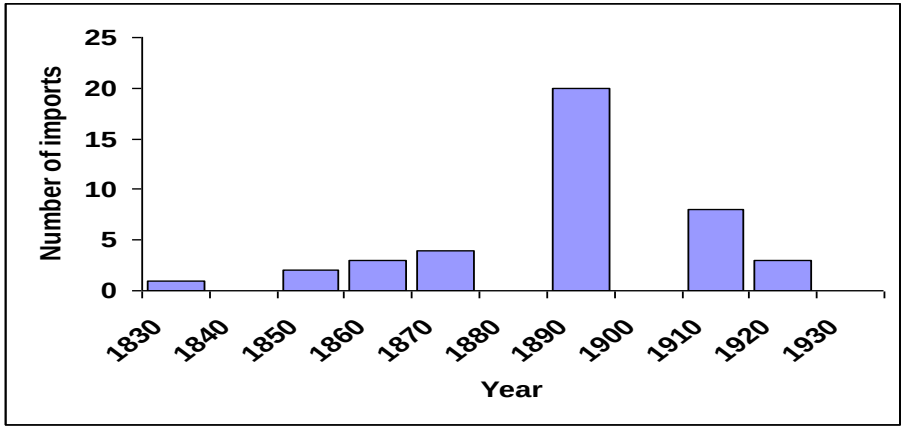
Ref: Paterson et al (1995); New Zealand Veterinary Journal, 43:7

Australian brushtail possum

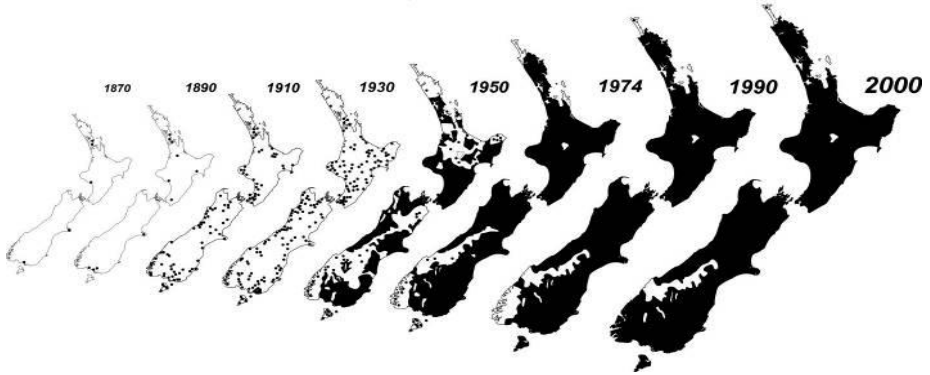
(Trichosurus vulpecula)

Imported from Tasmania & mainland Australia to establish a fur industry

OSPRI



NZ Possum spread 1870 - 2000



Australian brushtail possum (Trichosurus vulpecula)

- 31 batches of possums imported between 1837 & 1922
- Multiplied in captivity and liberated (160 sites)

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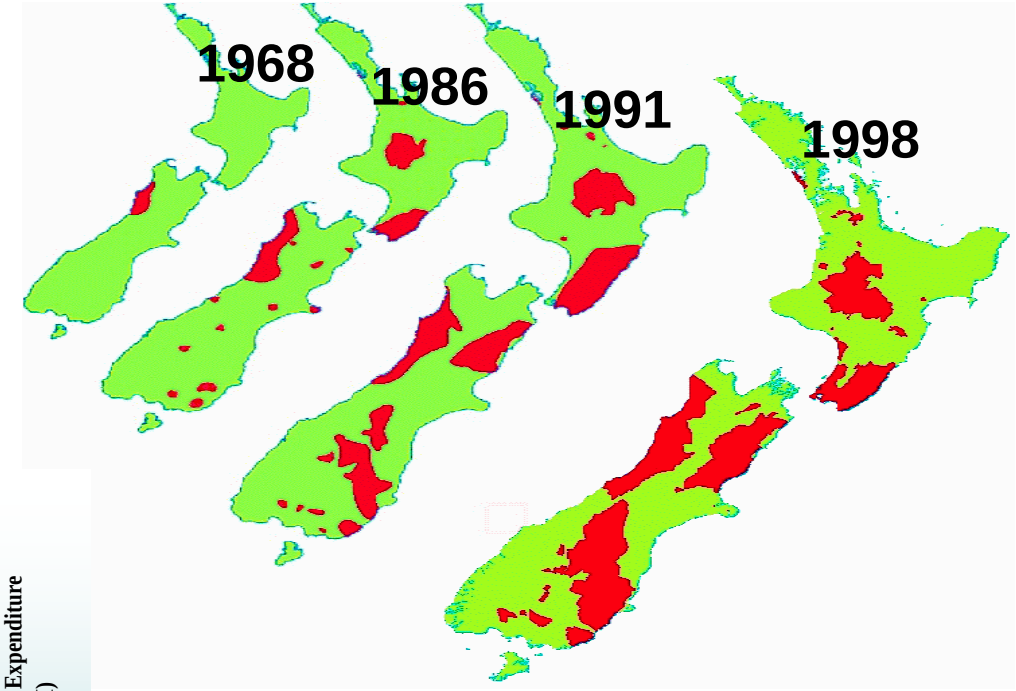
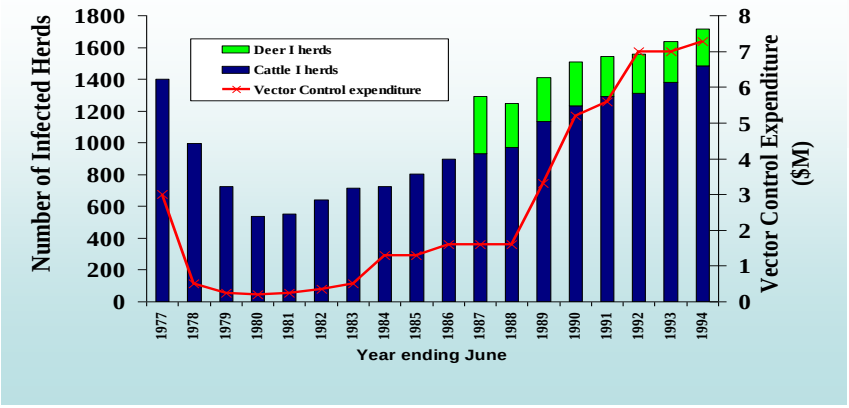
EARLY GAINS BUT SHORT-LIVED





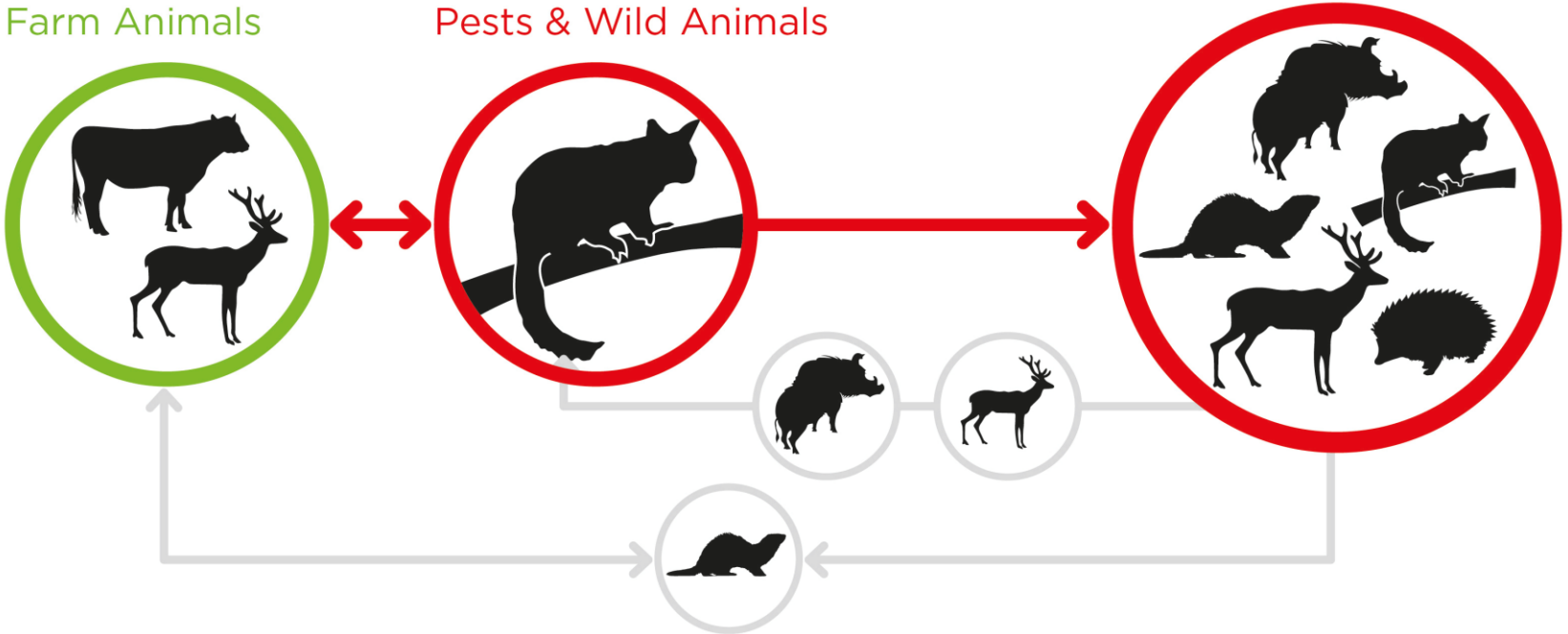
TB Endemic Areas

PROGRESSIVE BTB CONTROL UNDER THE BIOSECURITY ACT 1993

- NPMP 1 (1998-2001): Stabilisation of TB situation
- NPMP 2 (2002-2011): OIE country freedom
- NPMP 3 (2012-2015): Proof of concept TB eradication

CRACKING-THE-CODE FOR BTB ERADICATION

TB SPREAD BETWEEN SPECIES

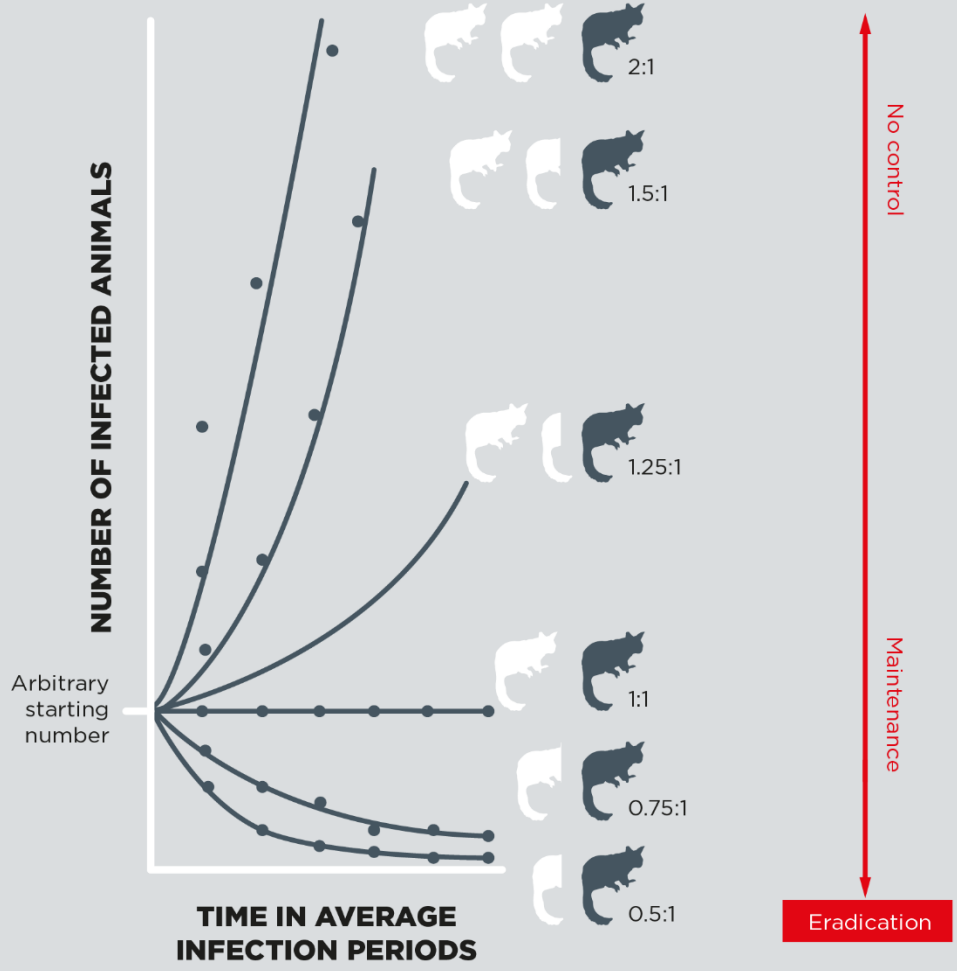


Ref: Morris & Pfeiffer (1995); New Zealand Veterinary Journal, 43:7

ERADICATING TB FROM POSSUMS

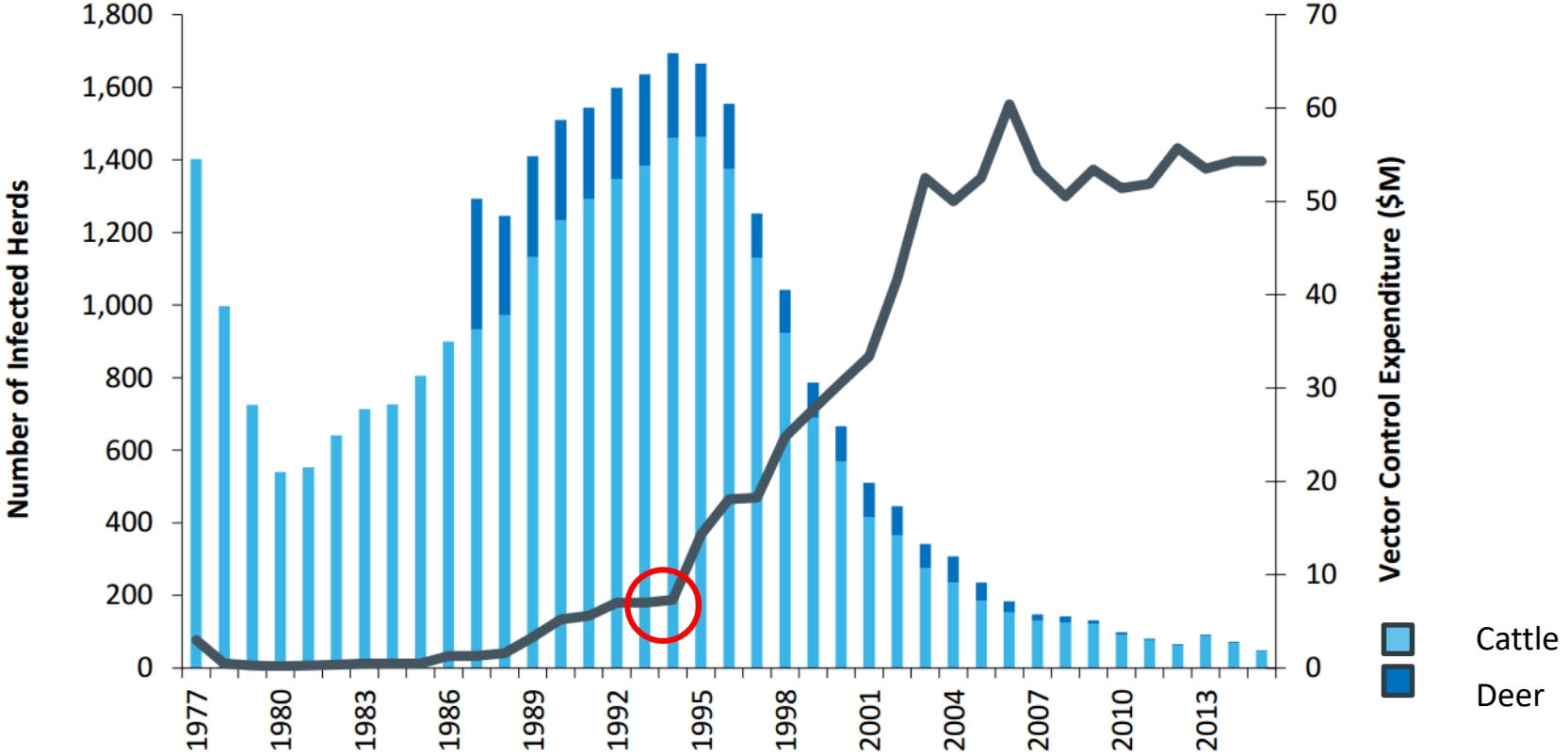
KENDALL'S THRESHOLD THEOREM

(Adapted from Veterinary Epidemiology 2nd Ed.1995)



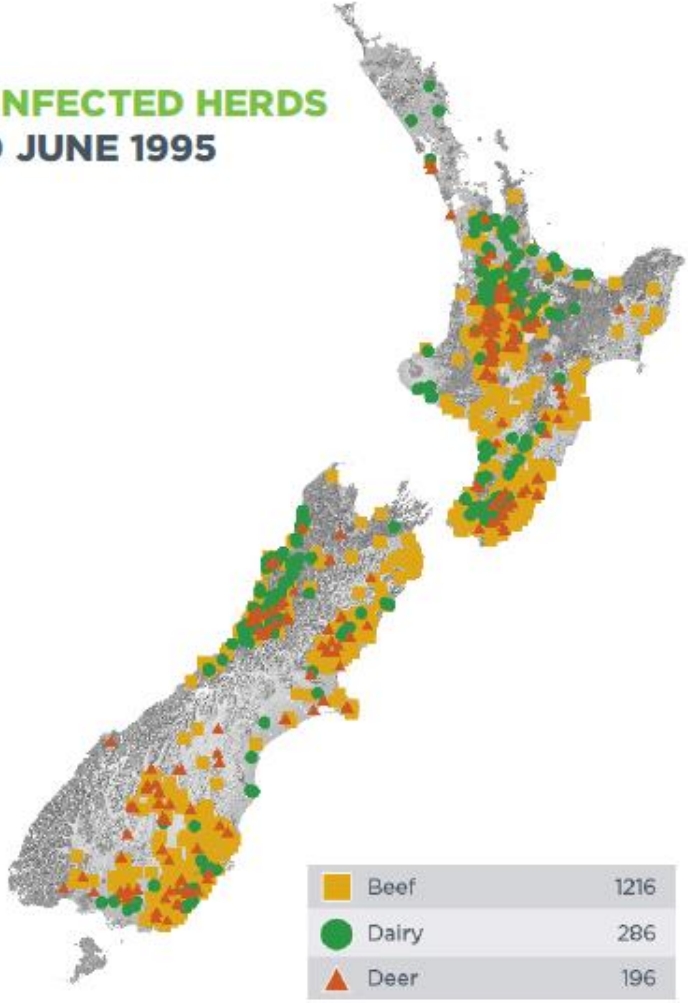
Ref: Ramsey & Efford (2010); Journal of Applied Ecology, 47

TB INFECTED HERDS 1977 - 2019

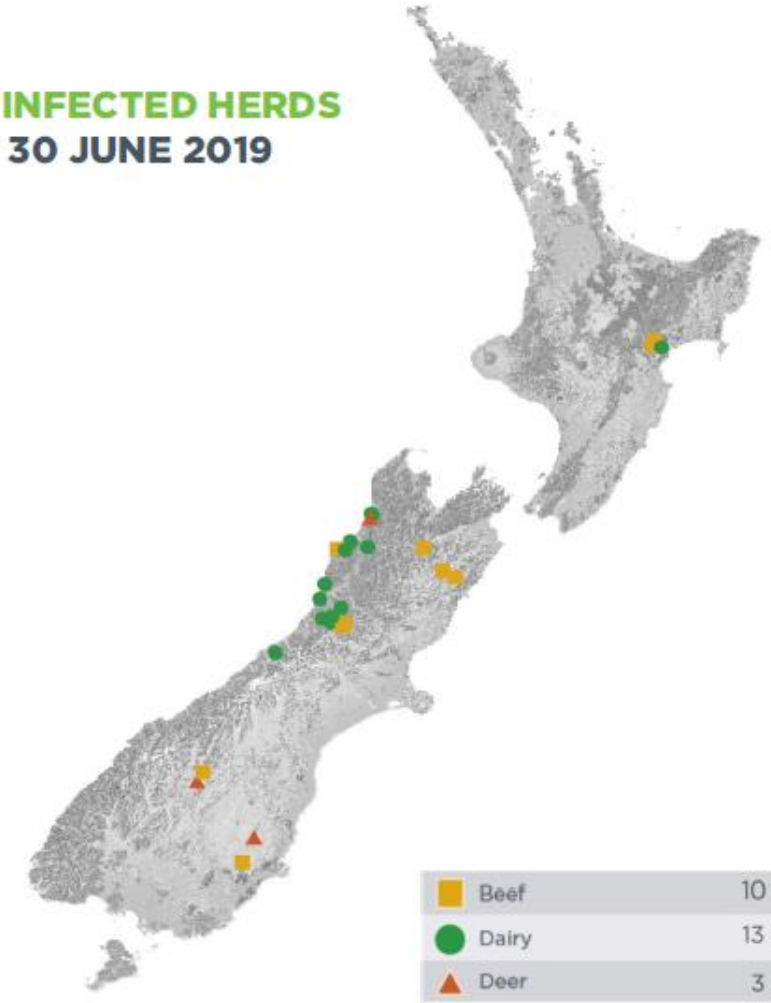


OSPRI

1698 INFECTED HERDS
AT 30 JUNE 1995



26 INFECTED HERDS
AT 30 JUNE 2019



NZ TB CONTROL UNDER THE BIOSECURITY ACT

Series of progressive National Strategies & Plans leading towards the ultimate goal of eradication:

- NPMP 1 (1998-2001): Stabilisation of TB situation
- NPMP 2 (2002-2011): OIE country freedom
- NPMP 3 (2012-2015): Proof of concept TB eradication
- **NPMP 4 (2016-2055): Biological eradication in NZ**

OUR GOALS

2026

2040

2055

< 0.2% PERIOD PREVALENCE

OUR GOALS

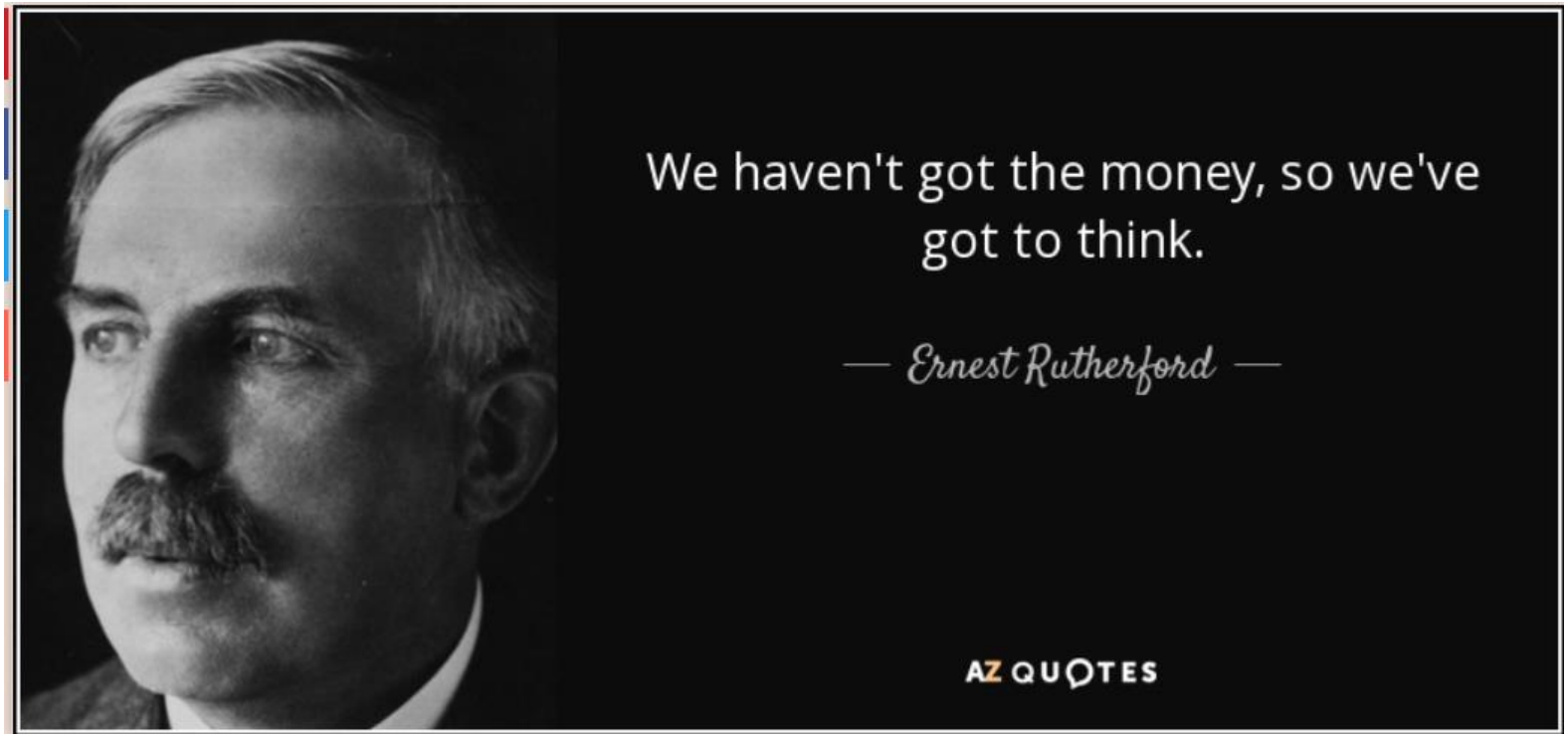
?

2026

2040

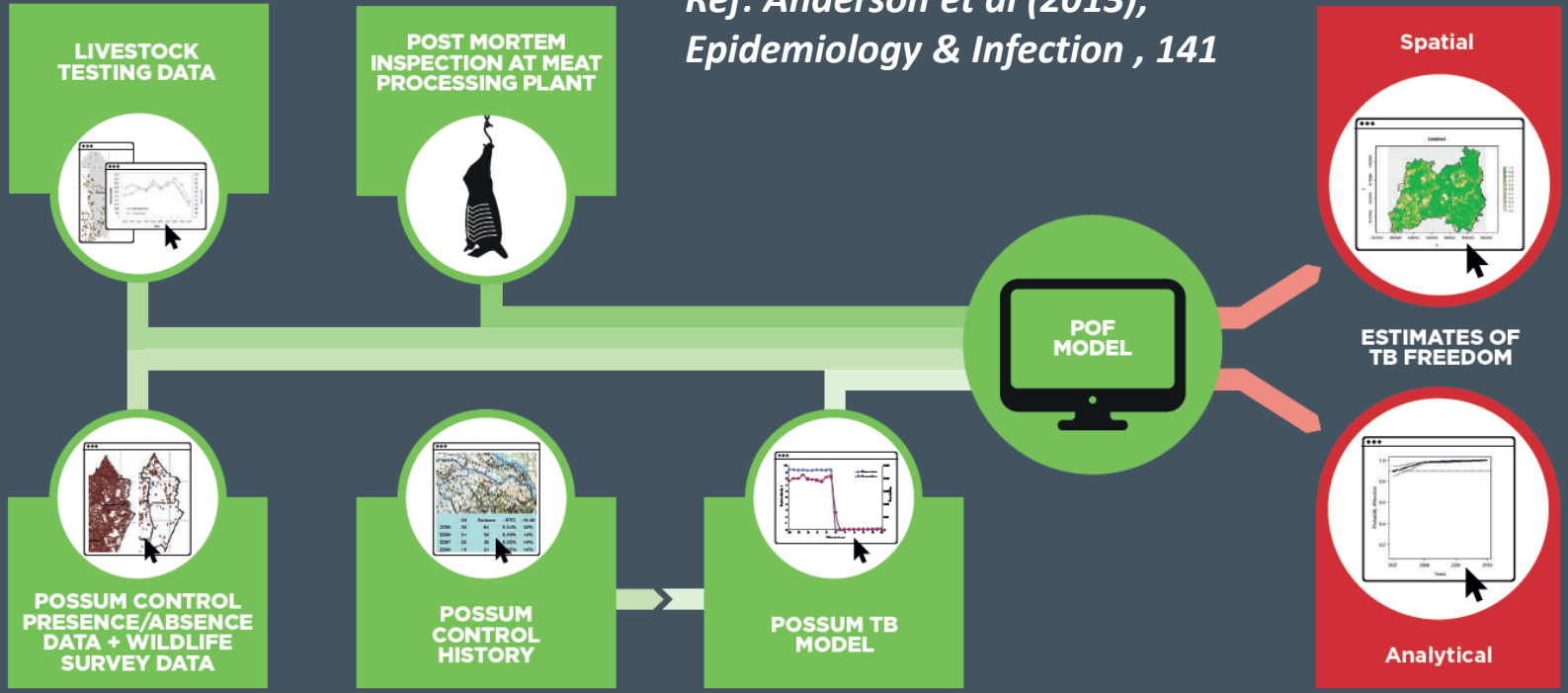
2055

< 0.2% PERIOD PREVALENCE


We haven't got the money, so we've got to think.
— Ernest Rutherford —
AZ QUOTES

PROOF-OF-FREEDOM FRAMEWORK
(POF) MODEL

Ref: Anderson et al (2013); Epidemiology & Infection , 141



Proof-of-Freedom

Probability of Freedom

Our conclusion depends on:

1. How confident we were that no TB remains in possums **before** looking.
2. How hard did we look?
3. How confident do we want to be in declaring wildlife is TB free

$$PoF = \frac{Prior}{1 - (SSe(1 - Prior))}$$

Thomas Bayes
1701-1761

Bayes' theorem

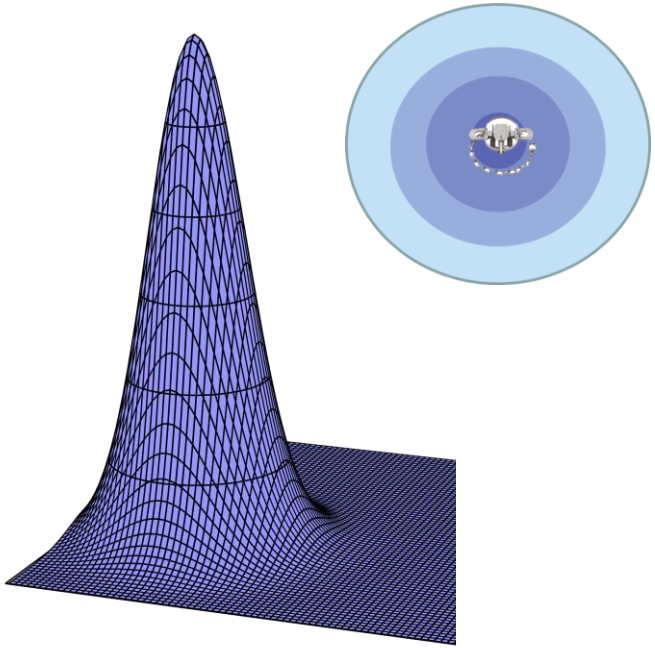
Prior: Prior probability TB is absent

SSe: System-level sensitivity - chance of finding TB if present

PoF: Posterior probability of freedom

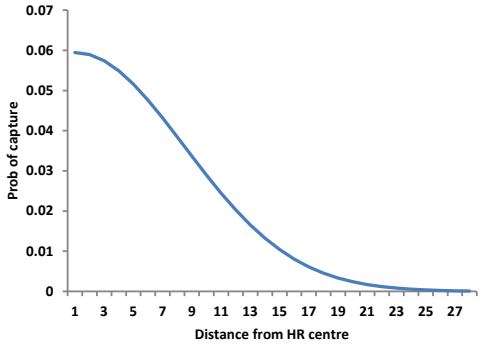
Source: Andrew Gormley, MWLR: OHA 2019

DETECTING PRESENCE/ABSENCE OF POSSUMS FOR TB POF



g0 = probability of catching or detecting an animal at the centre of its home range on one night

σ = Standard deviation of the half-normal curve



Source: Bruce Warburton (2012); MWLR

THE SPIRIT OF ERNEST RUTHERFORD

Novel devices to detect presence/absence of possums

Pros:

- Lightweight & easy to deploy in scale
- Cheap per unit cost
- Wide coverage in accessible terrain
- Readily convertible into data for POF

Cons:

- Manual deployment/recovery/interpretation
- Single use & short lifespan
- Moderate-to-poor detection sensitivity/specificity
- Unsuitable for certain terrain

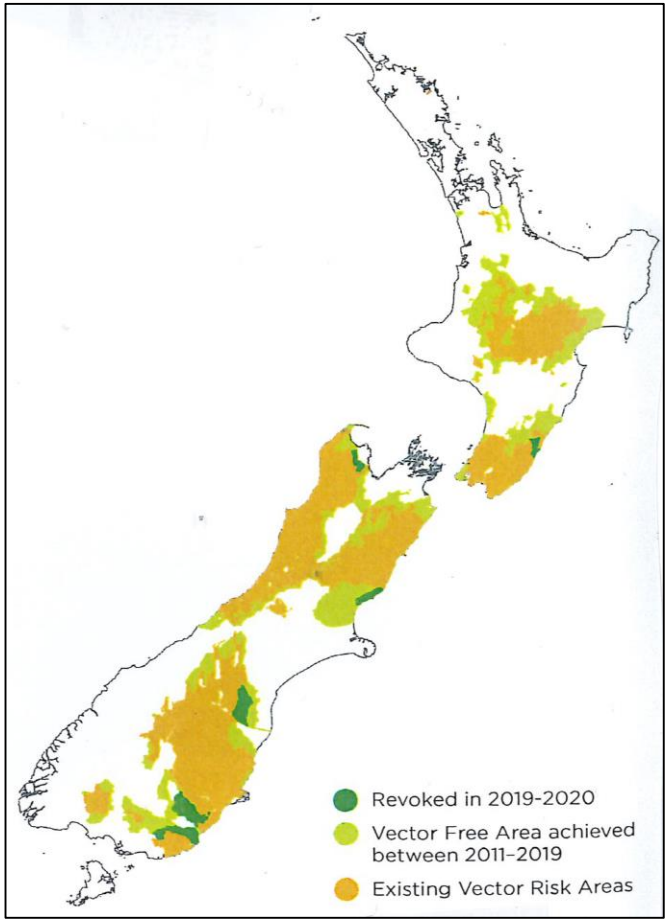
POSSUM TB FREEDOM FOR VECTOR RISK AREAS

- 2011: 10 million ha Vector Risk Area

- 2011-2020: 2.73 million ha declared TB free
  - Arguably the “low-hanging fruit”?

- 2020: 7.27 million ha remaining
  - Dense continuous native forest
  - Remote mountainous high country
  - Difficult & dangerous terrain
  - Expensive to control/survey

Source: OSPRI Annual Report 2019/20



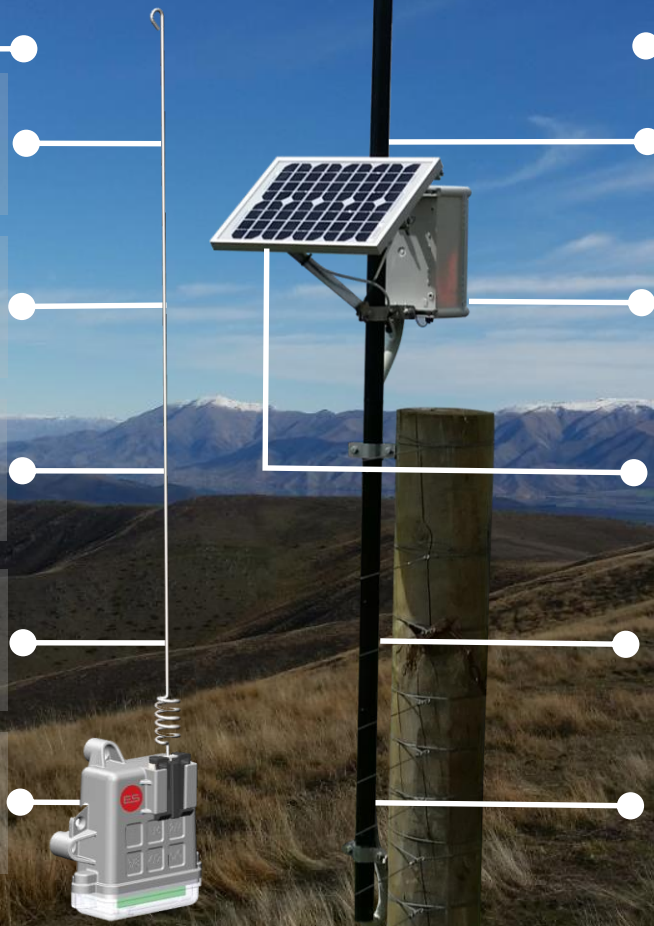
THE SPIRIT OF ERNEST RUTHERFORD
Novel detection devices 2.0 (the Internet-of-Things)

- Two proof-of-concept trials on use of remote sensing and remote data transfer for detecting possum presence/absence
- Areas where existing detection technology too difficult or dangerous to deploy
- Test concept of “set-&-forget” and “24/7” detection
- Address sensitivity/specificity weaknesses of existing detection technology
  - Increase SSe and greater POF confidence
- Test ability to direct data feed into OSPRI POF model

CELIUM EQUIPMENT

CELIUM NODE

- Wireless Communication Device
  Internal Sensors
  External Sensor Input Option
- Adaptable and Multi-Functional
  In Ground and Hub Relay Configurations
- Low Maintenance and Long Operating Life
  Configurable Battery Options
- Command and Control Over-The-Air
- Wirelessly Coupled Antenna
  Built-in Keypad for Standalone Operation



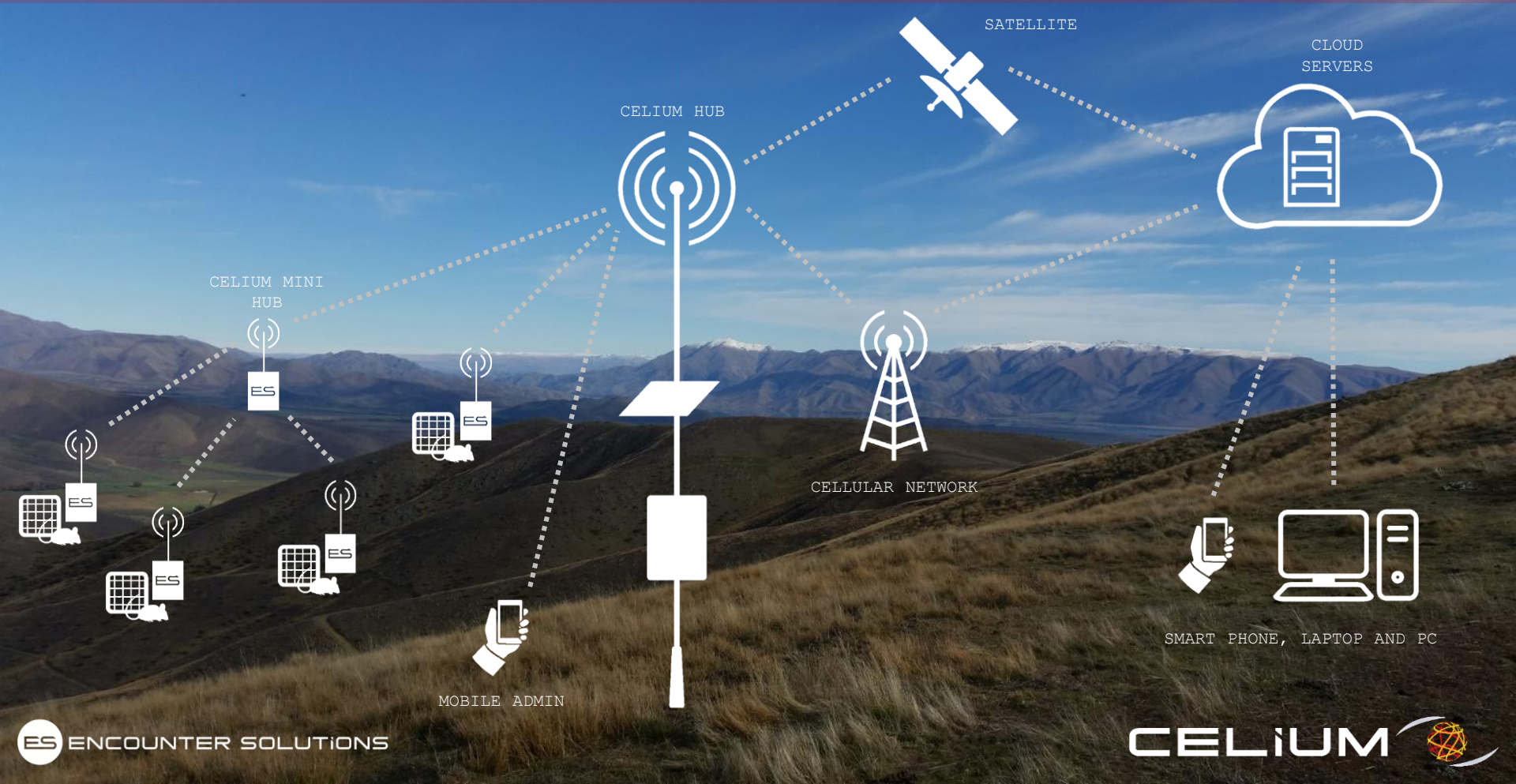
CELIUM HUB

- Administers Over 1000 Nodes
  Update Firmware Over-The-Air
- Iridium Satellite for Connectivity Anywhere
  Cellular and Relay Options
- Solar Charged
- Portable, Lightweight Design
  Ruggedized and Stock-Proof
- Flexible Mounting Options

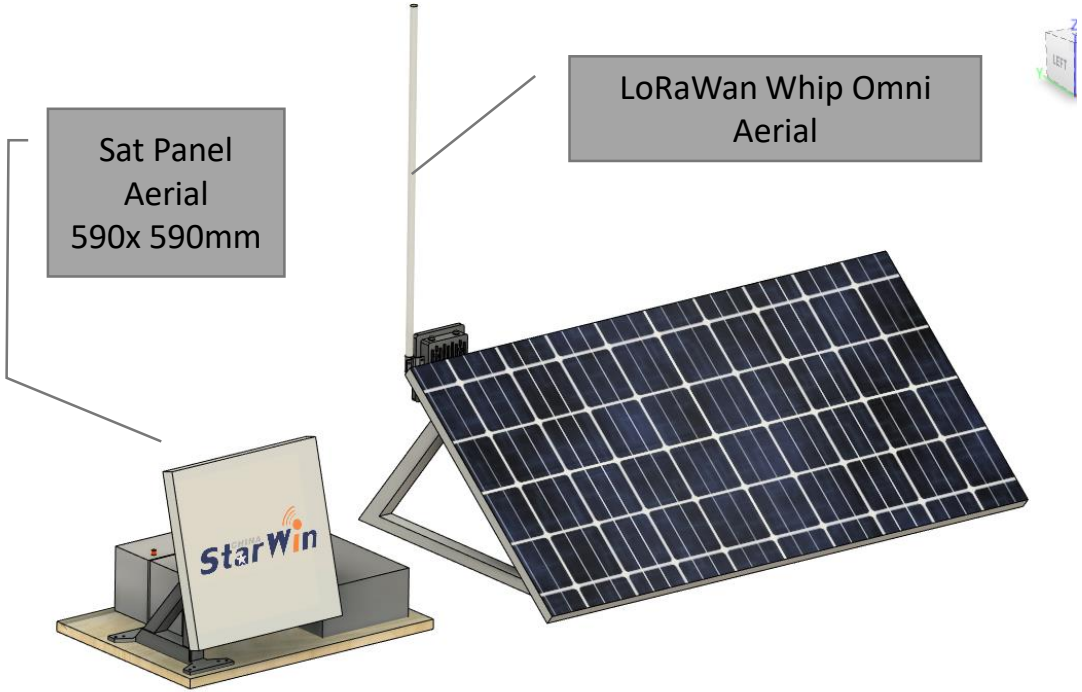
ENCOUNTER SOLUTIONS

CELIUM

CELIUM OVERVIEW



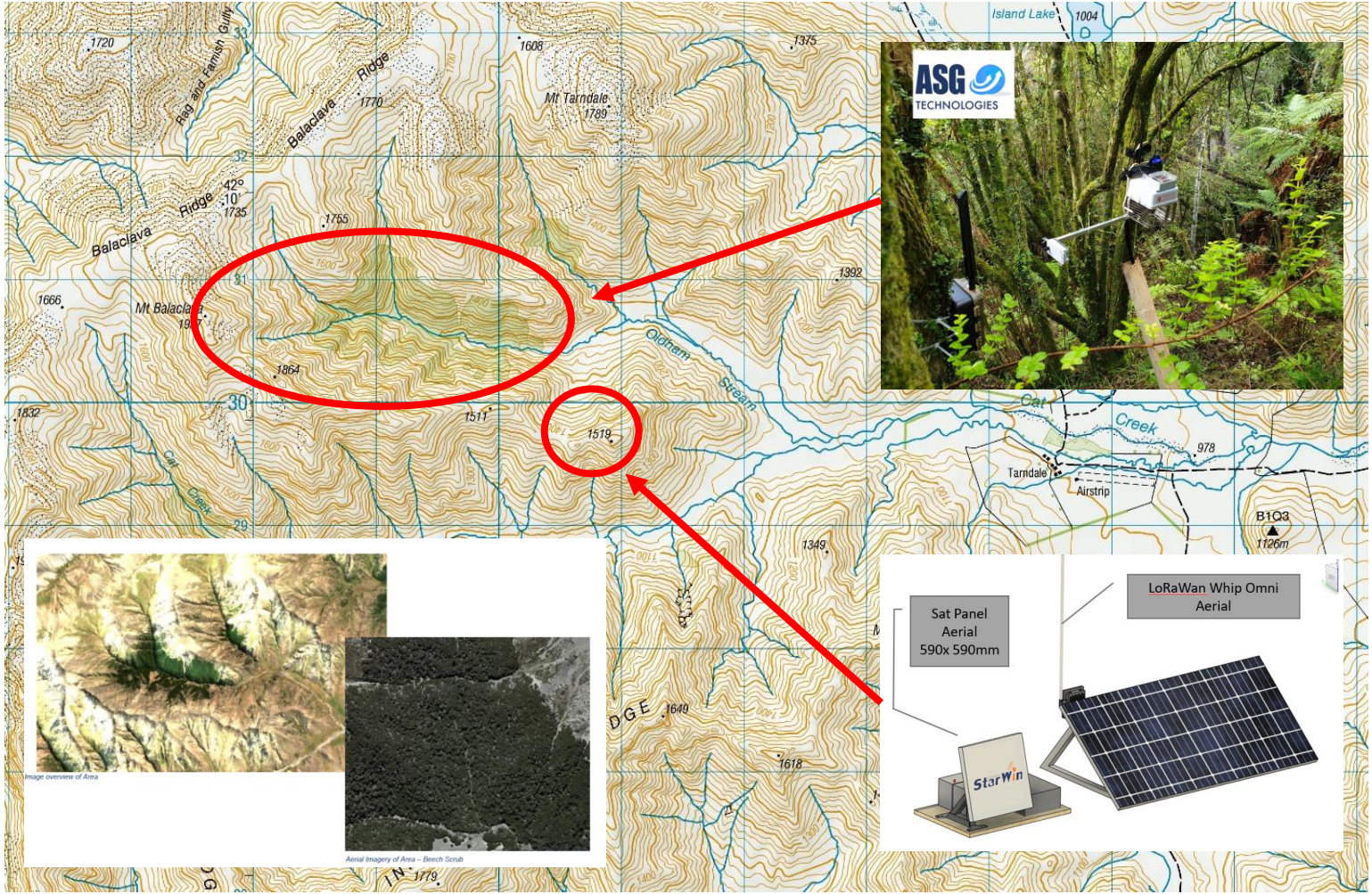
Indicative Layout and Dimensions



ASG TECHNOLOGIES

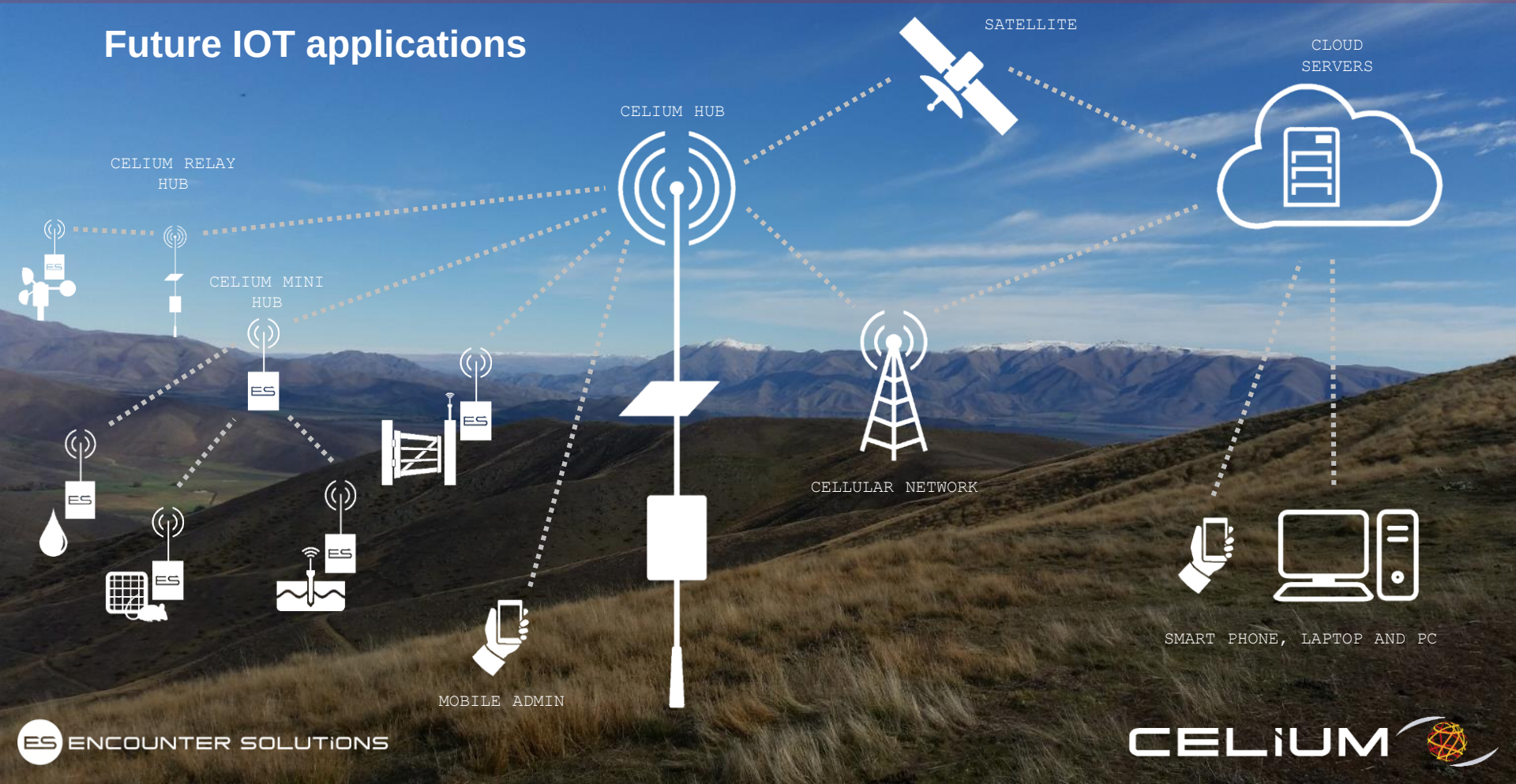
Solar panel size
1956 x 992mm
Foundation size
1000 x 700mm

ASG
TECHNOLOGIES


Island Lake
1004
1720
1608
1375
Rag and Famish Gully
Balaclava Ridge
1770
Mt Tarndale
1789
42° 10'
Balaclava Ridge
1735
1755
1392
1666
Mt Balaclava
1864
Oldham Stream
1832
1511
1519
Cat Creek
978
Tarndale
Airstrip
B1Q3
1126m
1349
1649
1618
1779
ASG TECHNOLOGIES
Image overview of Area
Aerial Imagery of Area – Beech Scrub
Sat Panel Aerial 590x 590mm
LoRaWan Whip Omni Aerial
StarWin

CELIUM OVERVIEW

Future IOT applications



ENCOUNTER SOLUTIONS

CELIUM

ACKNOWLEDGEMENTS

- Simon Croft: Encounter Solutions Ltd
- Andy Grant: ASG Technologies Ltd
- Andrew Gormley, Bruce Warburton: Manaaki Whenua-Landcare Research

OSPRI

THANK YOU

OSPRI