

Success in controlling bovine tuberculosis in domestic species in the face of wild animal reservoirs

Tēnā koutou, tēnā koutou, tēnā
tatou katoa –

Dr Paul Livingstone

Technical Manager

New Zealand Animal Health Board

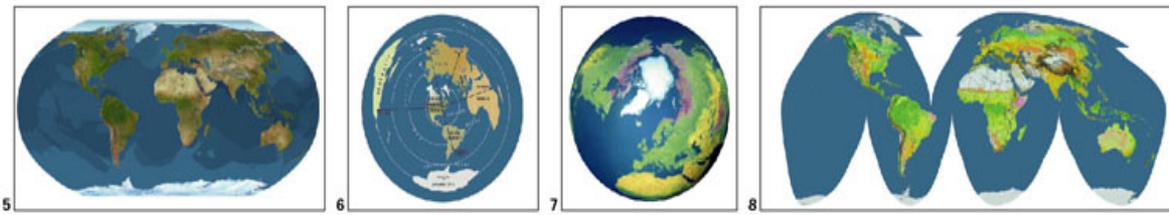


Items to cover

- New Zealand – an introduction
- History of important Tb events
- Pest Management Strategy and the Animal Health Board: Role and relations
- Tb Control Programme
 - Disease
 - Wild animals
 - Role
 - Control
 - Surveillance
- Success of programme

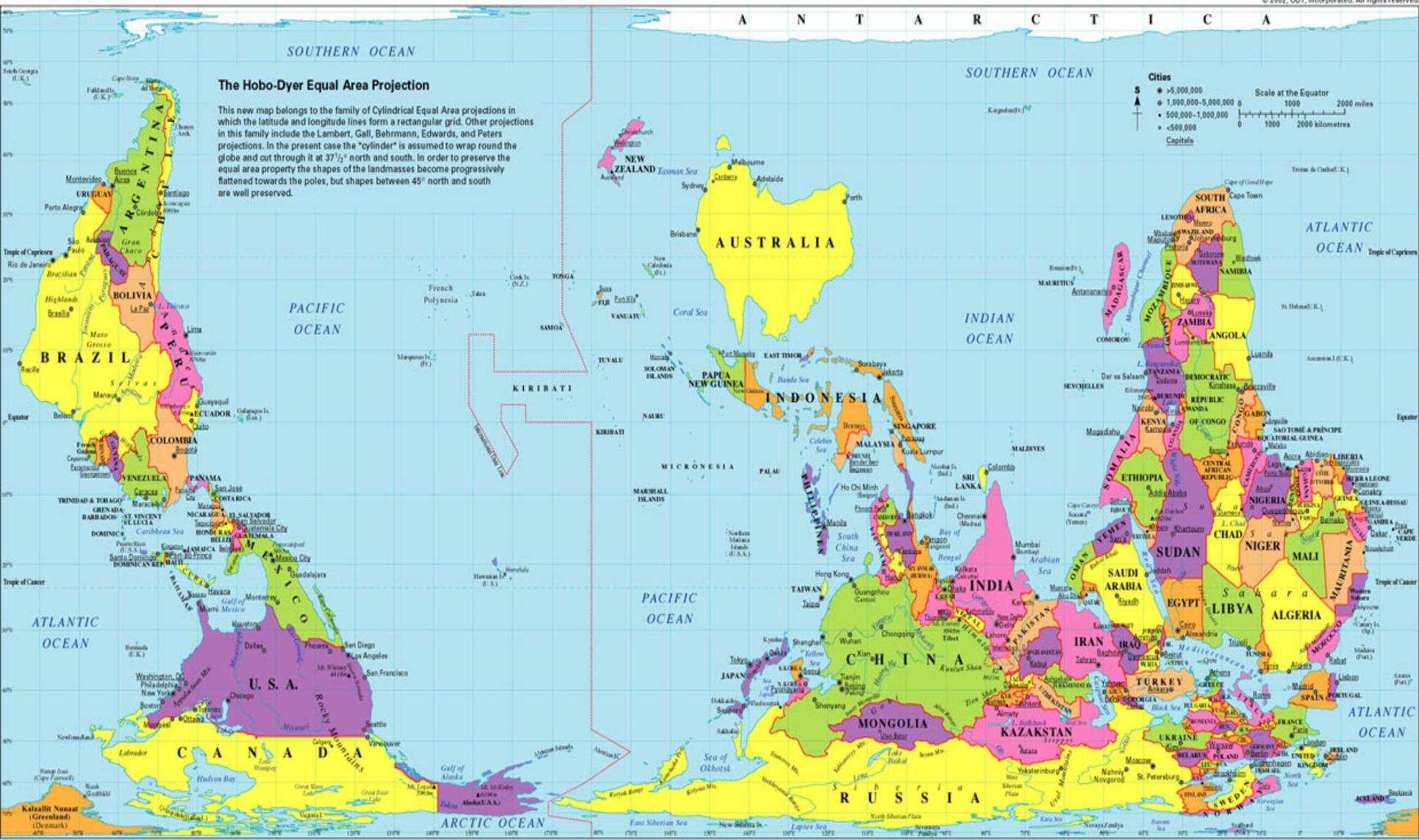


Take the quiz! Compare country size. Which of the images on both sides of this placemat are "area accurate?" How is the Hobo-Dyer projection below different from the one on the reverse side? Answers and details about all the images are at www.odt.org/hdp. To the right: (5) Van Sant's Geosphere, (6) Guelke's Toronto-centered projection, (7) the Oxford Globe, and (8) Goode's Homolosine



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NEW ZEALAND Aotearoa

Land Area

27 million ha or 66 million acres
(slightly bigger than Michigan)

People

4 million (68% European, 16%
Maori, 8% Polynesian, 8% Asian)

Cattle and Farmed Deer

9.6 million cattle – 72,000 herds

(5.8 million dairy cows in 14,500 herds)

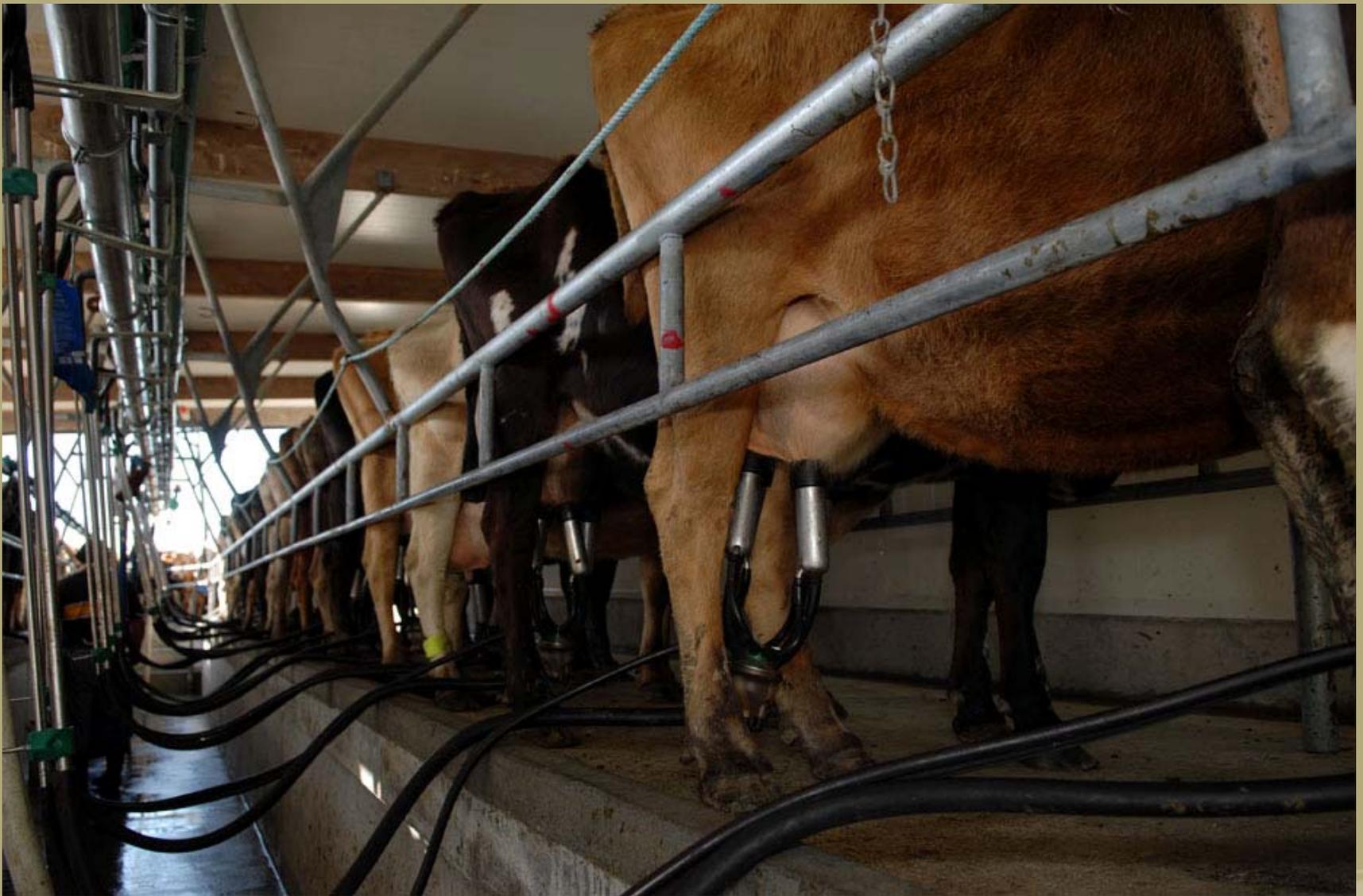
1.8 million farmed deer – 3,500 herds

Contribute >30% of New Zealand's export earnings

















Historical background to Tb situation in New Zealand



Bovine Tuberculosis control in New Zealand, 1905 - 1993

- 1905 – Voluntary Tb scheme introduced
– failed
- 1945 – Voluntary Tb testing of dairy cattle
- 1954 – Tb found in feral red deer
- 1961 – Compulsory testing of dairy cattle

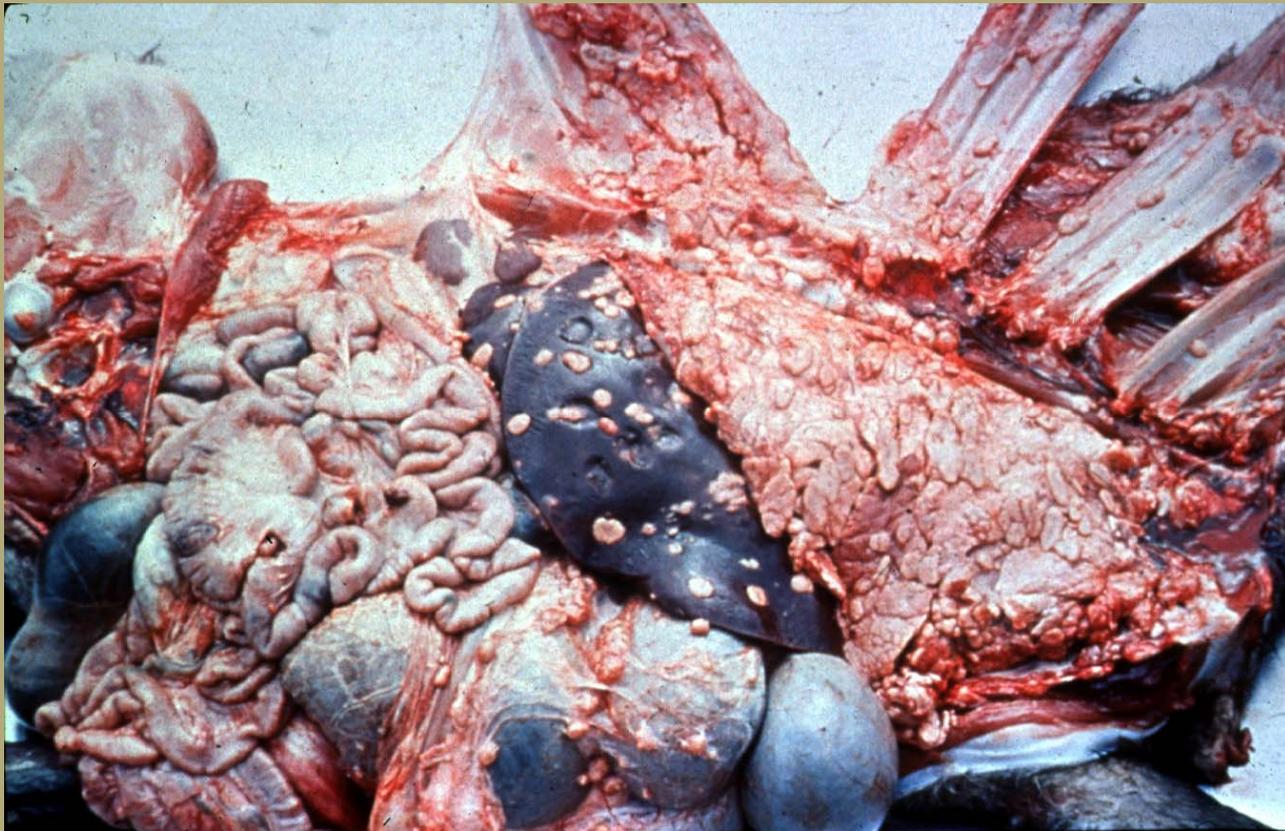
Bovine Tuberculosis control in New Zealand, 1905 – 1993 (cont'd)

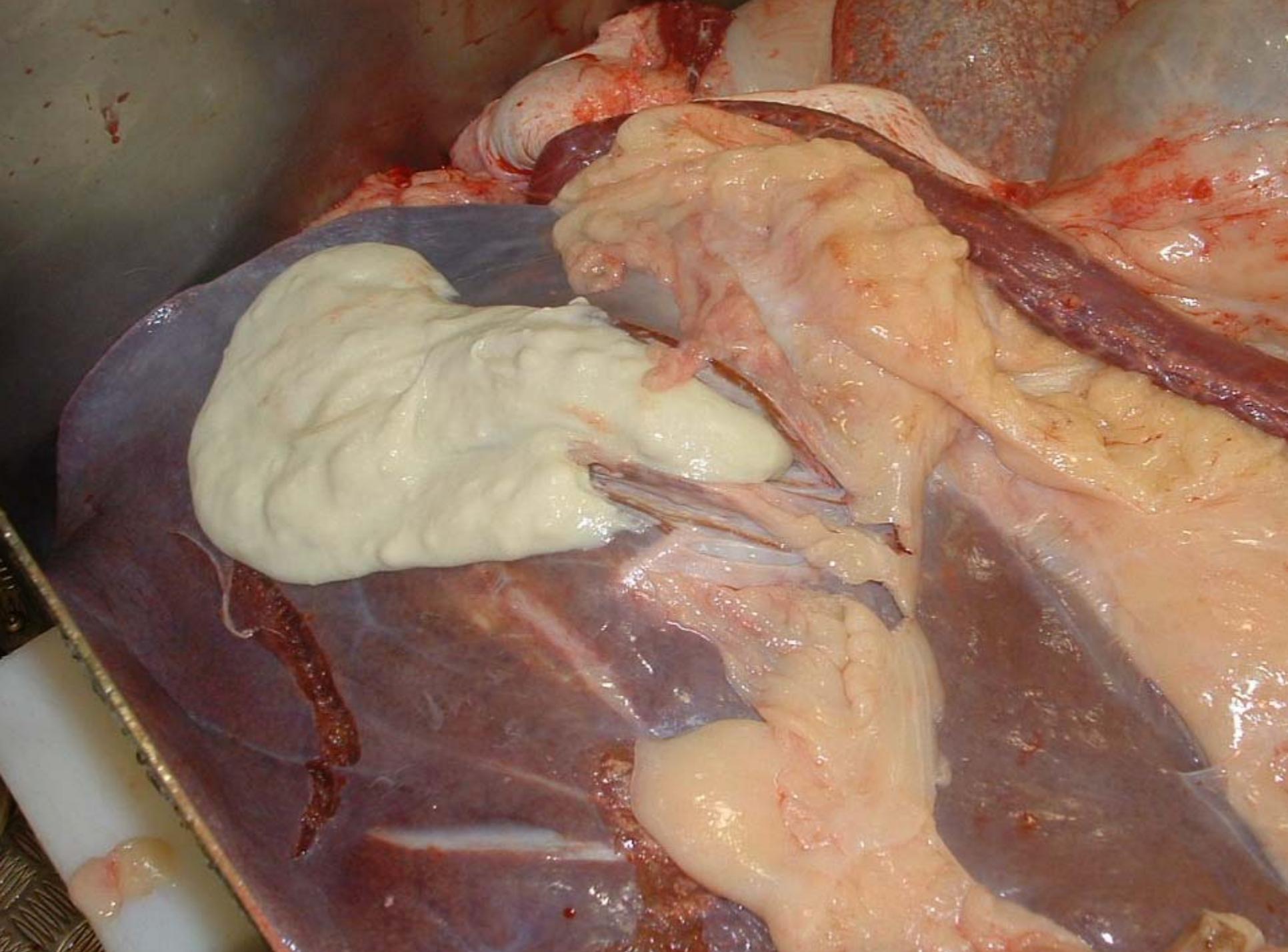
- 1962 – Tb diagnosed in feral pigs
- 1967 – Tb found in a possum (*Trichosurus vulpecula*)
- 1970 – All dairy cattle under test
- 1970 – Compulsory testing of beef cattle

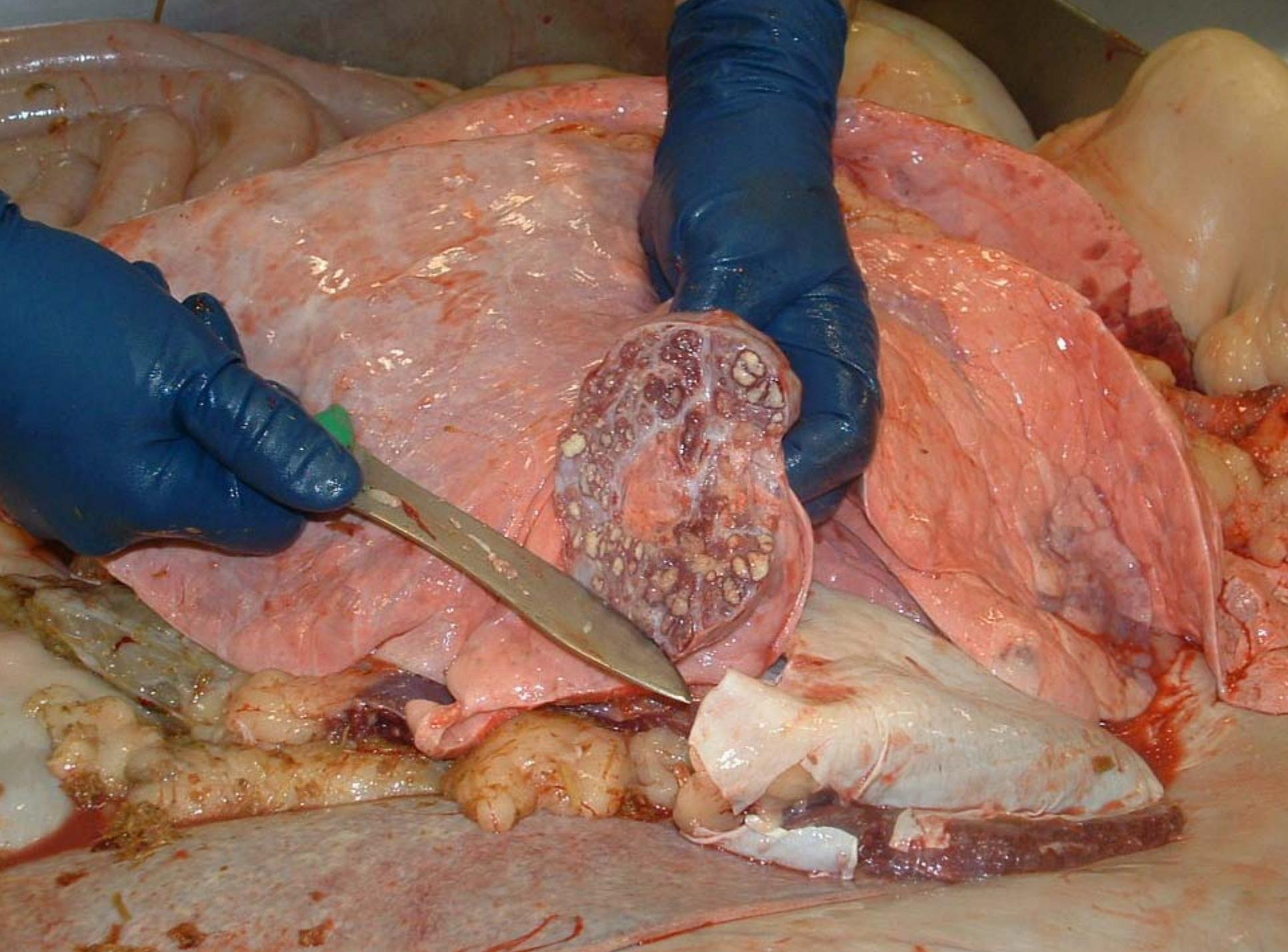
Tuberculous Dairy Cow (circa 1965)



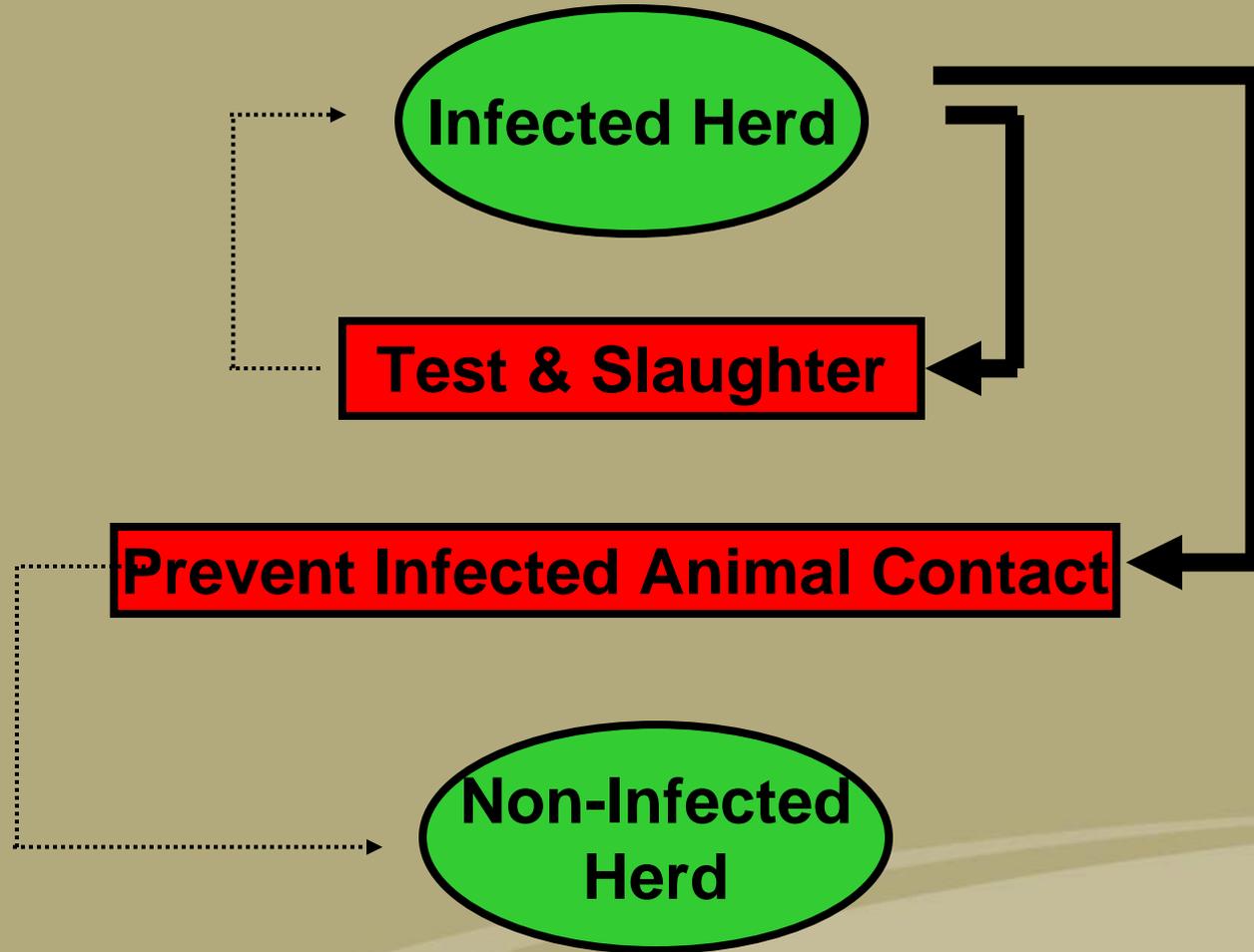
Generalised Tb in the Carcass of a Steer (circa 1965)





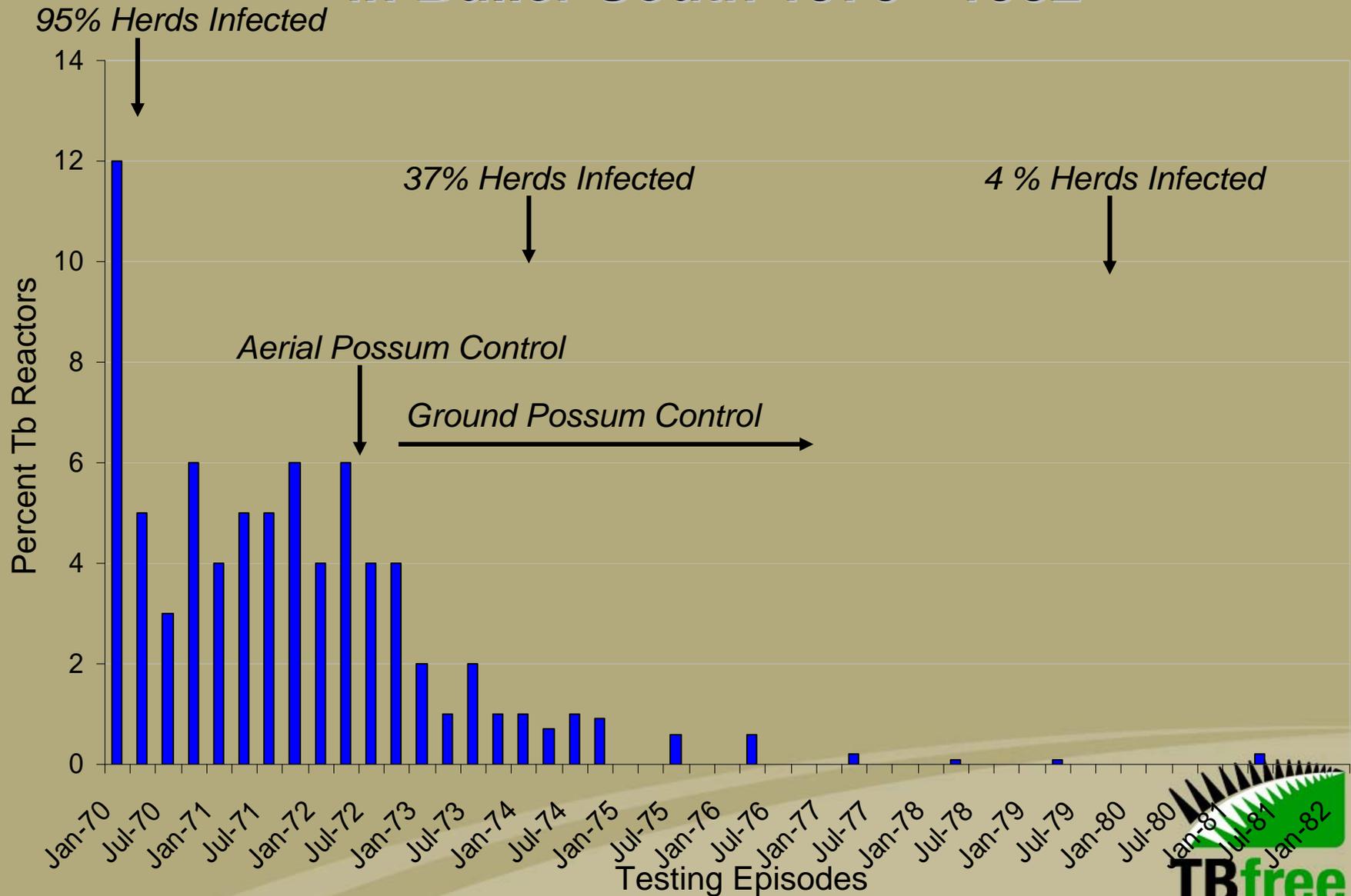


Tb - a simple disease to control?





Effects of Possum Control on Tb Reactor Rates in Buller South 1970 - 1982





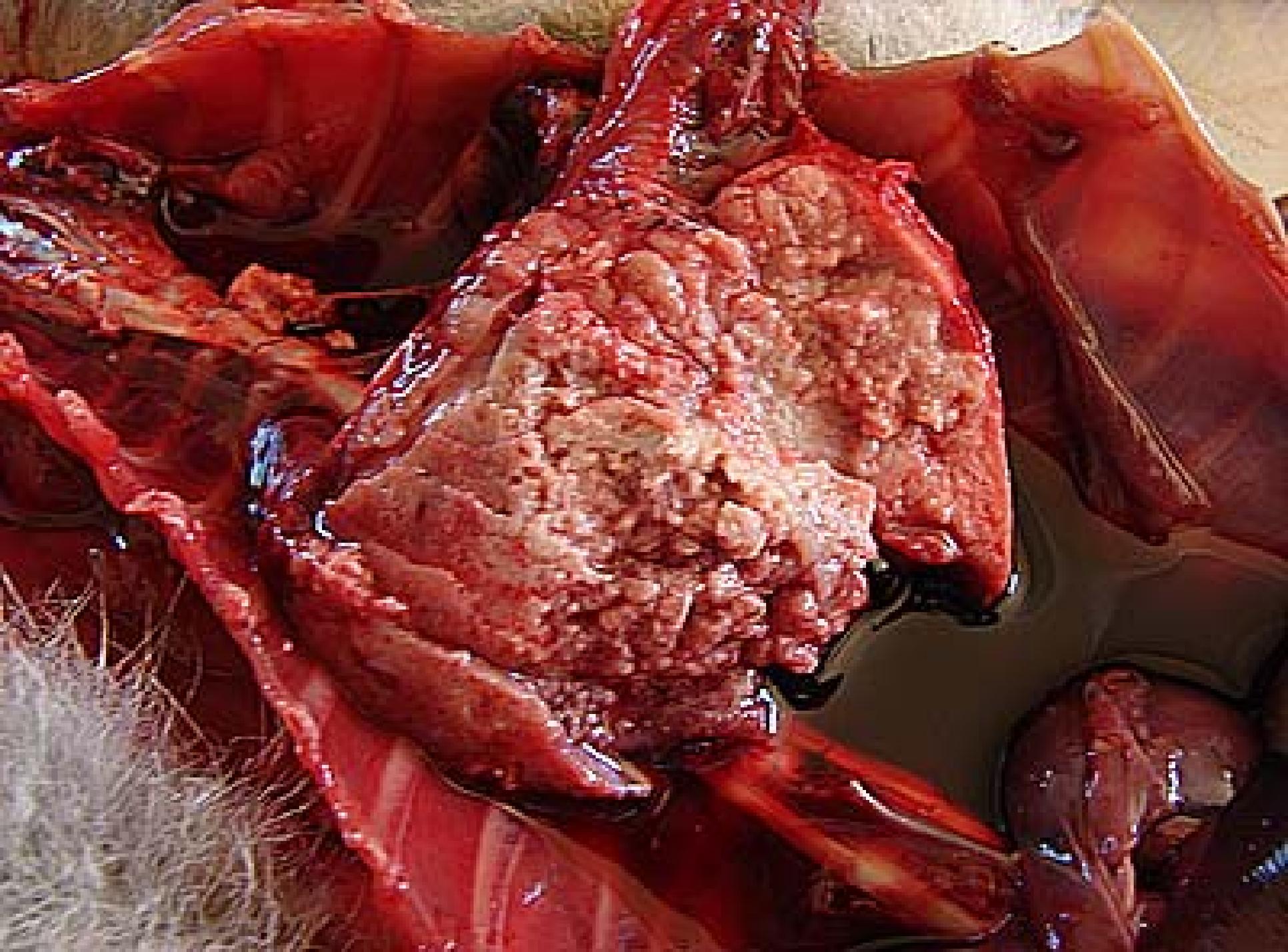




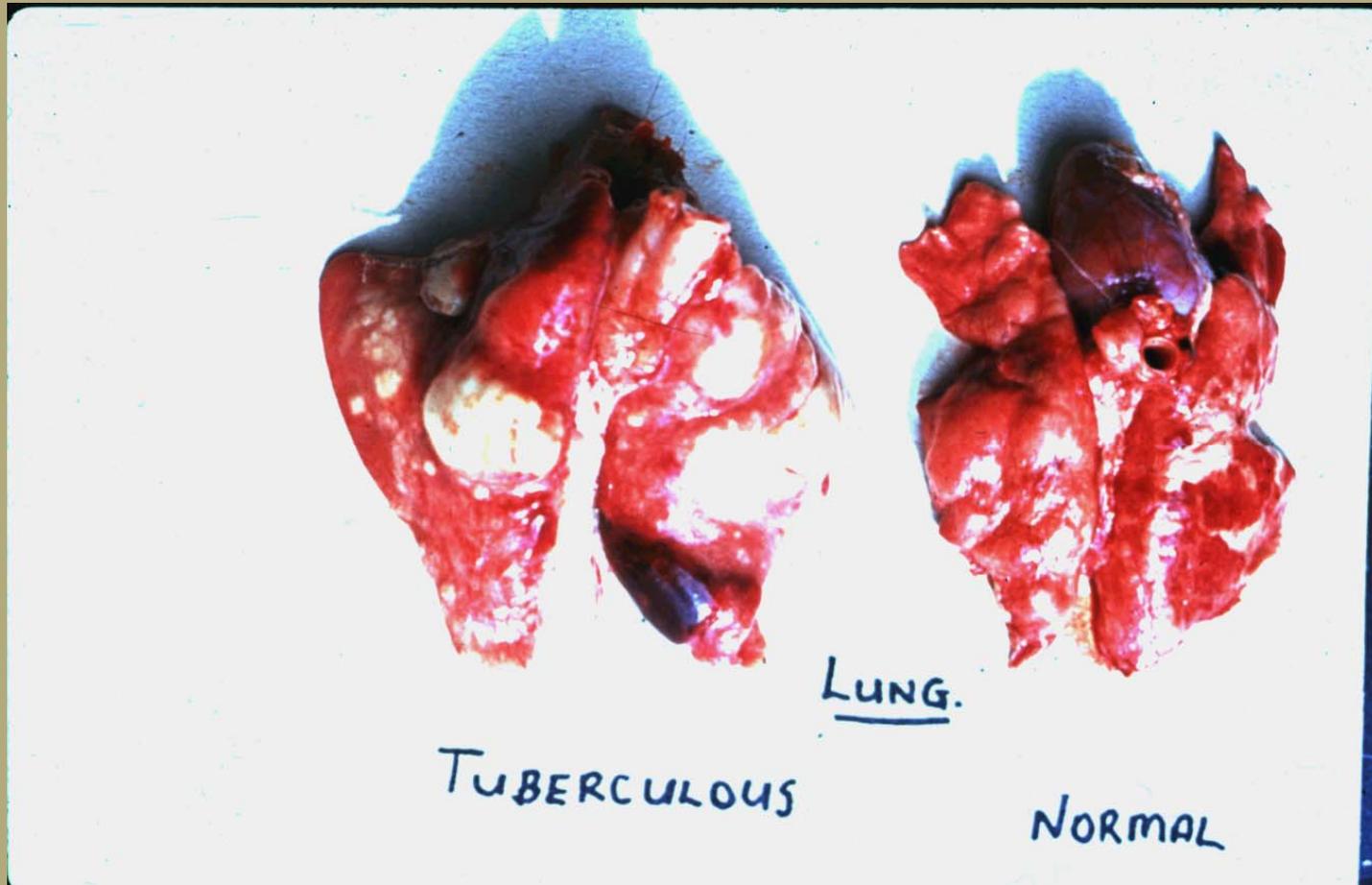
Tb Lesion in Axillary Lymph Node of a Possum







Tuberculous Possum Lung Compared with Normal Lung



Bovine Tuberculosis control in New Zealand, 1905 – 1993 (cont'd)

- 1972 – Possums recognised as a **Tb Vector** for cattle and control of infected possum populations began
- 1978 – Tb found in a farmed deer herd
- 1978 – Voluntary tuberculin testing of farmed deer
- 1978 – Government stopped funding possum control
- 1984 – Government began funding possum control again

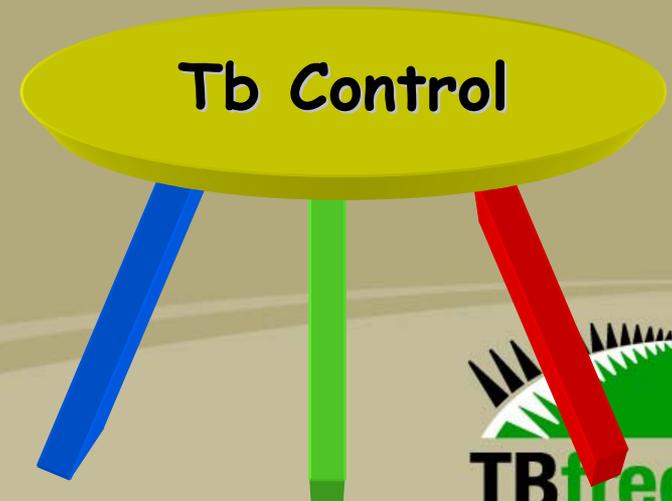
The 3-legged Stool

The three legs are:

Testing and removal of infected cattle and deer

Control of movement from infected herds

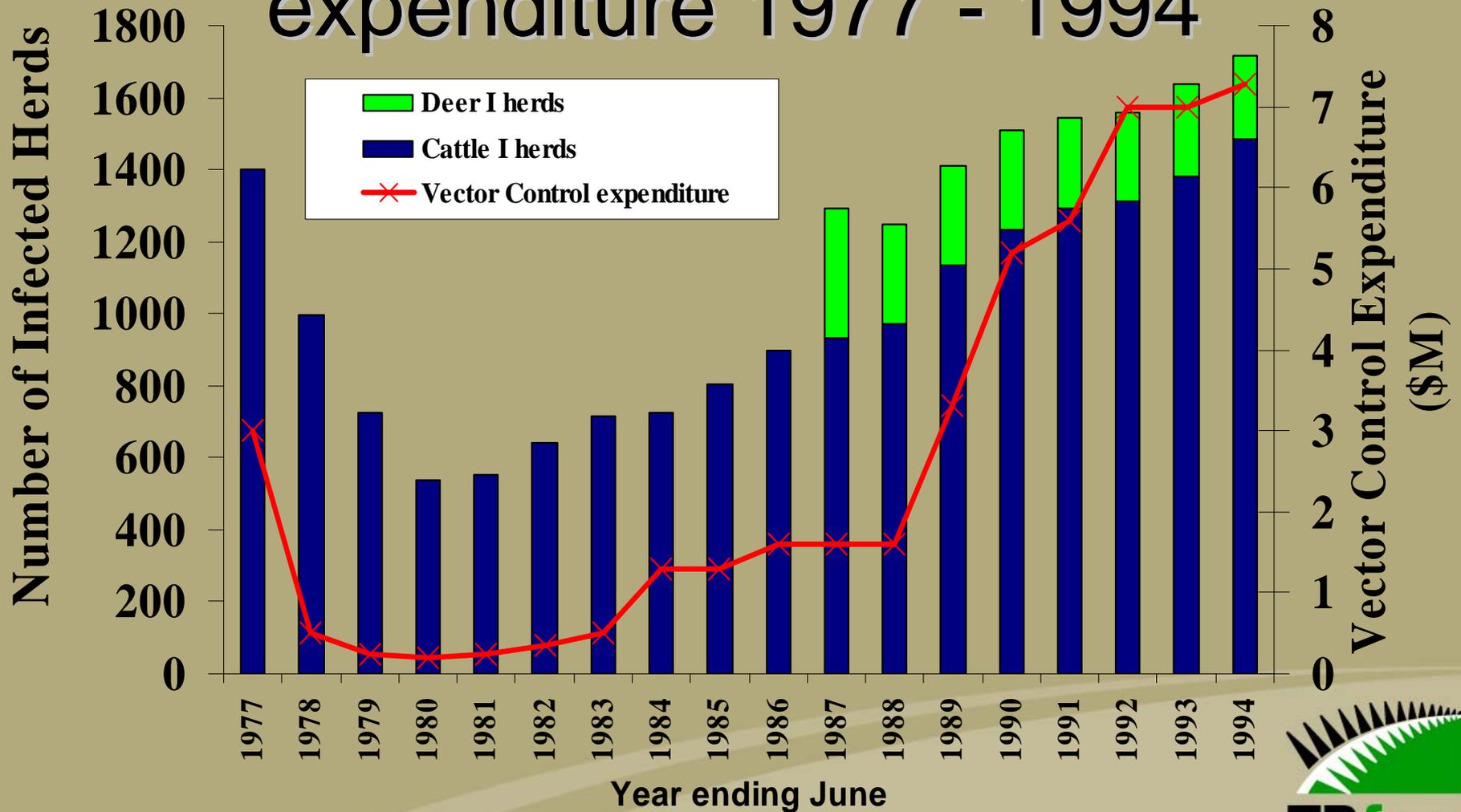
Control of vector populations



Bovine Tuberculosis control in New Zealand, 1905 – 1993 (cont'd)

- 1987 – Government indicated user pays for Tb control
 - National Animal Health Advisory Committee starts “User Pays – User Says” initiative
- 1989 – Animal Health Board formed from National Animal Health Advisory Committee
- 1989 – Compulsory Tb testing of farmed deer
- 1993 – Biosecurity Act introduced
 - Pest Management Strategy requirement

Number of infected cattle and deer herds and vector control expenditure 1977 - 1994



Pest Management Strategies (PMS)

- Biosecurity Act requires a PMS for any national or regional pest (plant, animal or micro-organism) proposed for control or eradication:
 - Fully describe the proposal and its costs
 - Time-bound measurable objectives
 - Requires consultation and agreement from funding stakeholders
 - Beneficiaries
 - Exacerbators
 - Identify rules and legislation to apply

Pest Management Strategies (PMS)

- Proposal submitted to Minister (of Agriculture)
- Minister:
 - Calls for submissions
 - Undertakes a Board of Inquiry
 - Approves Strategy through an Order in Council
 - Approves the Operational Plan
- Strategy funding reviewed every 5 years

Order in Council identifies

- Management Agency
- Strategy objectives
- Principle means of achieving
- Strategy powers, rules and obligations
- Funding

Controlling Bovine Tb in New Zealand

- PMS for bovine tuberculosis control is administered by the Animal Health Board
- The Animal Health Board (AHB):
 - Is an Incorporated Society, with members made up of those directly affected.
 - Is the Agency responsible and accountable for implementation of the National Pest Management Strategy (NPMS) for Bovine Tb.
 - Has a sole mission: the eradication of Bovine Tb to safeguard the export of dairy, beef and venison products.

MINISTER OF BIOSECURITY

CTO

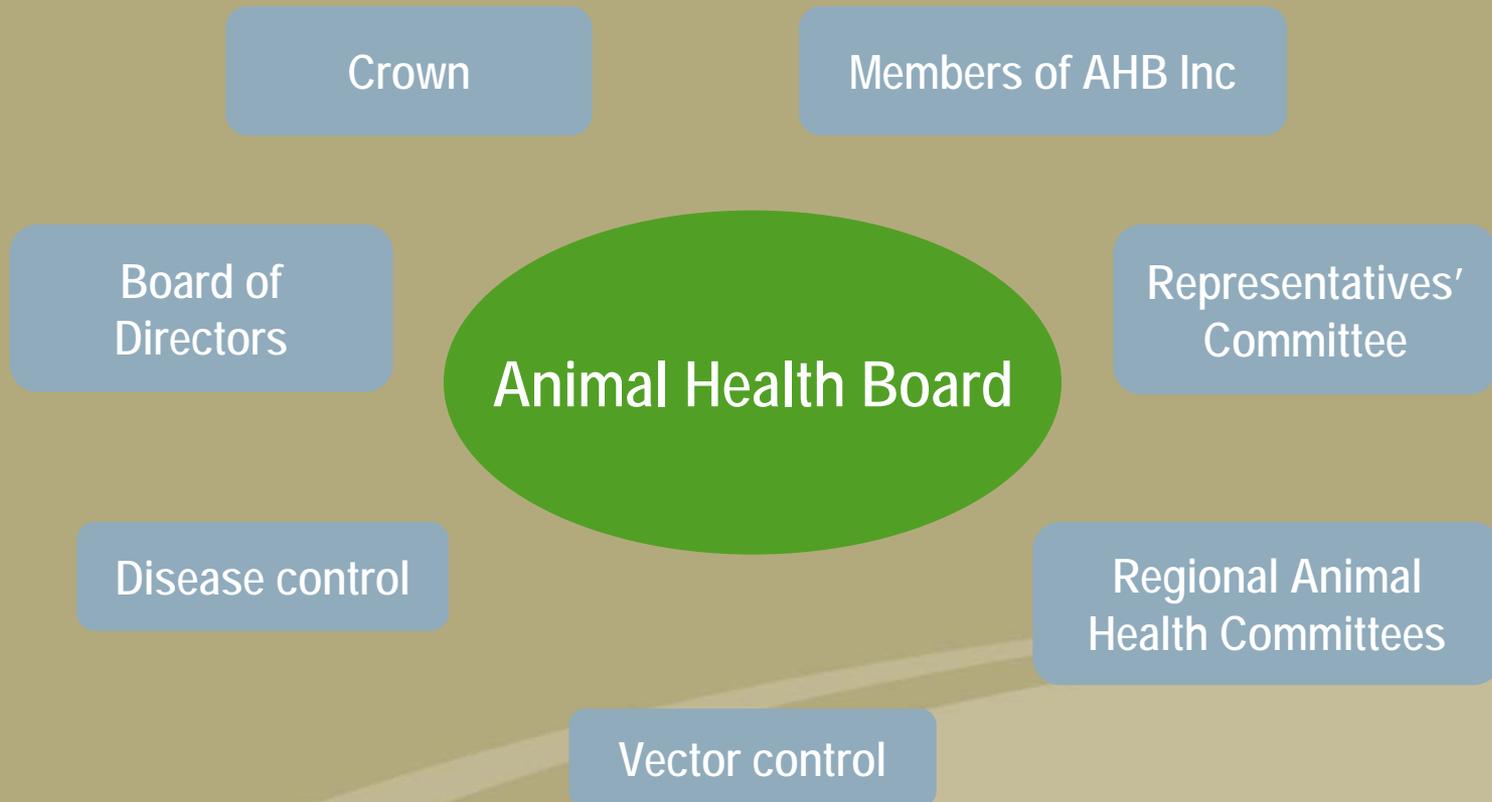
AHB

DIRECTORS ELECTED
BY REPRESENTATIVES:

- ◆ DairyNZ
- ◆ Meat NZ
- ◆ Deer Industry New Zealand
- ◆ NZ Deer Farmers Association
- ◆ Dairy Farmers of NZ
- ◆ Federated Farmers Meat & Fibre
- ◆ Local Government NZ
- ◆ Central Government

Partners in the Tb Strategy

- AHB manages the National Pest Management Strategy
- The implementation could not be achieved without the support of our partners



How we are funded

We are funded by:



Beef

Dairy

Deer

How is the \$ used:



Beef

Dairy

Deer

Vector Control

Disease control



Animal Health Board as Pest Management Agency

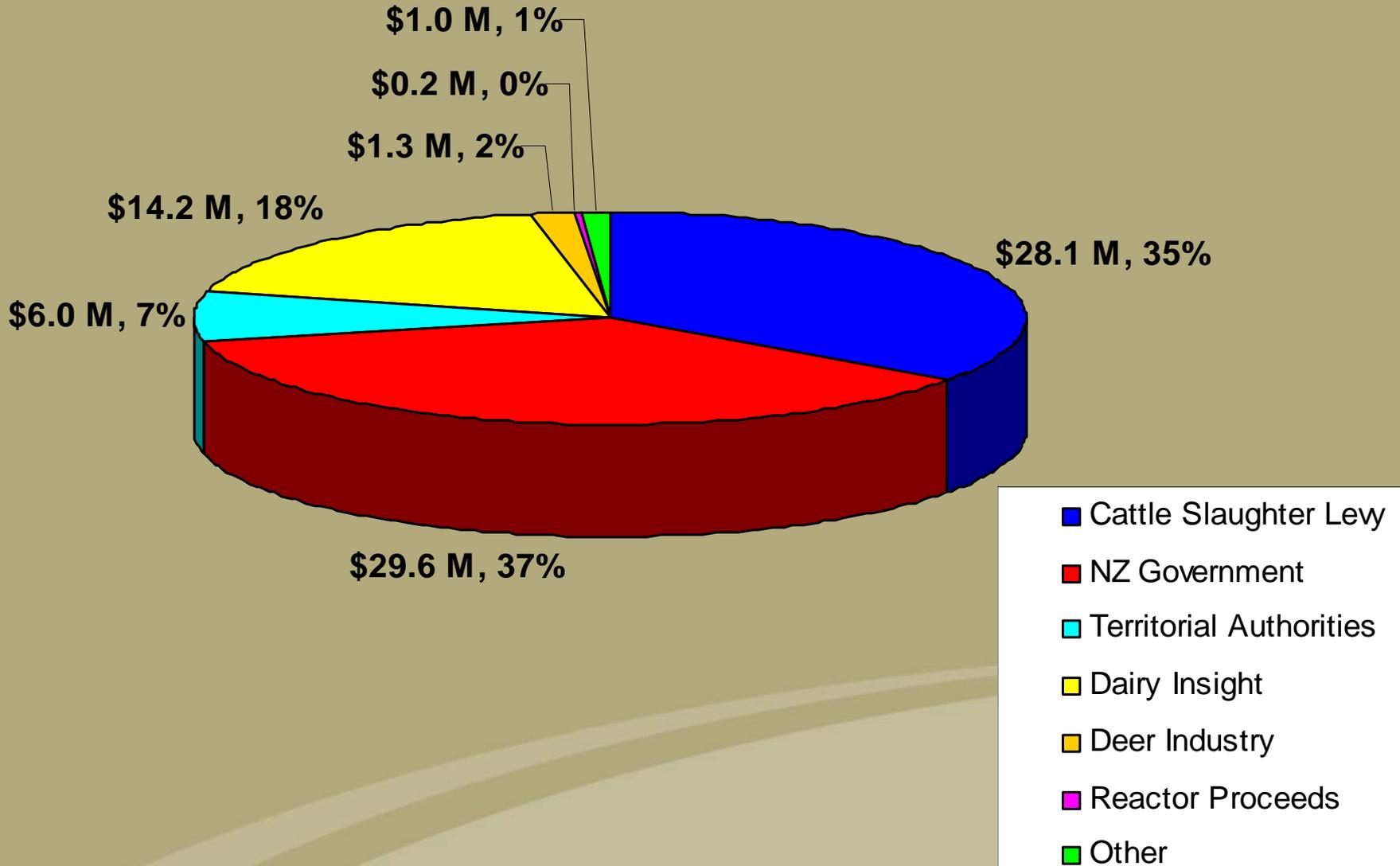
- Programme divided into disease and vector control for funding purposes:
- Disease
 - Farmers fund (Beneficiaries)
 - Disease administration and databases
 - Testing
 - Compensation
 - 65% FMV cattle
 - Carcass proceeds only for deer

Animal Health Board as Pest Management Agency (cont'd)

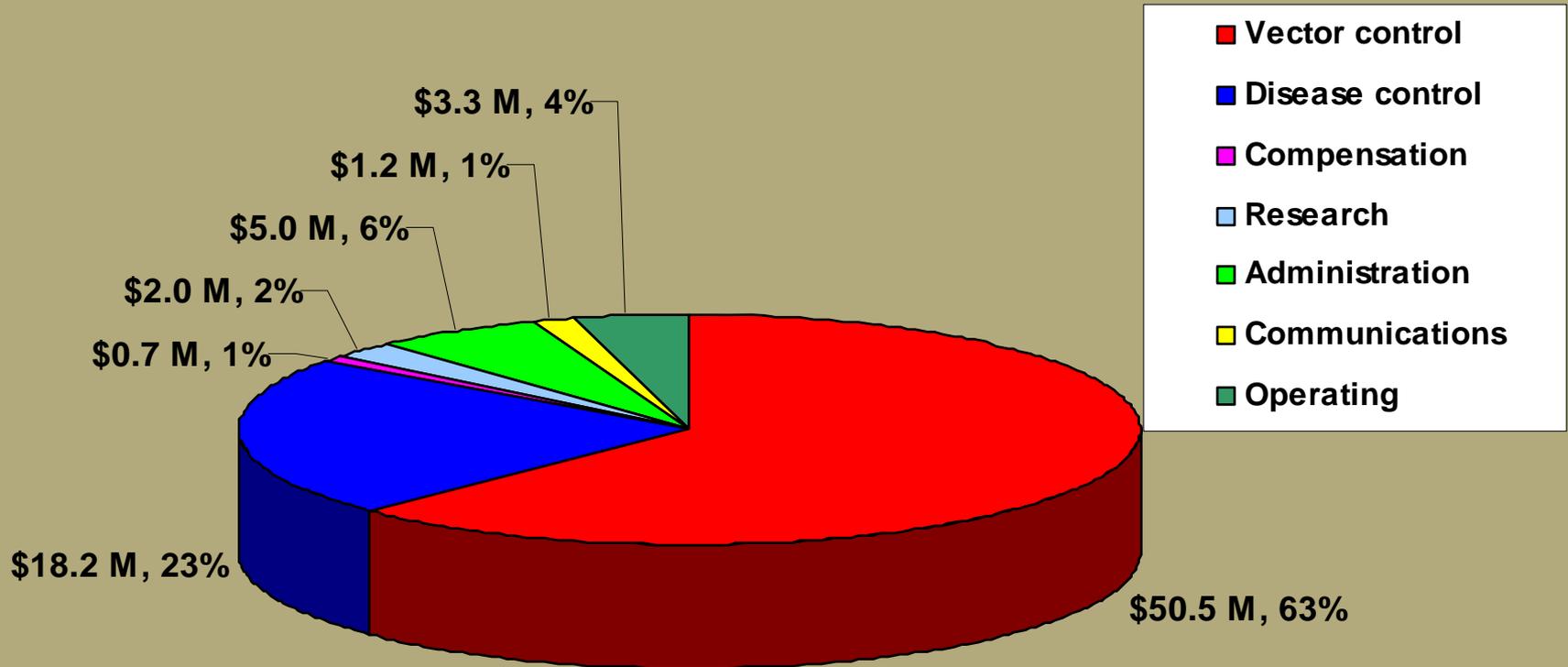
■ Vector Control

- Crown funds 50% (Exacerbator)
- Regions fund 10% (Exacerbator and beneficiary)
- Farmers fund 40% (Beneficiaries)

Income for 2007/08



Expenditure for 2007/08



What guides us?

1 The Biosecurity Act 1993

This Act sets out the responsibilities, legal powers and duties for Biosecurity in NZ.

2 National Pest Management Strategy

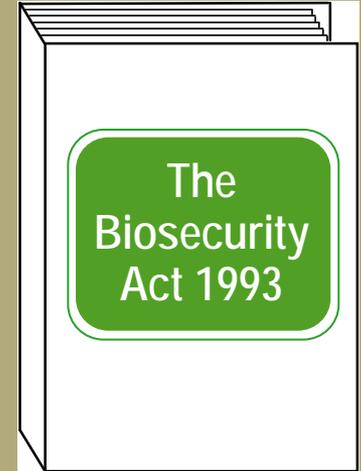
A Strategy is required under the Biosecurity Act. It has been developed by AHB and sets out what is to be achieved, how it is to be funded, structure and actions required.

It is approved by The Minister of Agriculture and Biosecurity and is updated every 5 years.

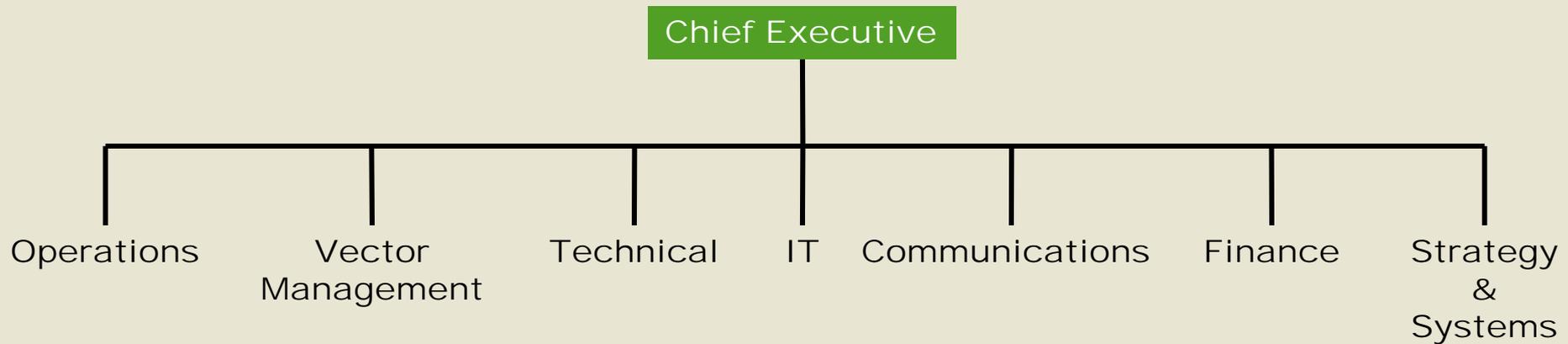
3 National Technical Operations Plan (NTOP)

AHB develops NTOP.

It details policies and procedures for the implementation of the Strategy.



AHB Business Units



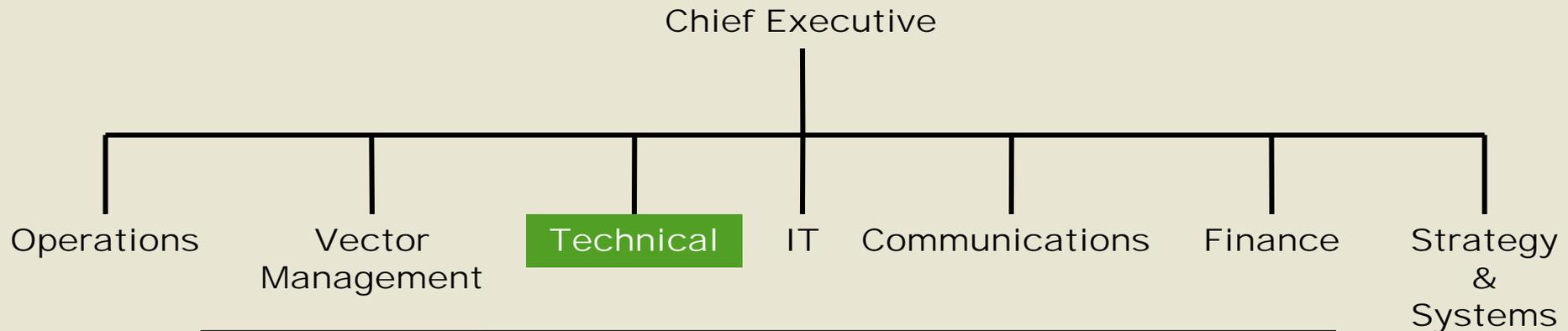
William McCook
Chief Executive

OUR BUSINESS STRUCTURE

- **Chief Executive and 7 Business units**
- **Each Business unit has a Manager**
- **Each Manager is responsible for a different aspect of the organisation**

(Manager to explain relationships between their Unit and others)

AHB Business Units



Paul Livingstone
Technical Manager

Technical Services Group is responsible for:

- **Provision of technical policy for disease and Vector Control Programmes**
- **Data analysis and decision making on Technical aspects of Disease and Vector Control Programme**
- **Approval of technical aspects of Vector Control Programmes**
- **Overseeing the research direction and quality**

Range of services AHB provides

DISEASE CONTROL

- Maintain a Disease Management Information System (DMIS)
 - Farm record
 - Herd record
 - People record
 - Testing history
 - Map locations
- Tb testing programme
- Movement control
- Managing positive Tb results
- Monitor and enforce compliance
- Animal ID system
- Advice to farmers
- Ongoing education
- Manage local disease control plan

Provided by the
Operations and Technical
units

VECTOR CONTROL

- Manage the Vector Control Programme
 - Prepare programmes
 - Manage approved control
- Vector surveys
- Research

Provided by the
Vector Management and
Technical units

National Pest Management Strategy (NPMS) for Bovine Tb (cont'd)

- Current strategy is for the period 2001 through to June 2013
- Prime objective of the NPMS:
 - To have no more than 2 infected herds per 1,000 herds (infected herd period prevalence of $\leq 0.2\%$), by 30 June 2013
- Supporting objective:
 - prevent spread of Tb wild animals from existing Vector Risk Area boundaries

The Tb Control Programme



The Tb Control Programme

- Technically managed by:
 - Technical Manager
 - National Disease Control Manager (3)
 - District Disease Control Managers (7.5/10)

- Operational
 - Disease Manager
 - Contracts Tb testers
 - Vector Manager
 - Contracts possum killers

Tb Control Strategies

- Domestic cattle and deer population
 - Surveillance programme
 - Test and slaughter of reactors
 - Cattle reactors receive 65% FMV
 - Deer reactors receive carcass proceeds
 - Slaughter surveillance
 - Movement control programme
 - General – Animal Status Declaration
 - Area Movement Control
 - Infected herd movement control

Tb Control Strategies (cont'd)

- Control and Surveillance of infected wild animal populations for purpose of:
 - Containment
 - Control
 - Eradication

Tb Control Strategy - Testing

- The testing programme is based on assessment of disease risk to herds and takes account of herd type, status and location
- Herd status:
 - Clear C1 – C10
 - Infected I1 – I...
 - Suspended

Tb Control Strategy - Testing (cont'd)

- Screened with intradermal tuberculin test
 - Cattle - caudal fold test
 - Deer - mid-cervical test
- Ancillary serial tests
 - Cattle - Bovigam (gamma interferon)
 - Deer
 - ETB (IgG1 ELISA)
 - CCT

Tb Control Strategy - Testing (cont'd)

- Ancillary parallel testing
 - Cattle - Bovigam
 - Deer - IgG ELISA

Approved diagnostic tests - cattle

	Sensitivity	Specificity
Caudal Fold test	85 ± 5%	>99.8%
Comparative Cervical Test	>60%	>95%
Serial Bovigam (gamma interferon) test		
■ Standard	93%	>93%
■ Modified	>90%	>95%
■ Special Antigen	>90%	>98%
Parallel Bovigam	>85%	>93%

Approved diagnostic tests - deer

	Sensitivity	Specificity
Mid-cervical test	85 ± 5%	>98.8%
Comparative Cervical Test	60-80%	>98%
Serial ETB (IgG1 ELISA) test	>90%	>80%
Parallel IgG ELISA	>85%	>85%

Tb Control Strategy - Testing Areas - Movement Controlled Areas

- Defined area has an annual infected herd period prevalence $\geq 1\%$ (raster analysis or kernal density)
- Annual testing of all animals over 3 months of age
- Pre-movement testing for all animals over 3 months of age

Tb Control Strategy - Testing Areas

- Special Testing Areas

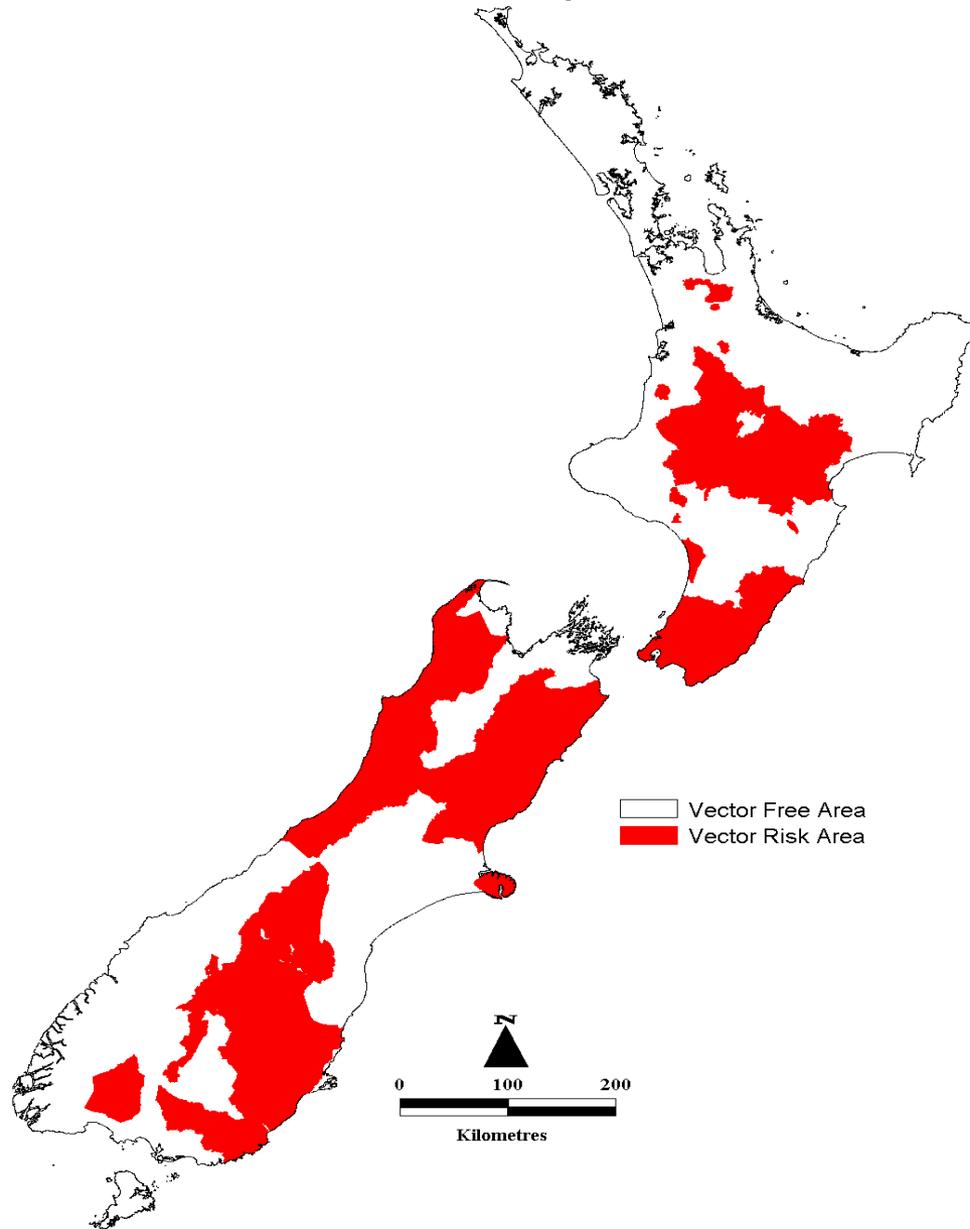
- Detect spread of Tb wild animals
- Increased or unknown risk of herd infection
- No pre-movement testing

	Annual testing	Biennial testing
≥ 3 months		
≥ 12 months		
≥ 24 months		

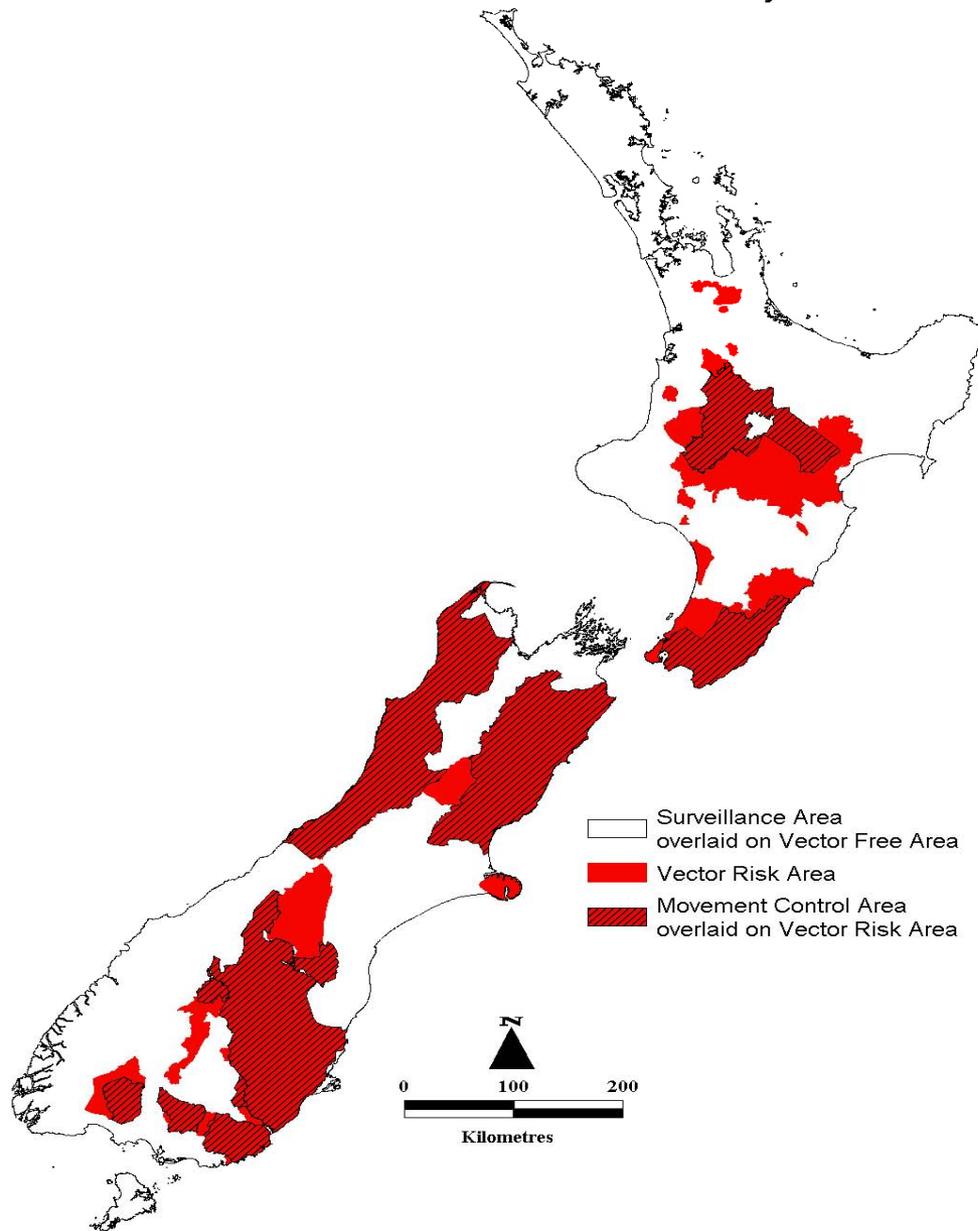
Tb Control Strategy - Testing Areas - Surveillance Areas

- Triennial testing
- All breeding animals over 24 months of age
- No pre-movement testing

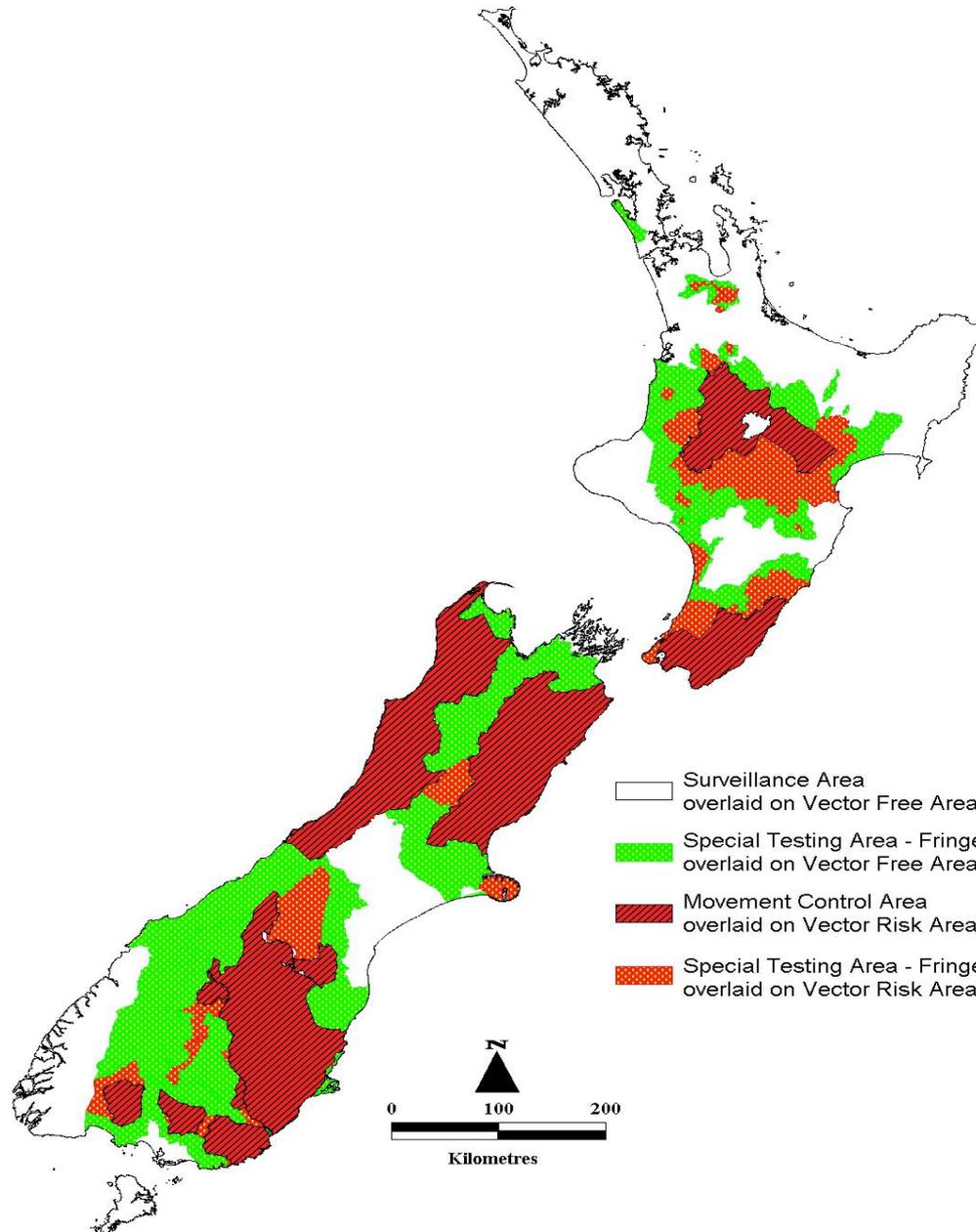
Map of New Zealand showing Vector Risk and Vector Free Areas
as at January 2005



Map of New Zealand showing Movement Control Area overlaid on
Vector Risk and Vector Free Areas as at January 2005



**Map of New Zealand showing Tb Testing Zones overlaid on
Vector Risk and Vector Free Areas as at January 2005**



Tb Control Strategy – Infected herds

- Biannual testing
- All animals over 3 months of age are tested except if:
 - being slaughtered within 3 months
 - 100% animals are slaughtered annually
- Animals can move from herd, but:
 - Require pre-movement testing & tagging
 - Require post-movement testing
 - Suspension of new herd status

Tb in Wild Animals

- *M. bovis* has been diagnosed in all mammals in New Zealand except for thar, chamois, bats, rats and mice
- Tb possums and ferrets are source of infection for >85% New Zealand's cattle and farmed deer herds

Maintenance of Tb in possums

- Close contact between individuals
 - at den sites (enclosed air spaces)
 - fighting, feeding, nursing, mating
- Infection of new populations
 - pseudo-vertical transmission and migration of juveniles

Spread of Tb from wild animals to domestic animals

- Intimate contact between infected wild animals that are excreting *M. bovis* and inquisitive, dominant cattle or deer
- Wild animals which infect domestic livestock and other wild animals are referred to as **Tb vectors**





Scavenging as a source of infection for wild animals

- Tb carcasses provide a source of infection for wild animals
- Ferrets, feral pigs and cats, as well as hedgehogs and possums scavenge carcasses
- Ferrets and possums then infect cattle and farmed deer

Epidemiology of Tb in Wild Deer



Tb Deer



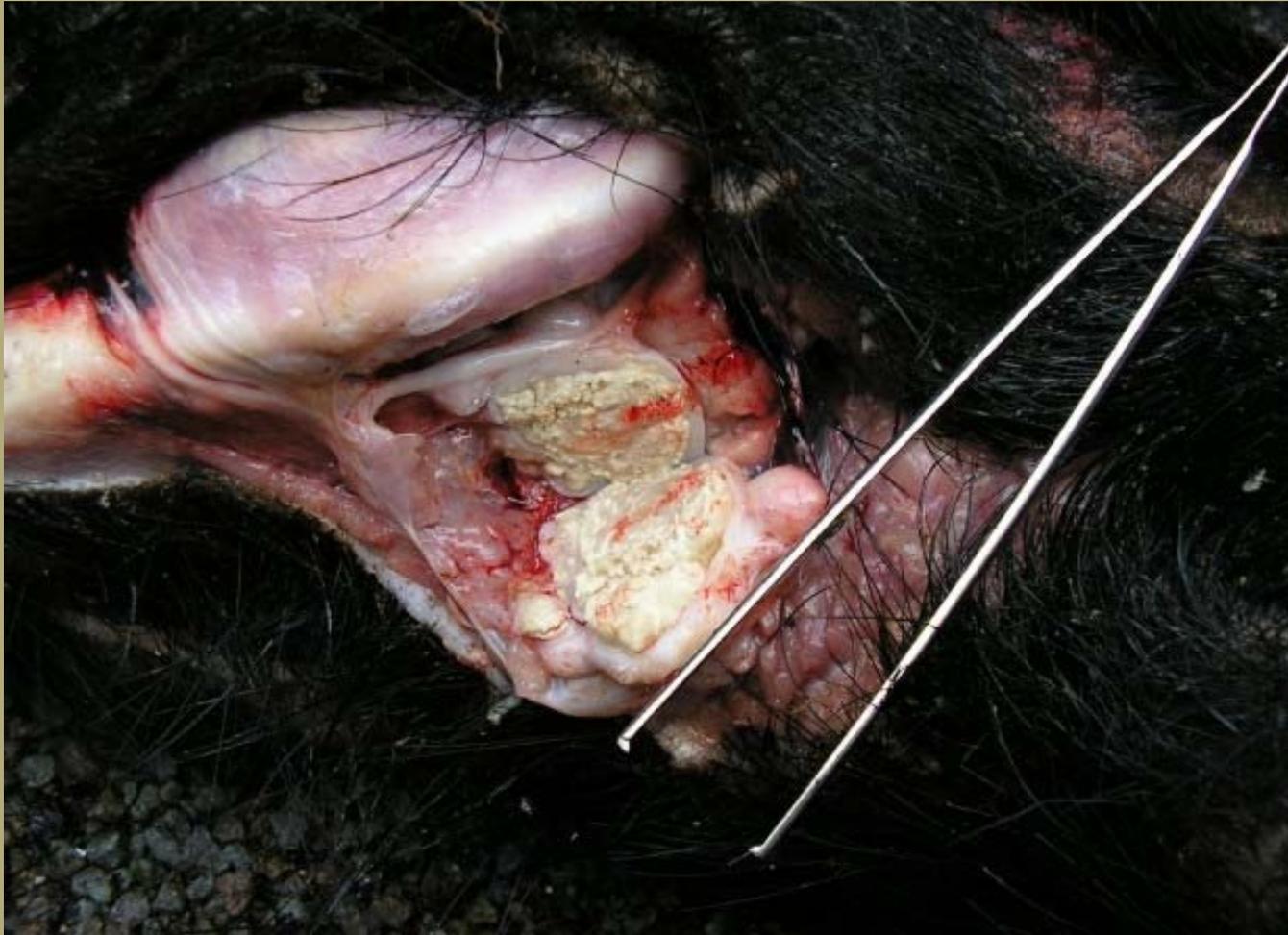
Epidemiology of Tb in Wild Deer (cont'd)

- Wild deer are infected after contact with Tb possums living within their home range
- Density of wild deer in New Zealand generally too low for deer to deer transmission to occur
- A “spill-over” host, rarely a Tb vector
- An infected deer may live a natural life – implications for control
- Useful sentinel for detecting possum infection

Epidemiology of Tb in Feral Pigs



Pig - Tb mandibular lymph node



Epidemiology of Tb in feral pigs (cont'd)

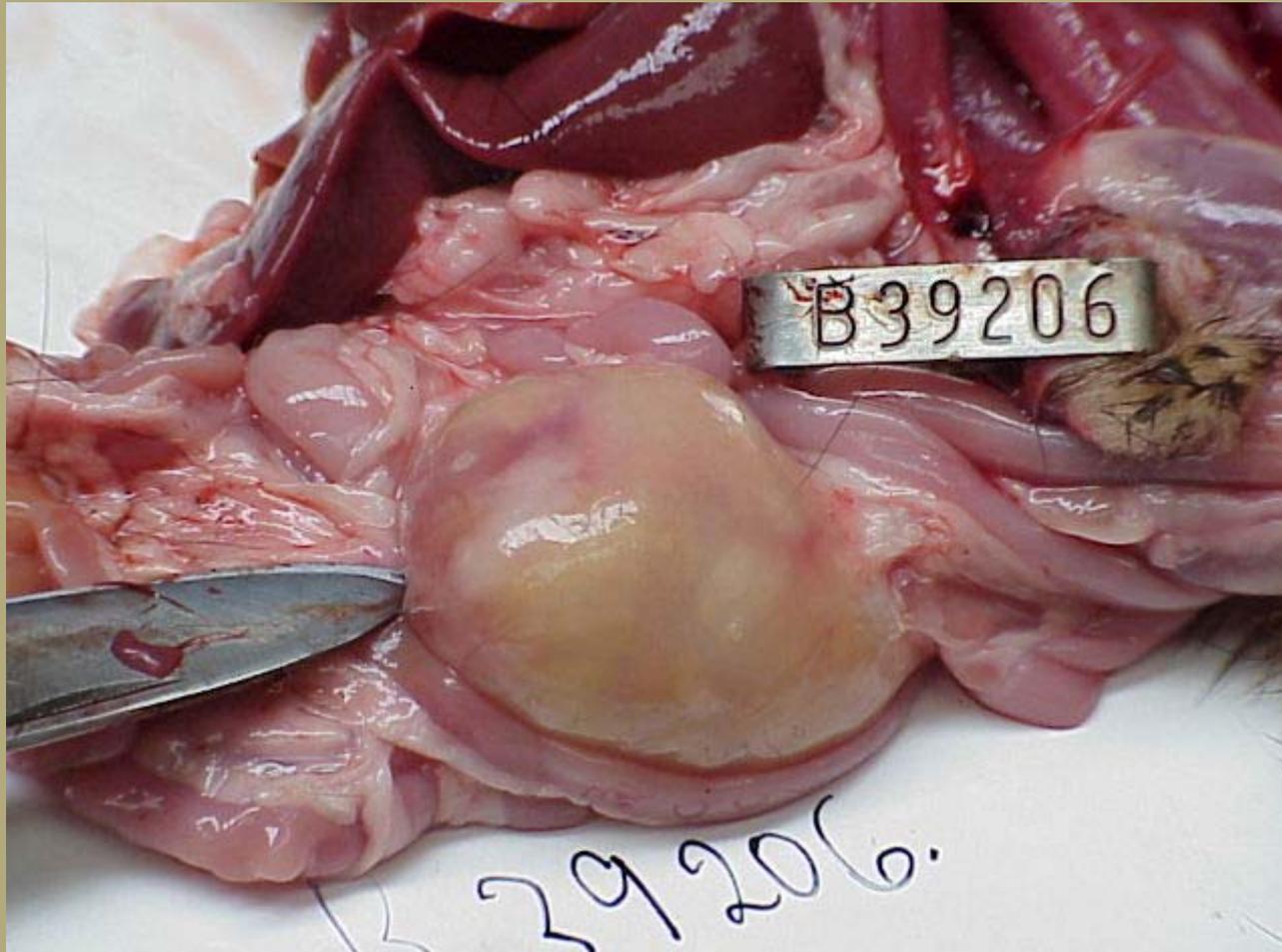
- Feral pigs are infected after scavenging Tb carcasses
- Relatively rare for pig to pig transmission of infection
- A “spill-over” host, rarely a Tb vector
- An infected pig will live a natural life
- Most sensitive and best sentinel for detecting possum infection



Epidemiology of Tb in ferrets (*Mustela furo*)



Mesenteric Tb Lesion from a Ferret



Epidemiology of Tb in ferrets (cont'd)

- Ferrets are infected after scavenging Tb carcasses within home range
- Ferrets are cannibalistic. If ferret density $>3/\text{km}^2$, (North Canterbury), then could be a maintenance host through cannibalism
- An important Tb vector for farmed deer ?
- Unknown what impact Tb has on life span
- A sensitive indicator of Tb and best sentinel for detecting possum infection in farmland environments

Role of other Tb wild animals

- Other wild animals found infected in NZ include stoats, weasels, rabbit, hares, feral goats, feral sheep, feral cats, hedgehogs, **seals**
- Apart from seals, these animals are all spill-over hosts and rarely a Tb vector to cattle and deer
- May act to infect other animals as a result of their carcasses being scavenging
- Stoats can be a useful sentinel in some situations

Tb Control Strategies – Wild animals

- Determine control objective:
 - Analysis of disease and vector control parameters
 - Habitat stratification
- Control priorities - only possums
 - Containment
 - Control to reduce number of Infected herds
 - Eradication from wild animal populations
- Measure of control outcome
- Are there any Tb possums ?

Tb Control Strategies – Wild animals (cont'd)

■ Containment

- Determine “outer boundary” of established wild animal infection
 - Cattle and deer surveillance
 - Wild animal surveys
 - Scavenger species
 - Others
 - Geospatial analysis
- Establish low density possum buffers around area where established wild animal infection identified
- Continue Tb surveillance outside boundary

Tb Control Strategies – Wild animals (cont'd)

■ Control

- Reduce and maintain possum densities at <15% of carrying capacity (<5% RTCI)
- Control of ferrets if considered to be acting as a vector
- Evaluation of infected cattle and deer herds and animal data relative to other herds in defined area to assess progress

Tb Control Strategies – Wild animals (cont'd)

■ Eradication of Tb

- Maintaining the possum density at very low density (<10% of carrying capacity) for minimum of 5 years with no patches or immigration, has 95% probability of eradicating Tb from possum population (Ramsey & Efford)
- After a time lag will eradicate infection from other wild animals
 - deer longest

Tb Control Strategies – Wild animals (cont'd)

■ Eradication of Tb

- Knowing when to stop
 - No vector-related infected herds for last 5 years
 - Possum density has been maintained below 10% of carrying capacity ($RTC \leq 2\%$) for last 5 years
 - No Tb detected in wild animals within last 24 months
- Development of a model based on Bayesian statistics to assist

Possum Control



What type of control is used

- There are four main poisons used for vector control

1080

Cyanide

Cholecalciferol

Brodifacoum

Note

Each poison has different attributes and is used in different situations according to:

- Possum numbers
- Accessibility
- Habitat
- Land use

Poisons and traps



- Where there are high possum numbers, more efficient to use poison to achieve the initial knockdown
- Once numbers have been reduced, trapping is useful for targeting the remaining possums
- Trapping is very intensive work, as traps need to be checked each day





Photograph courtesy of EPRO

Possum control

- Aerial application of sodium monofluoroacetate (1080) bait gives effective, even control over large tracts of rugged terrain or difficult vegetation cover
- Accuracy of application and adherence to bait



1080 possum baits





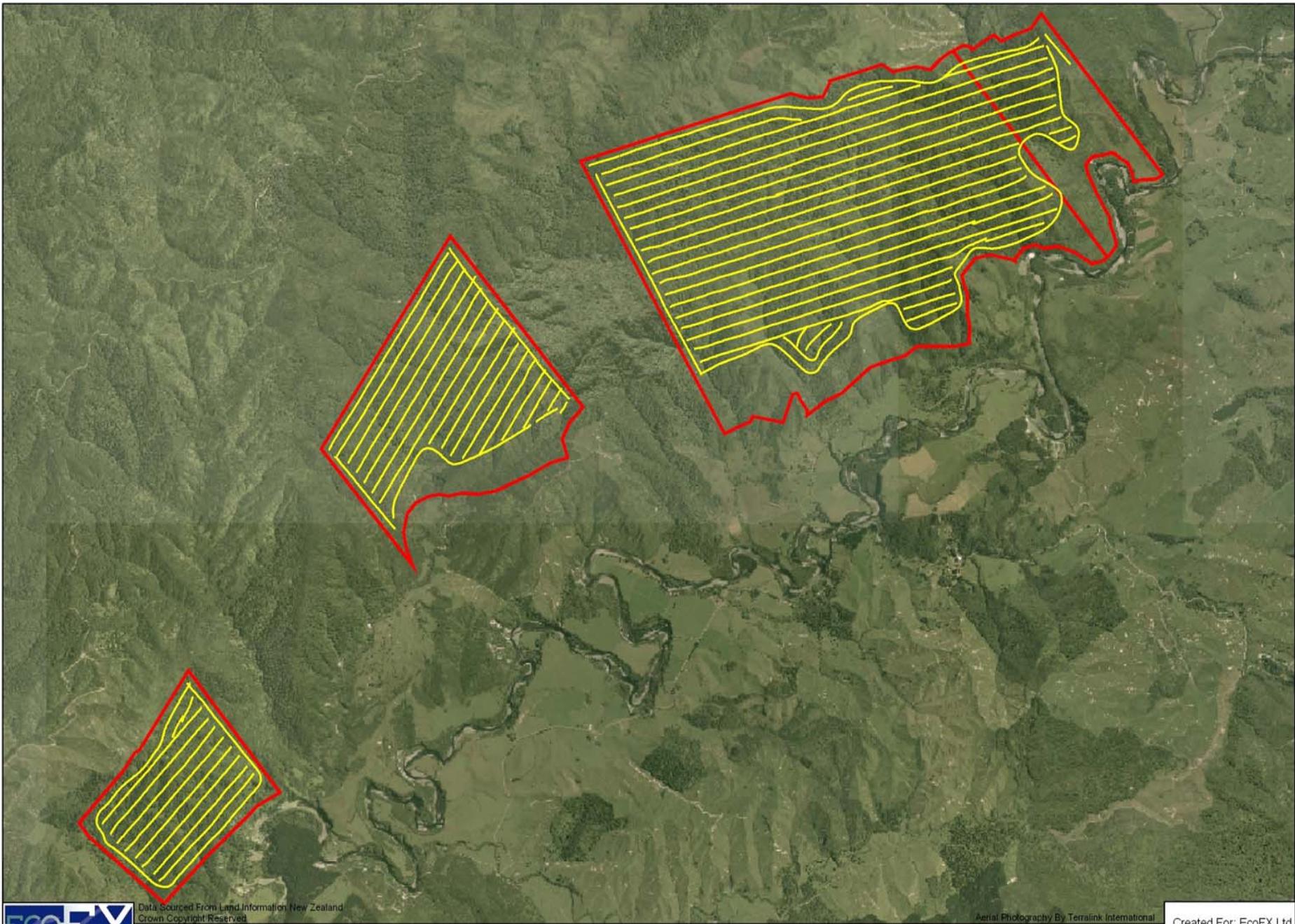
Photograph courtesy of EPRO



Photograph courtesy of EPRO



Photograph courtesy of EPRO



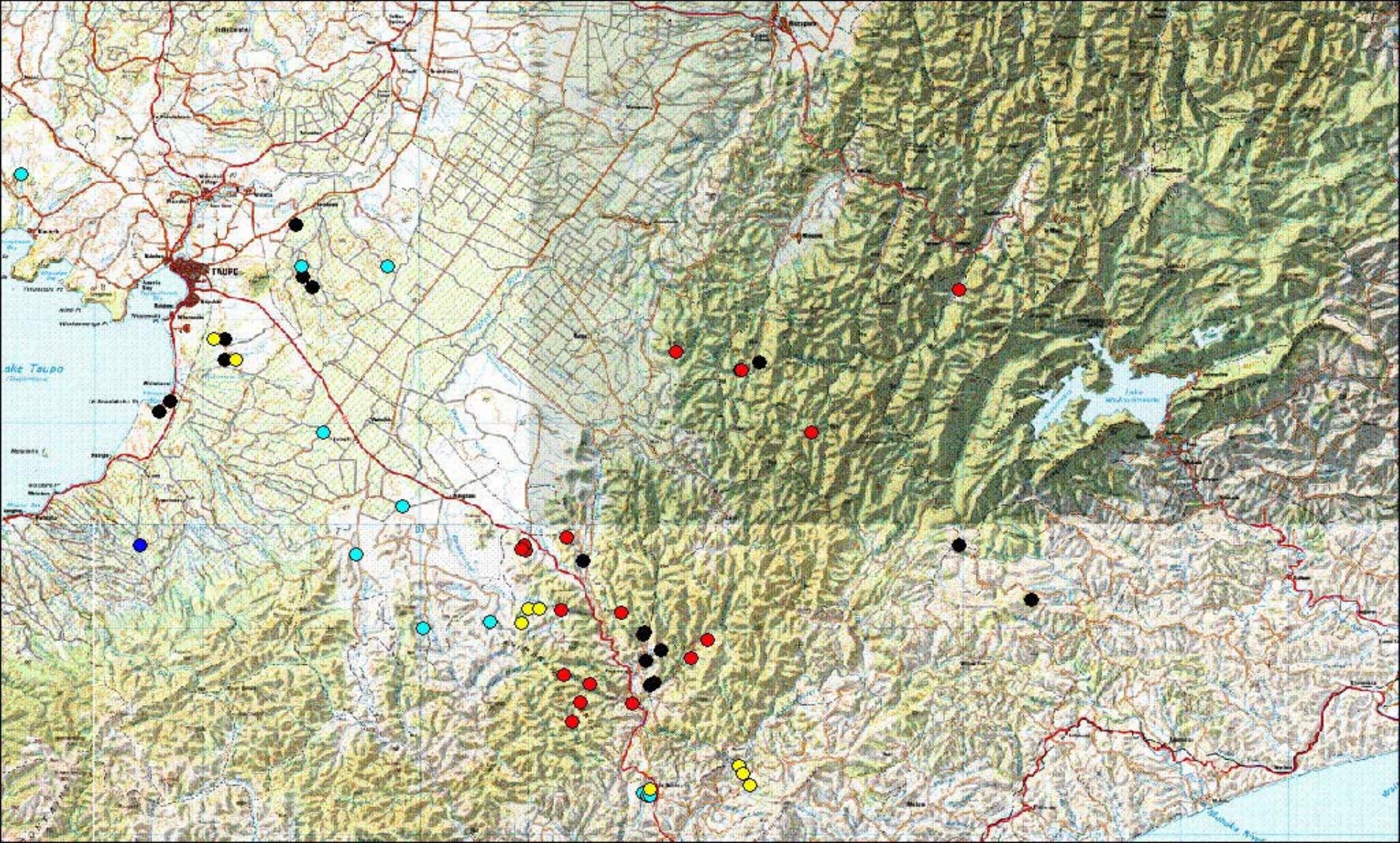
Are Tb possums present?

- Following control where possums have been maintained at a low, even density
- In areas outside existing VRA boundaries

Detecting presence of Tb possums

- Cattle and farmed deer
- Wild animal sentinels
- Priority is: feral pigs > ferrets > wild deer > cattle and deer > possums
 - Release radio-collared feral pigs

Map showing all recent Tb identification



Have Tb possums spread?

- Needed to validate with extensive survey pigs, deer and possums around the area that infection found. Using possums, Pigs and Deer.

Detection Probabilities for presence of Tb possums

- Based on the home range of sentinel species (modified by sex) determine the probability of a sentinel animal being infected if a Tb possum present within its home range
- Collate data for all sentinels of same species and present as probability kernels of Tb possums being present

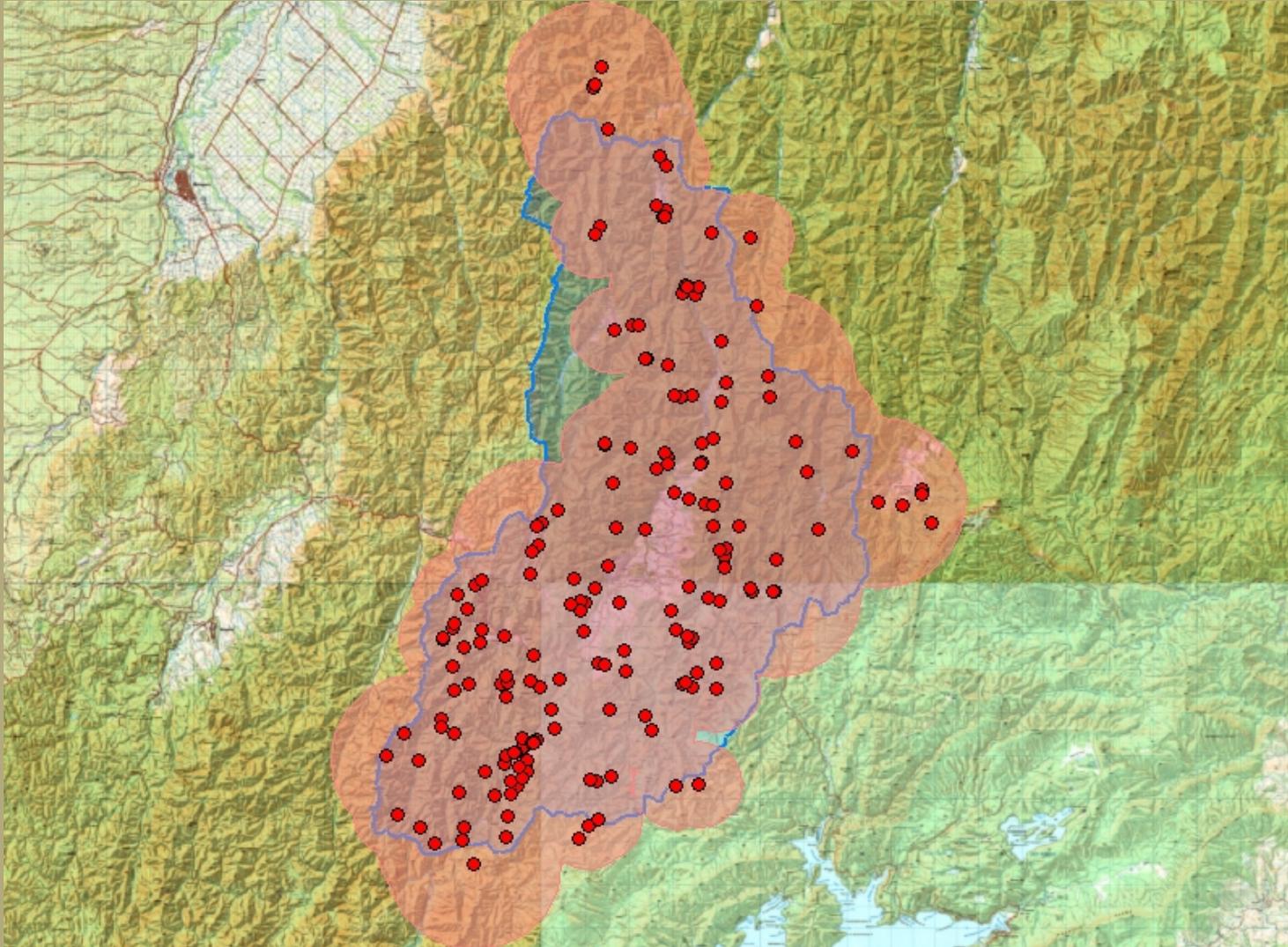
Detection Probabilities for presence of Tb possums (cont'd)

- Can create an “additive” effect over time and species using Bayesian statistics to provide an objective measure of probability of no Tb being present

Ruatahuna and Hanamahihi Surveys

- Undertaken in 2005/06 to find if Tb had spread further north than Te Urewera operation and investigate/validate “Whites Clearing Deer”
 - Combination of Pig, Possum and Deer samples used
 - Sampling spread out to make sure even distribution across area examined
 - Used home range of species to give confidence that no holes left
 - Used mapping to examine area throughout survey process

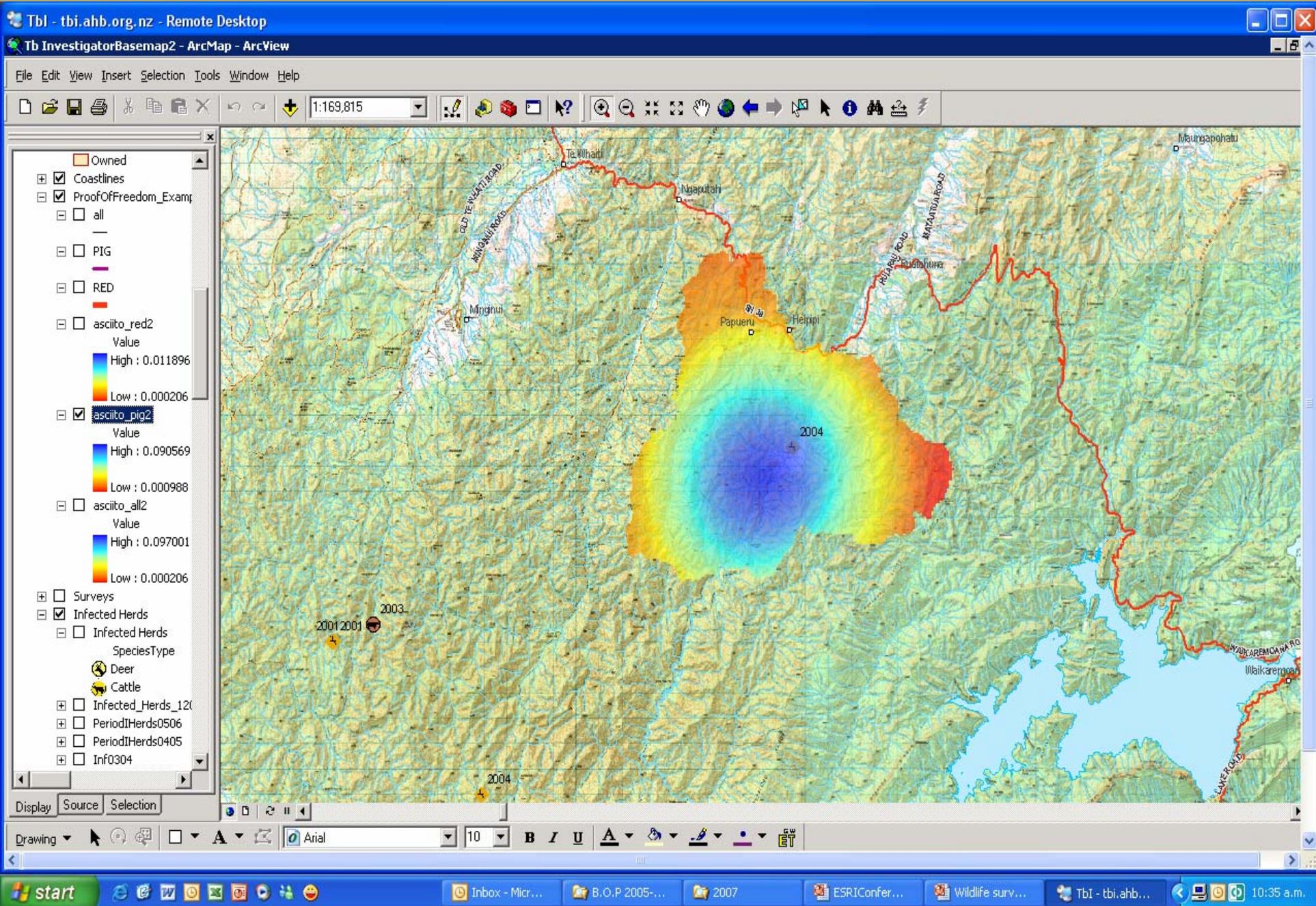
Survey Home Ranges



Survey results

- 912 possums caught - Tb free
- 121 deer caught - Tb free
- 88 pigs caught - Tb free

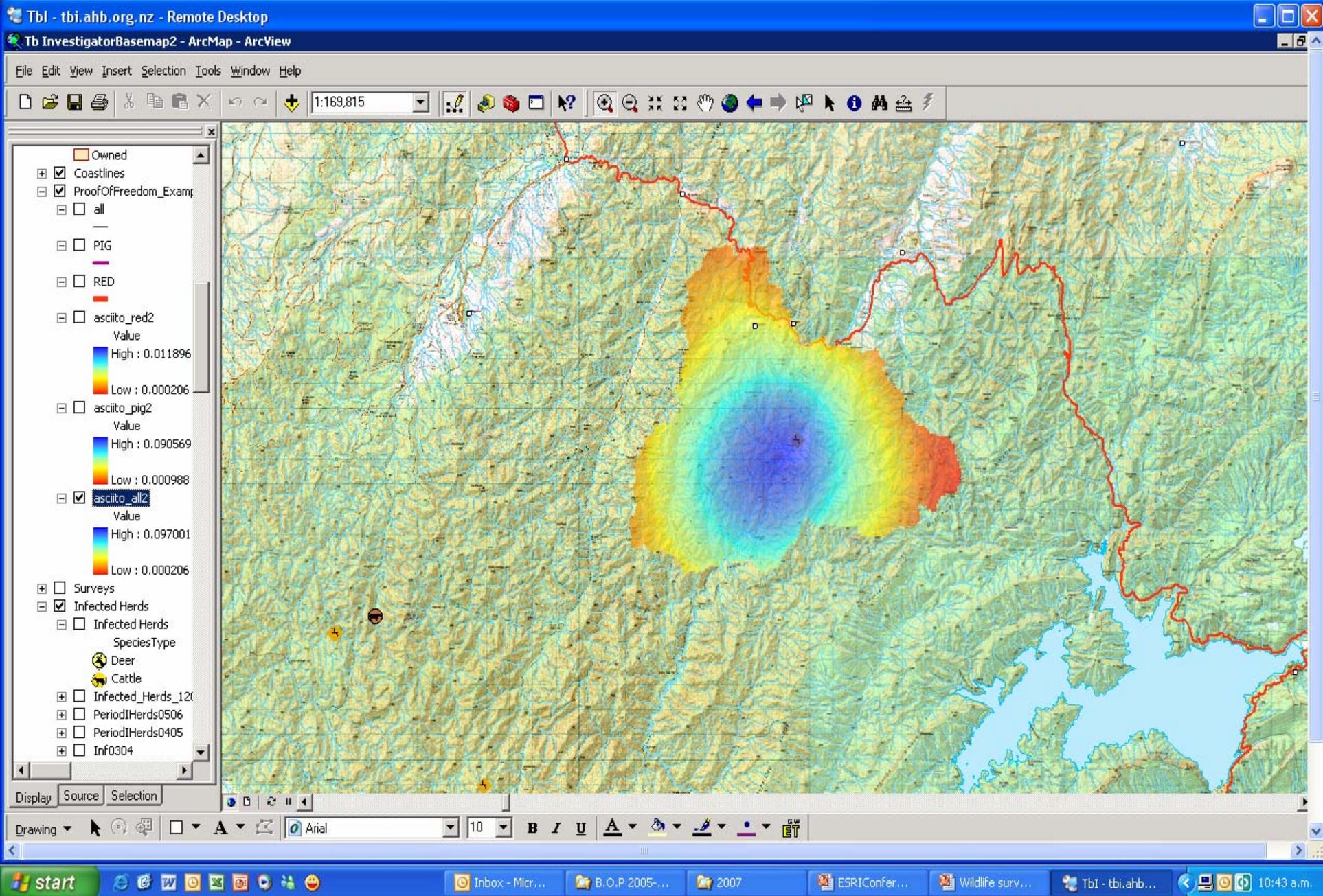
Pigs only data as detection probability: 0.90





Combined pig and deer data

Outcome: Very high probability (0.97) no Tb possums in this area.



So how successful has the Tb programme been?



Number of infected cattle and deer herds and expenditure on vector control 1977 - 2008

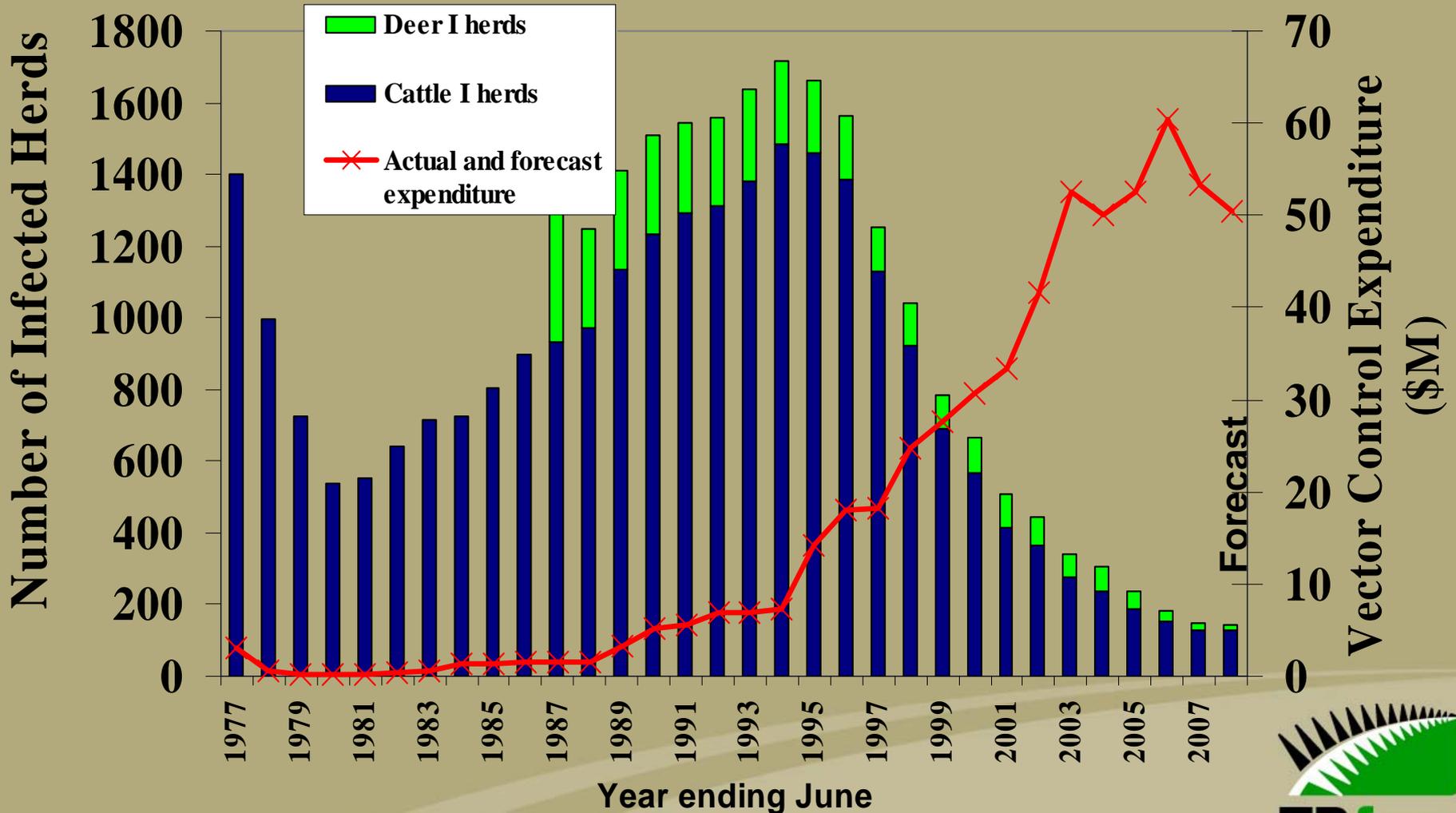
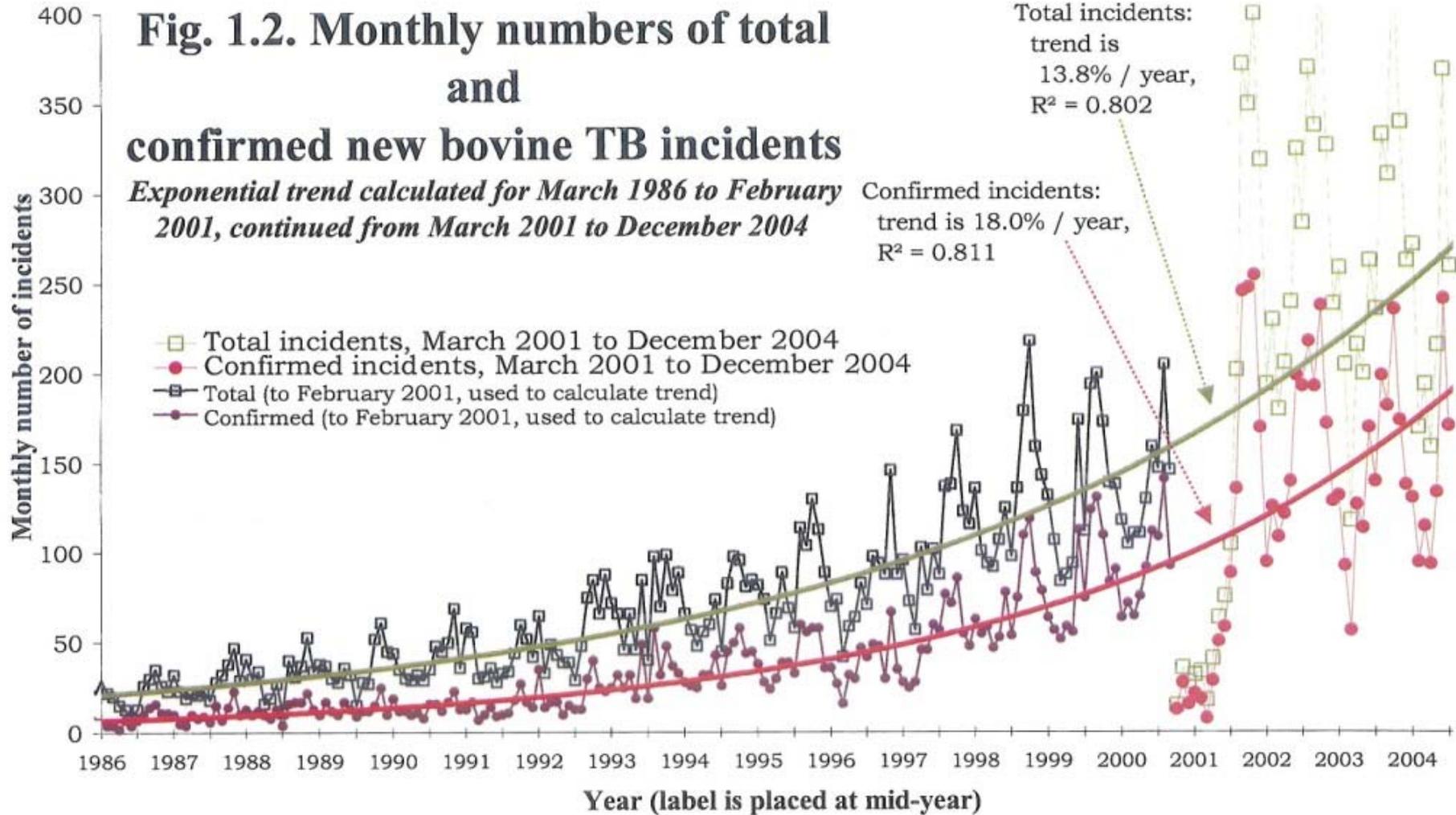
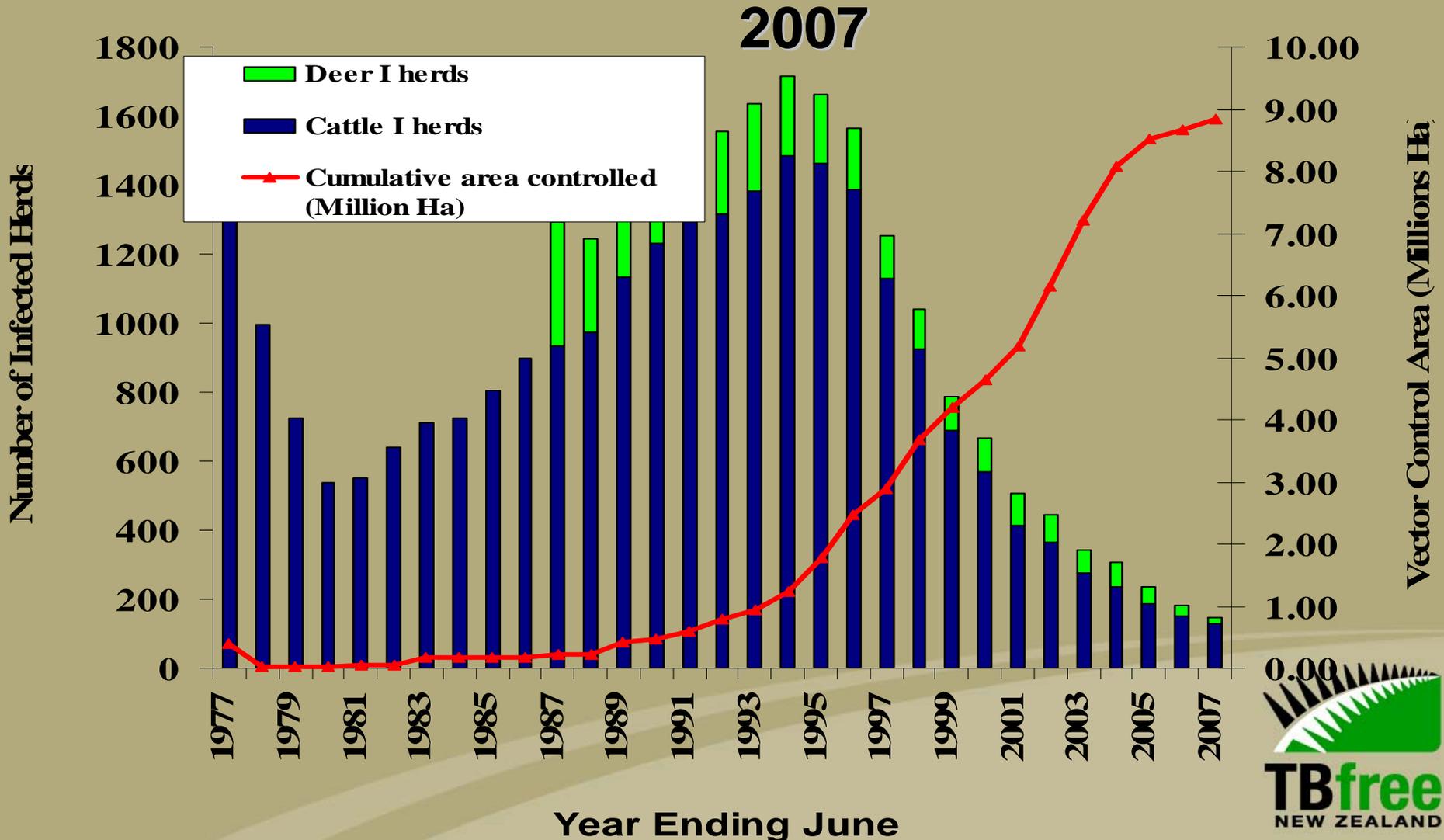


Fig. 1.2. Monthly numbers of total and confirmed new bovine TB incidents

Exponential trend calculated for March 1986 to February 2001, continued from March 2001 to December 2004

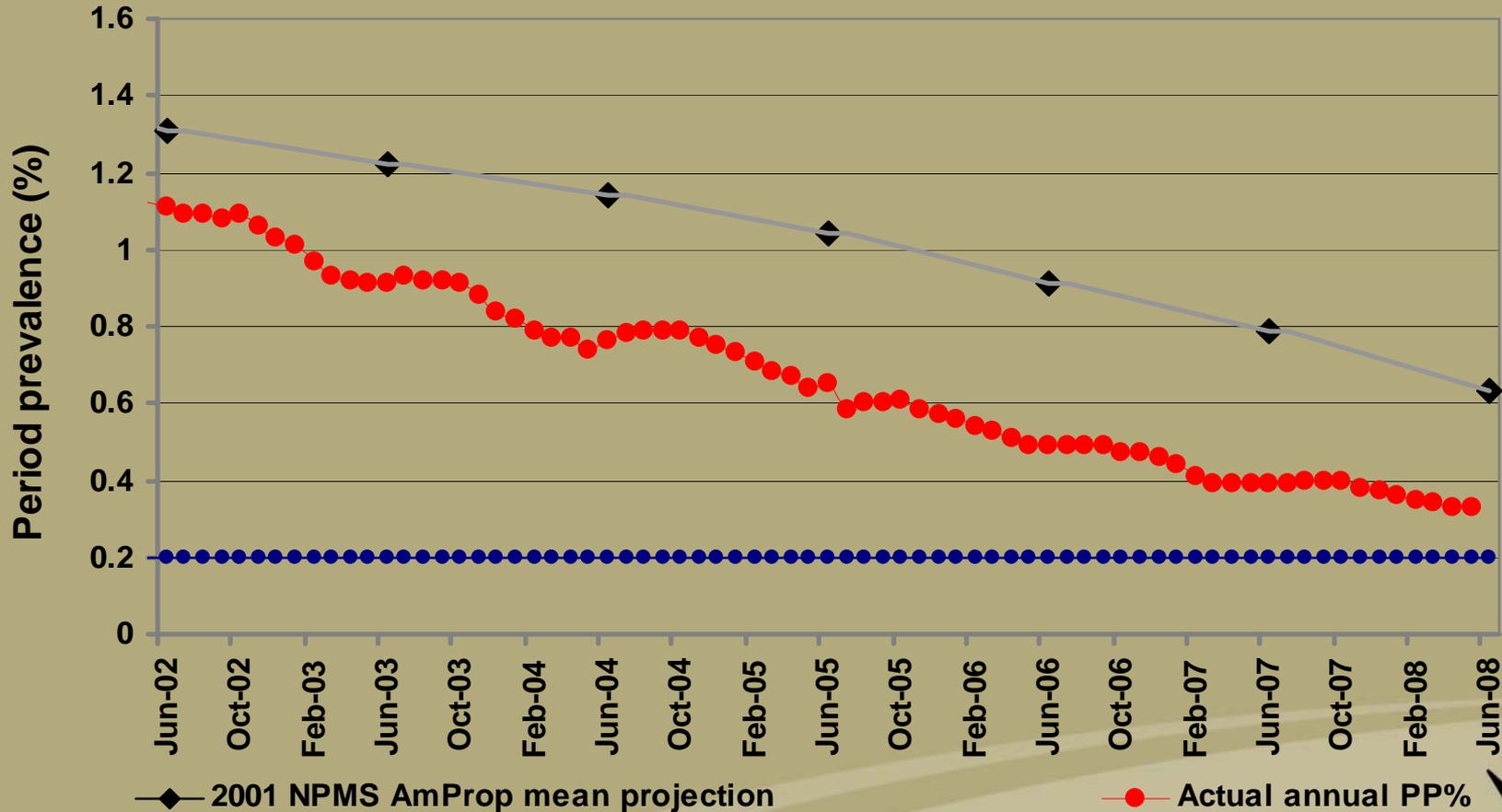


Number of infected cattle and deer herds at June relative to the cumulative area (M ha) receiving possum control June 1977- June 2007



Rolling 12-month Herd TB Prevalence

2001 Projections & Actual Annual Period Prevalence



INFECTED HERDS

30 June 2000

689 Herds

20 June 2008

138 Herds

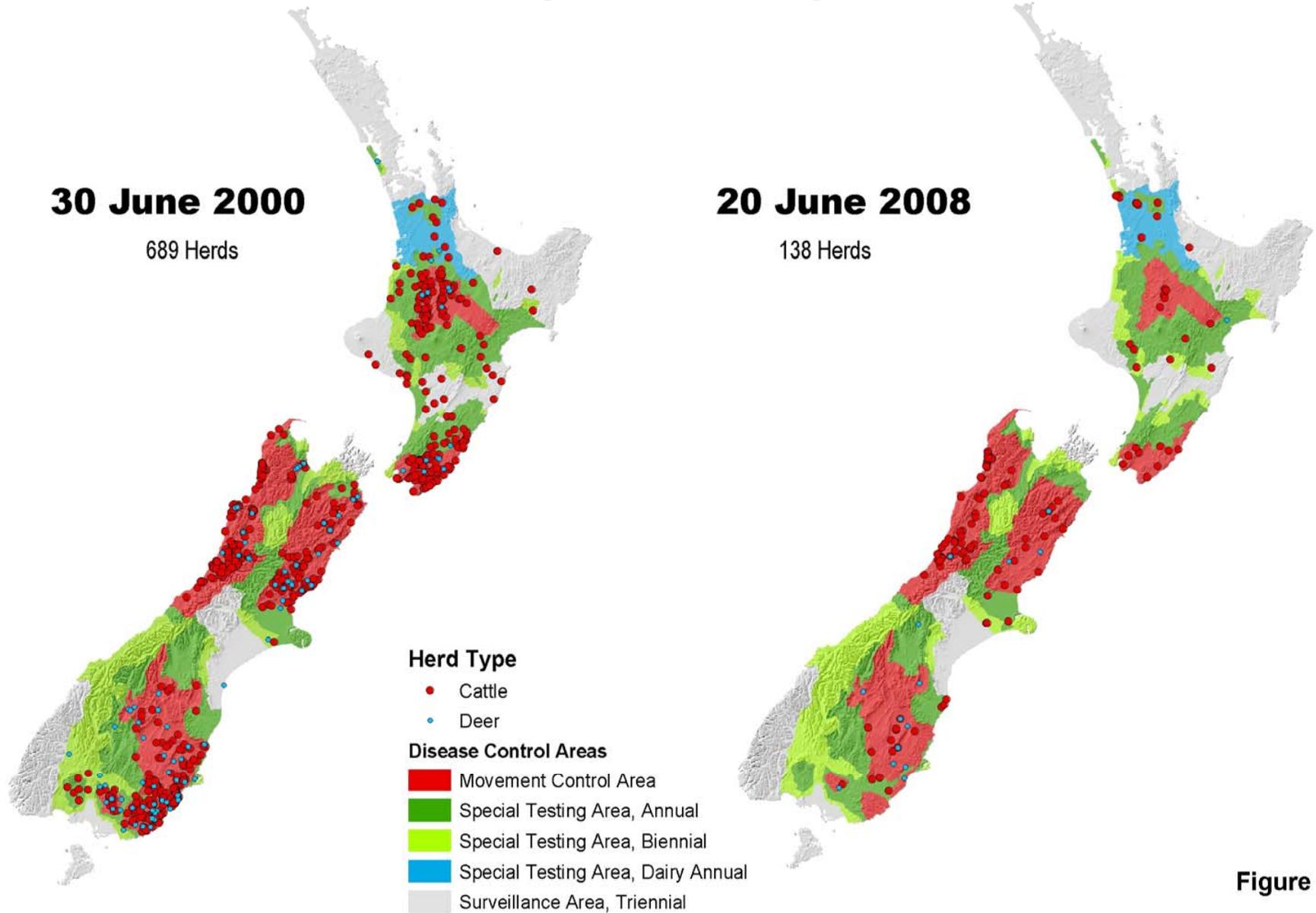


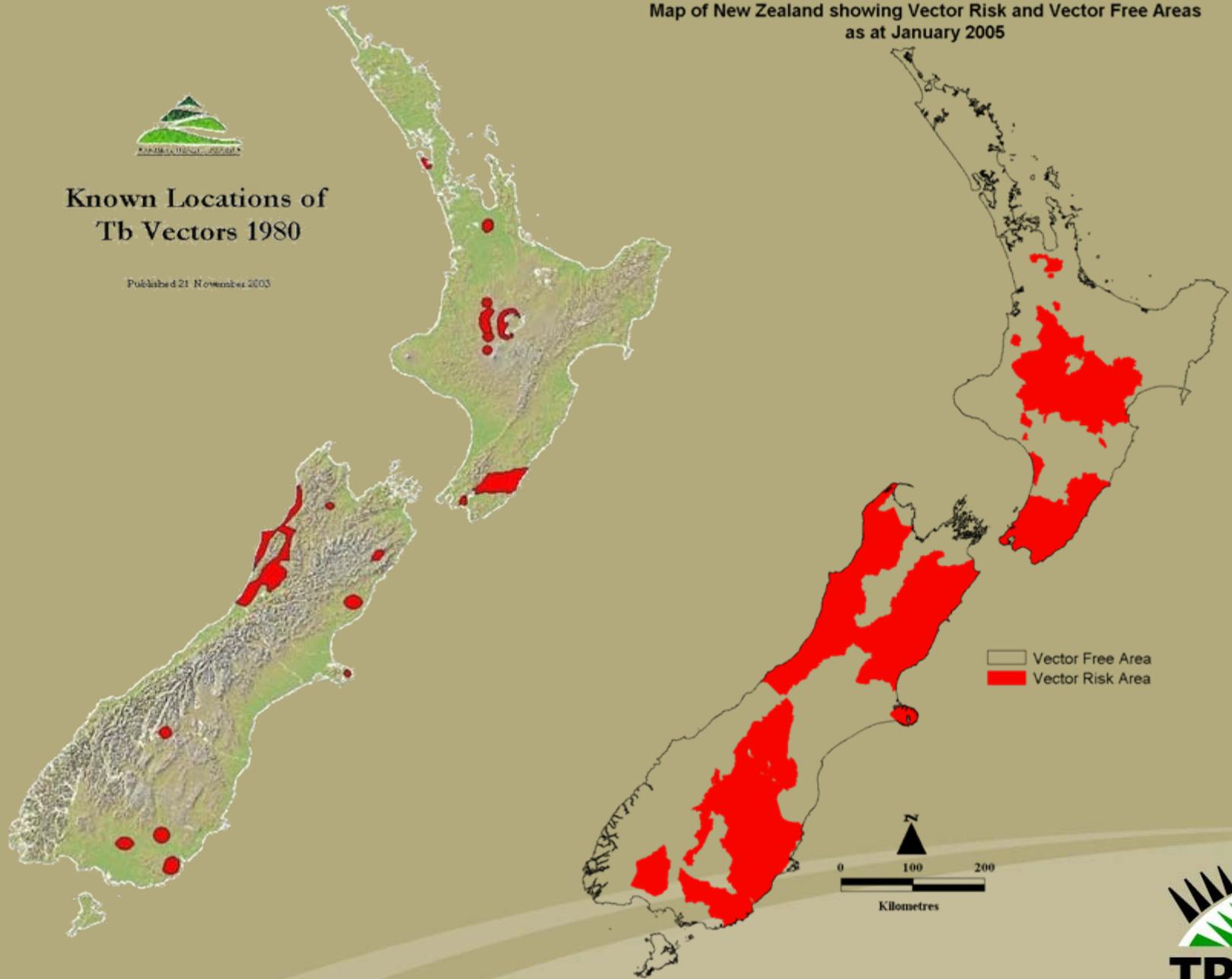
Figure 5

Map of New Zealand showing Vector Risk and Vector Free Areas
as at January 2005



Known Locations of Tb Vectors 1980

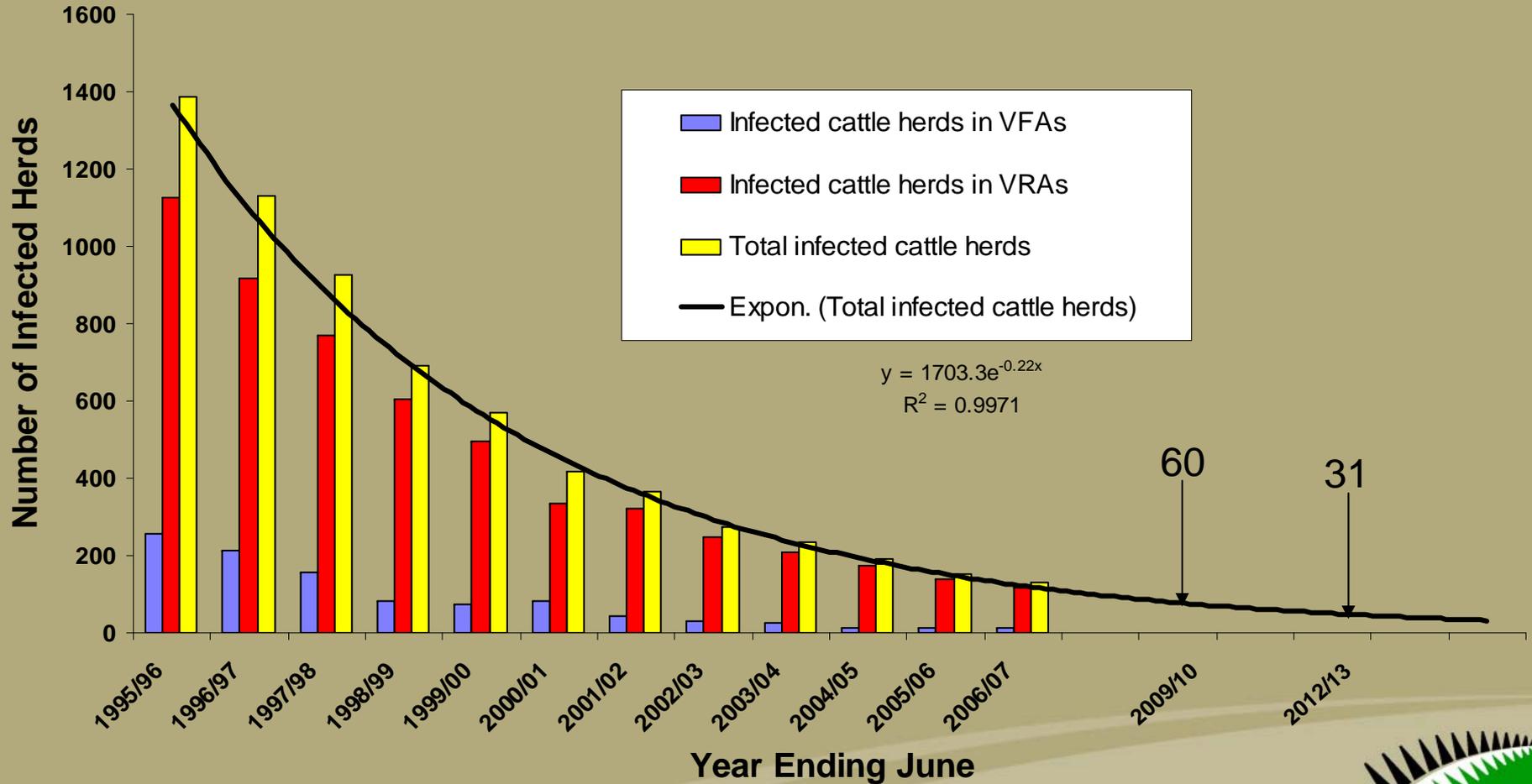
Published 21 November 2003



Infected Cattle Herds

- **Number of cattle herds = 71,510**
- **Number of Infected herds at:**
 - June 2004: 235
 - June 2005: 185
 - June 2006: 151
 - June 2007: 130
 - June 2008: 126
- **Period prevalence (June 07) = 0.35%**
- **Period prevalence (June 08) = 0.32%**

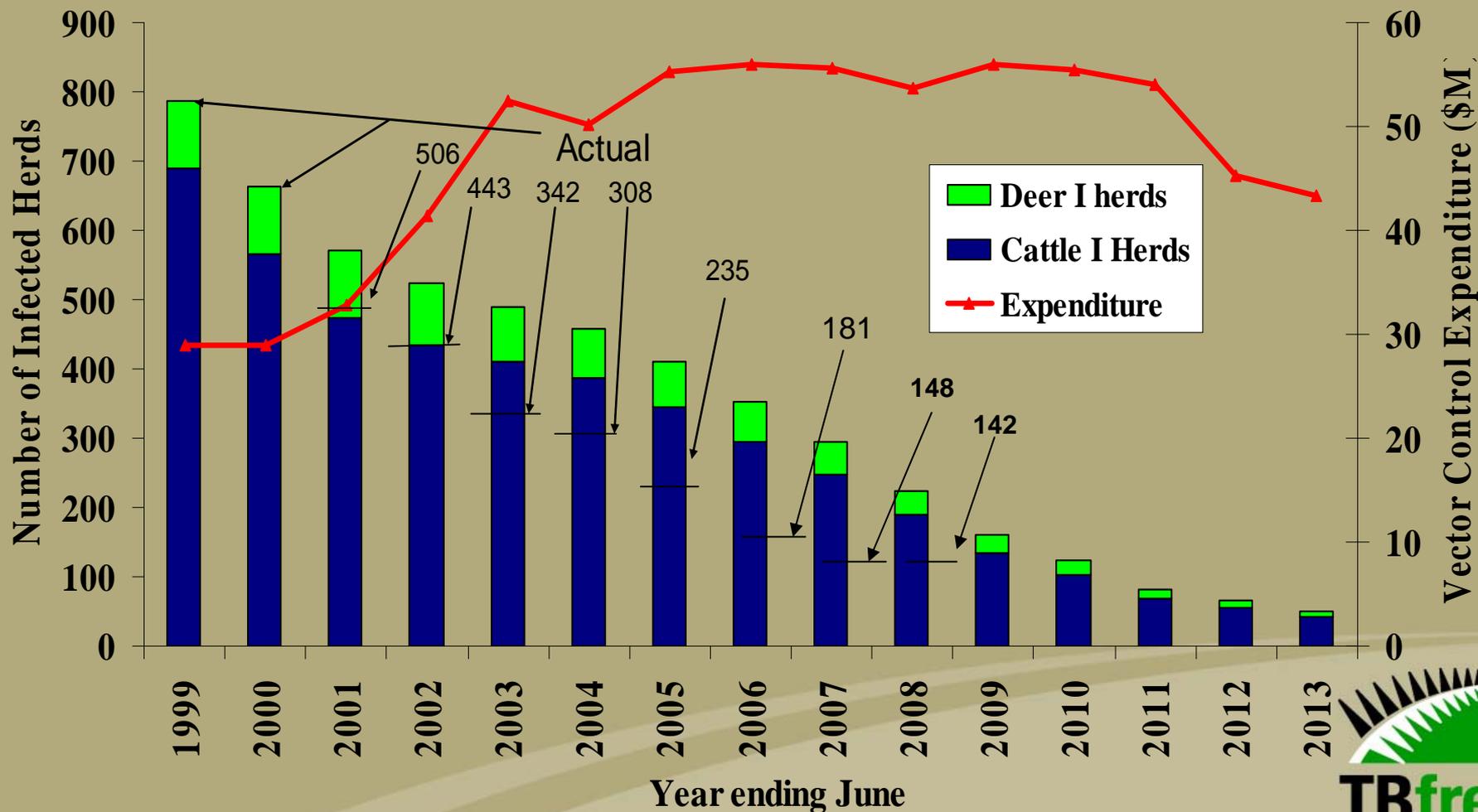
Number of Tb Infected Cattle Herds



Infected Deer Herds

- **Number of deer herds = 4,200**
- **Number of Infected herds at:**
 - June 2004: 73
 - June 2005: 50
 - June 2006: 30
 - June 2007: 18
 - June 2008: 16
- **Period prevalence (June 07) = 0.89%**
- **Period prevalence (June 08) = 0.62%**

Predicted and Actual Number of Tb Infected Cattle and Deer Herds and Expenditure on Tb Vector Control (as at 30 June)



Reasons for the success

- Research and acquired knowledge
 - Modeling and historic evaluation identified that reduction and maintenance of low possum density would eradicate infection from wild and domestic animals
 - Improvements to possum control and outcome monitoring
 - Improvements to targeting of control
 - Spatial databases
 - Veterinarians skilled in disease epidemiology, wild animal ecology and control methodologies

Reasons for the success (cont'd)

- Increased funding for vector control
 - From \$30M in 2000/01 to a mean of \$52M/year for period 2001/02 – 2007/08
 - Cumulative area under control increased from 4.6M ha in 2000/01 to 8.8M Ha in 2007/08
 - Extra funds
 - Efficiencies gained
 - better targeting
 - contracting

Next NPMS!!

- Since 2005, AHB has had problems meeting twin demands of trying to eradicate infection from wild animals and reducing infected herds to meet NPMS objective
 - inefficiencies of vector control
- In 2006 AHB decided to undertake a full review of strategy to present to the Minister of Agriculture by September 2009

Next NPMS!! (cont'd)

- AHB staff evaluated four options
 - No Control
 - Ad-Hoc control
 - Containment
 - Eradication
- Both the containment and eradication options are being considered by MAF Biosecurity and Industry stakeholders

The Future

- In the short term
 - More targeted vector control based on better data combined with intelligent analysis and modeling
- In the medium term
 - Oral BCG vaccine for possums
 - Possum specific toxin
- In the longer term
 - Vector transmitted immuno-contraceptive for possum biocontrol?????

Conclusion

- Expect the current strategy to meet the 0.2% period prevalence objective by 2012/13
- Deer industry has provided incentives to assist *at risk* deer herd owners
- Current vector control strategy becoming inefficient in trying to reduce infected herd numbers and eradicate infection from wild animal populations
- AHB consulting on modifications to the current NPMS

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