

# Sanctuaries, & biodiversity responses to pest control

John Innes, Rachelle Binny

Andrea Byrom, Neil Fitzgerald, Alex James, Roger Pech

Manaaki Whenua - Landcare Research



Colbourne

Fitzgerald

LINK seminar, Wellington, 19 October 2017

# Outline

- What and where are NZ's sanctuaries?
- Major pest management regimes
- Importance of monitoring with standard methods
- Some Maungatautari results

John  
Innes



- What can we learn from monitoring in fenced sanctuaries and mainland islands?
- Biodiversity monitoring database
- A meta-analysis of outcomes for sanctuaries

Rachelle  
Binny





Dog



House mouse



Red deer



Norway rat



Hedgehog



Feral goat



Fallow deer



Rabbit



Ship rat



Cat



Ferret

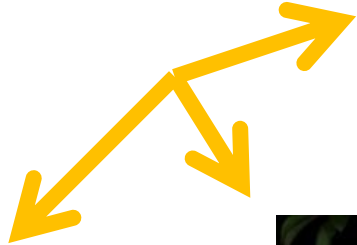
Weasel



Stoat



Brushtail possum



Nga Manu Images

Nga Manu Images

# What are 'biodiversity sanctuaries'?

Sites that:

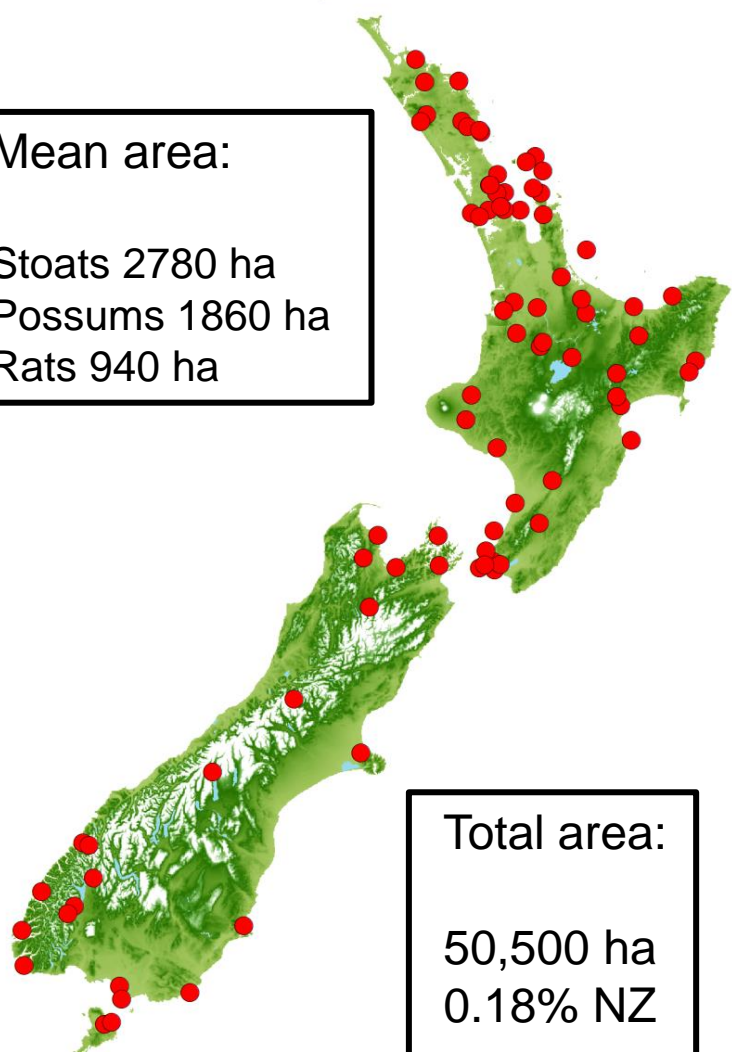
- experimentally restore NZ ecosystems to indigenous dominance and full species complement
- 
- control or eradicate a broad suite of pests with best practice techniques
  - reintroduce missing species
  - manage a permanent and substantial risk of pest reinvasion
  - inspire and galvanise communities to local conservation

We identified 82 such projects on or near the  
NZ mainland

# SANCTUARIES

Aongatete Forest Restoration Project  
 Arthur's Pass Wildlife Trust  
 Ark In The Park  
 Bluff Hill  
 Boundary Stream Mainland Island  
 Bream Head Conservation Trust  
 Brook Waimarama Sanctuary  
 Bushy Point Restoration Project  
 Bushy Park  
 Cape Sanctuary  
 Cleddau Delta  
 Te Puka - Hereka / Coal island  
 Dancing Star Ecological Preserve  
 East Taranaki Environment Trust  
 Eglinton  
 Friends of Flora  
 Kotuku Peninsula Sanctuary  
 Habitat Te Henga  
 Halfmoon Bay  
 Project Island Song  
 Project Janszoon  
 Kaipupu Point Mainland Island  
 Kapiti Island  
 Zealandia  
 Kepler Peninsular Conservation Project  
 Long Point  
 Longbush Ecosanctuary  
 Mahakirau Forest Estate  
 Mana Island  
 Manawatu Estuary  
 Mangaokewa Reserve  
 Matakoho / Limestone Island  
 Matiu / Somes Island  
 Maungataniwha  
 Maungatautari Ecological Island  
 Tuhua / Mayor Island  
 Port Charles Rat Attack  
 MIRO  
 Mokoia Island  
 Motu Kaikoura Trust  
 Motuihe Island

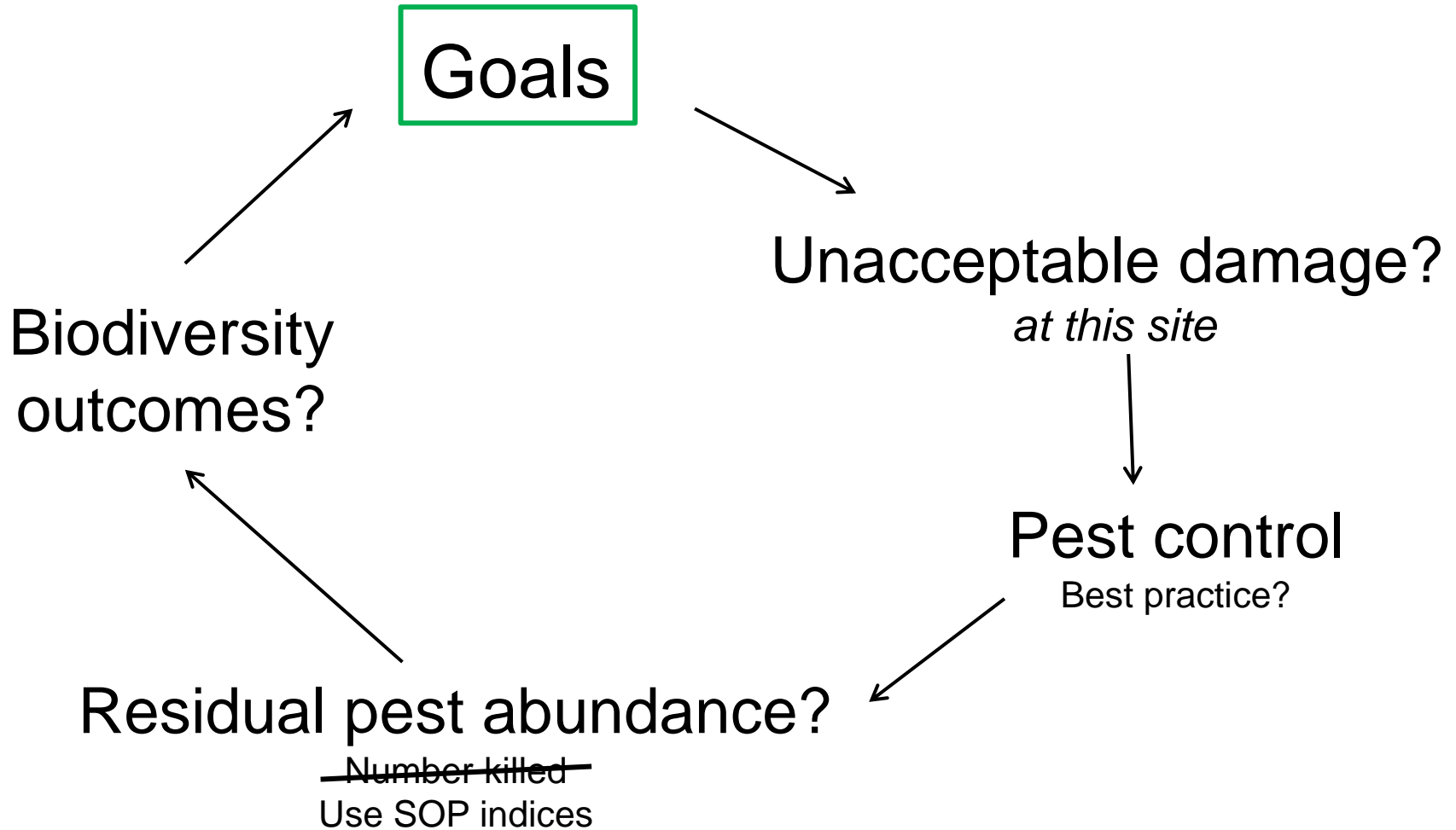
**Mean area:**  
**Stoats 2780 ha**  
**Possums 1860 ha**  
**Rats 940 ha**



**Total area:**  
**50,500 ha**  
**0.18% NZ**

Motuora Island  
 Pukaha Mt Bruce  
 Ngapukeariki Mainland Island  
 Te Urewera Mainland Island  
 Orokonui EcoSanctuary  
 Otanewainuku  
 Otari - Wilton's Bush  
 Pikiariki Ecological Area  
 Pirongia  
 Pomona and Rona Islands  
 Poutiri Ao o Tane  
 PRR / Kaki  
 Pukenui Forest  
 Puketi Forest  
 Puppu Rangi Nature Sanctuary  
 Otamahua / Quail Island  
 Rangitoto - Motutapu Islands  
 Resolution Island  
 Rotoiti Nature Recovery Project  
 Rotokare Scenic Reserve  
 Rotoroa Island  
 Secretary Island  
 Sinbad Sanctuary Project  
 Shakespear Open Sanctuary  
 Taurikura Ridge Landcare  
 Tawharanui Open Sanctuary  
 Te Kauri - Waikuku Trust  
 Te Kopi Biodiversity Project  
 Tiritiri Matangi Island  
 Totara Reserve  
 Trounson Kauri Park  
 Waikawau Bay Wetland Project  
 Wainuiomata Water Reserve  
 Waipapa Ecological Area  
 Wairakei Golf Course  
 Waitemata Coastal Sanctuary  
 Wenderholm  
 Whakaangi Landcare Trust  
 Whakatane Kiwi Project  
 Windy Hill - Rosalie Bay  
 Young Nicks Head

# Pest control 101



# Major regimes

## 1. Repeated aerial 1080

- a) Ospri for Tb/DOC for forest health
- b) Battle for our Birds (timed for mast)
- c) 2-3 yearly – sustained ship rat control

## 2. Mainland island

- kaka, kiwi, kokako, robin, whio, tree weta

## 3. Fenced sanctuary/island

- hihi, tieke, takahe, kakapo, tuatara, giant weta

# Regime 2

## Mainland island



kokako



robin



tree weta



ship rats



possum

Nga Manu Images



NI brown kiwi



whio



kaka

ferret

stoat



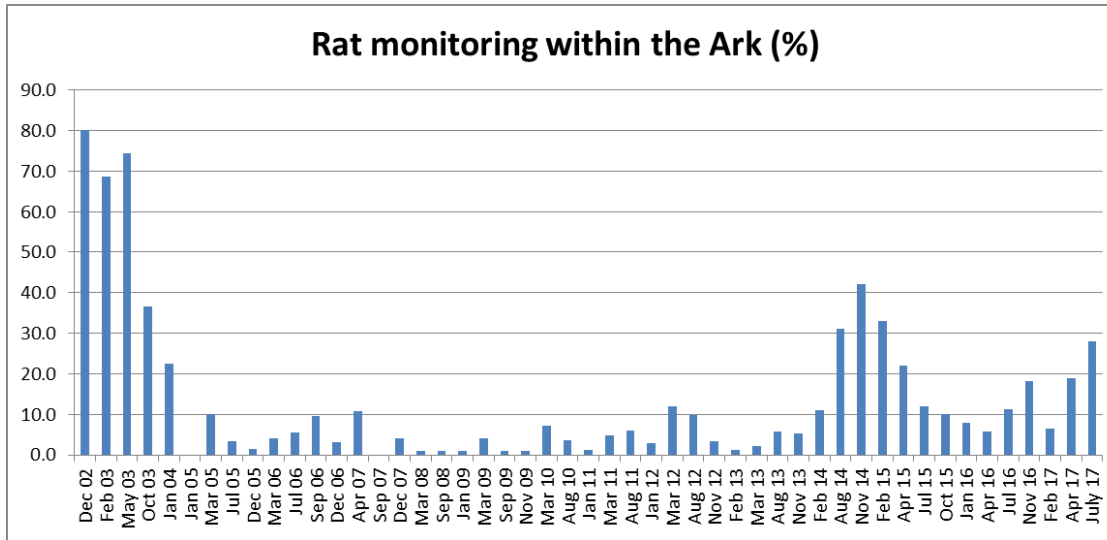
M. Rothwell  
Kakariki Games

S. Wills



# Ark in the Park, Waitakeres, 2002-17\*

Rat tracking rate

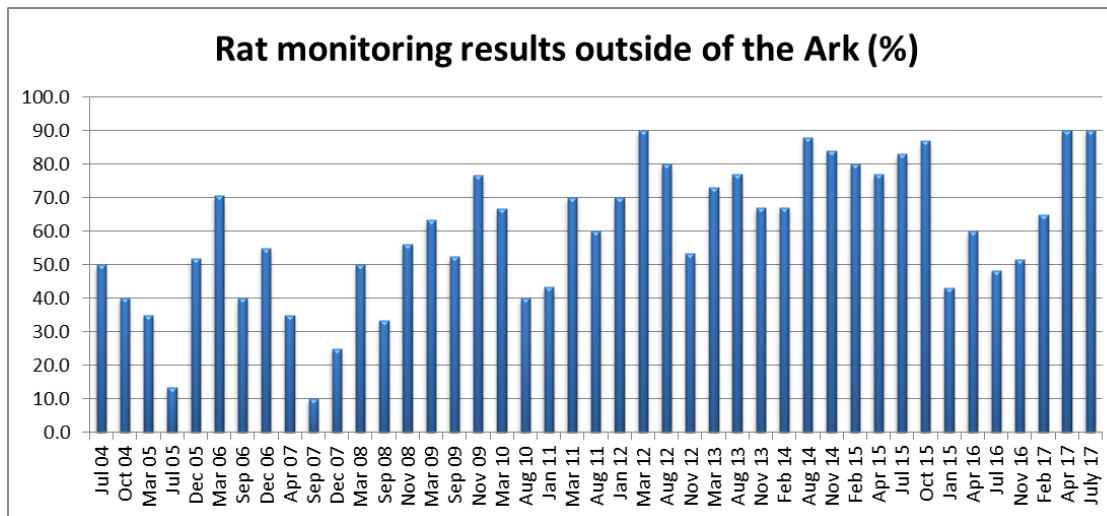


Ship rat



Norway rat

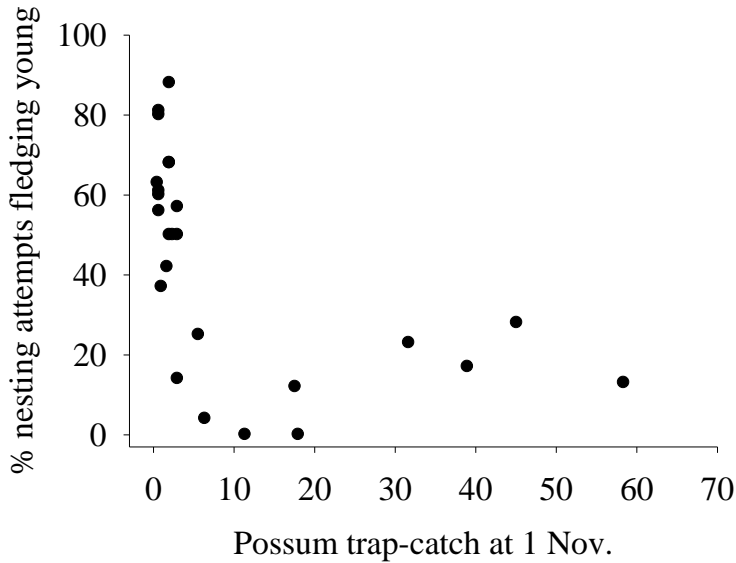
Rat tracking rate



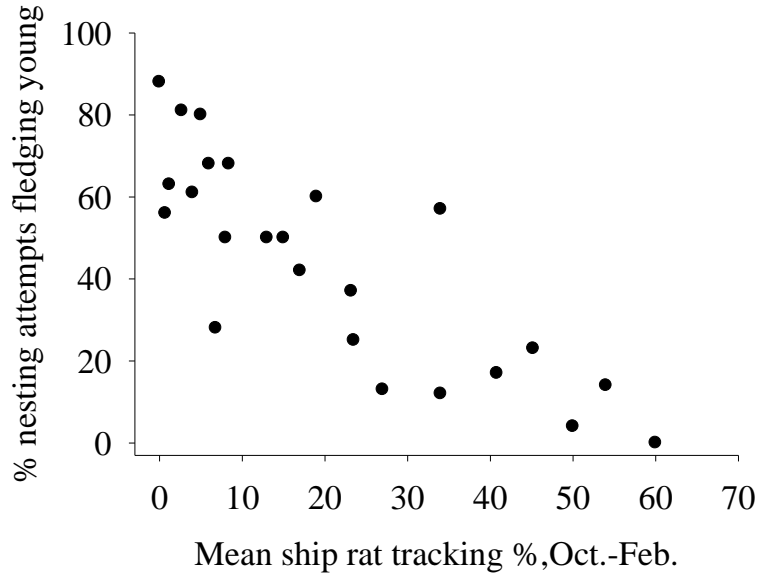
\*Gillian Wadams, Forest and Bird

# Kokako nesting success\* vs

## a) Possum trap-catch



## b) Ship rat tracking rate

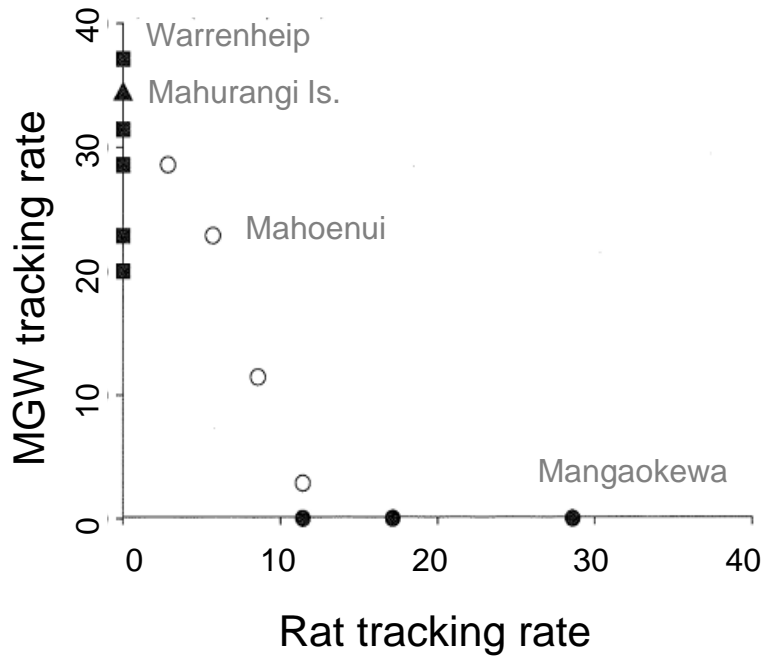


CR Veitch

Norbury *et al.* 2015. *Biol. Cons.* 191 409-420. Density-impact functions for terrestrial vertebrate pests and indigenous biota: Guidelines for conservation managers.

\* Innes *et al.* 1999. *Biol Cons* 87:201-214

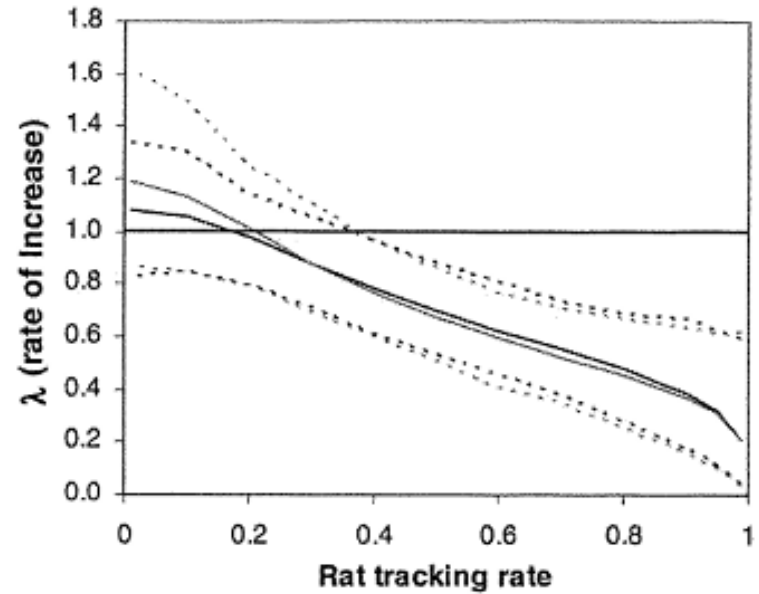
# Mahoenui giant weta



Corinne Watts *et al.* 2017.  
Weta as bioindicators.  
Jnl Insect Conservation

Thornburrow

# North Island robin



M. Rothwell  
Kakariki Games

Doug Armstrong *et al.* 2006.  
Robin viability vs predators.  
Jnl Wildlife Management

# Regime 3

## Fenced sanctuary/island



Hihi



Little spotted kiwi



Tieke



Kakapo



Duvacel's gecko



Giant weta

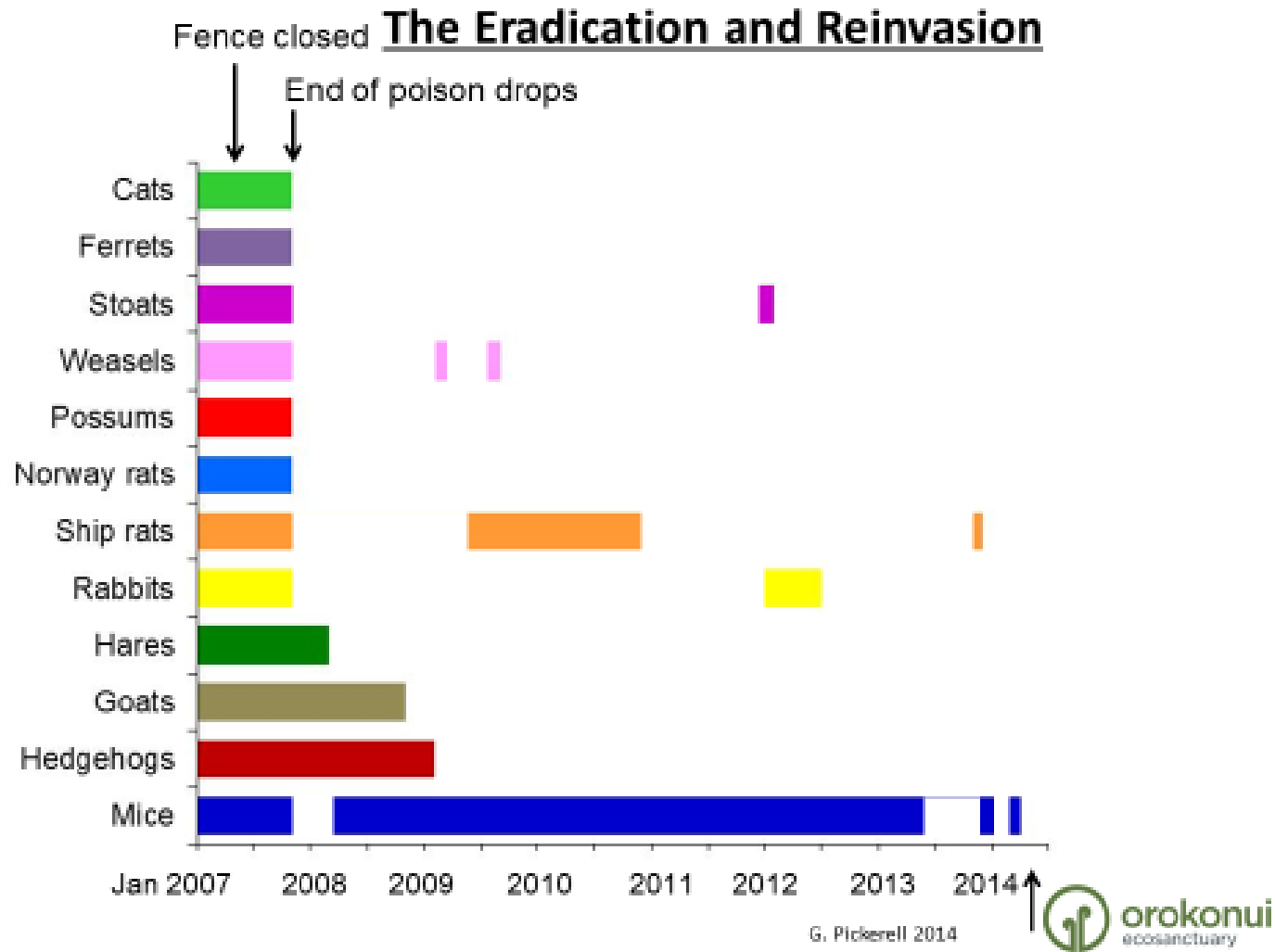


Tuatara

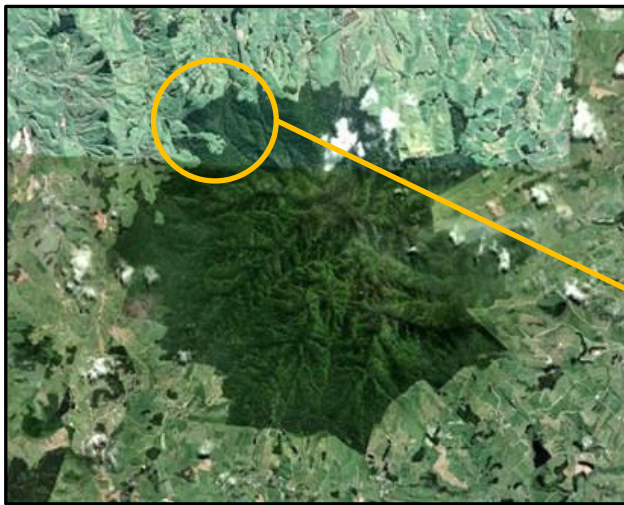


Takahe

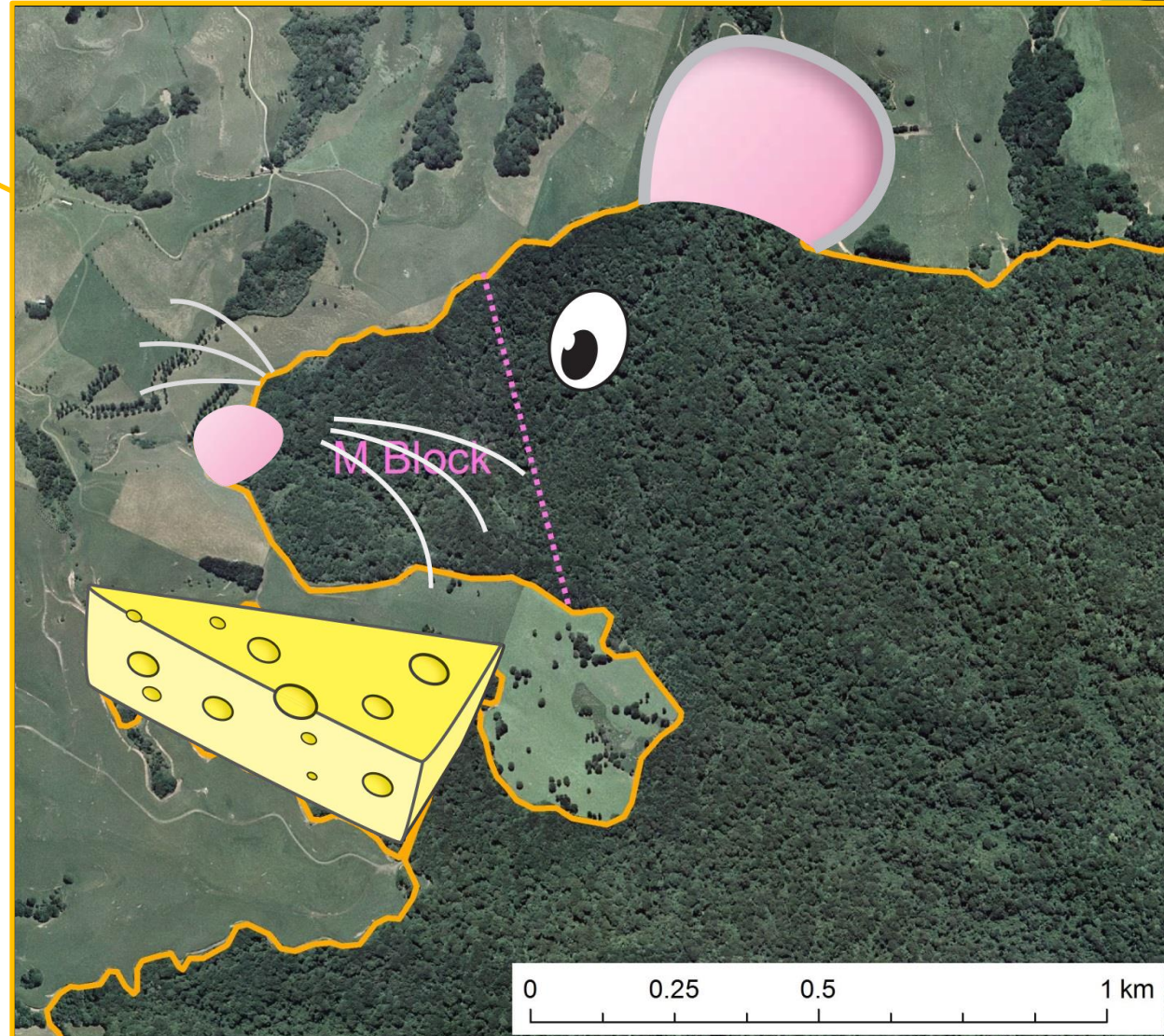
# Invader pests at Orokonui, Dunedin (Elton Smith)



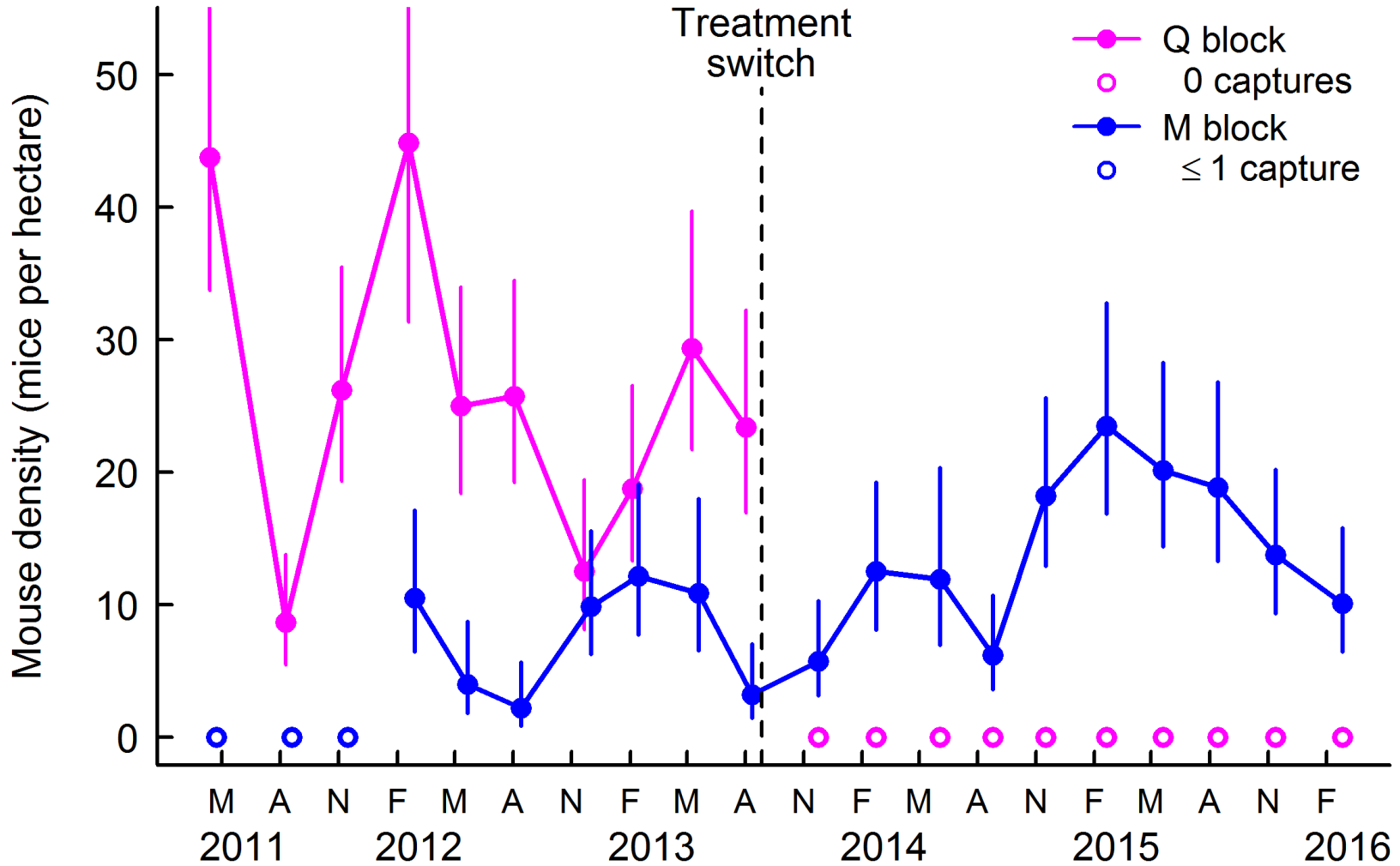
# Mice alone at Maungatautari



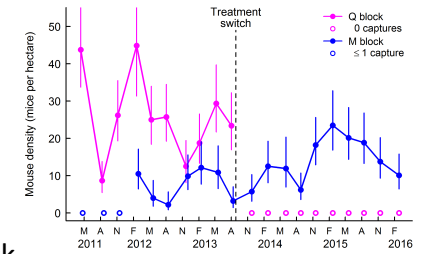
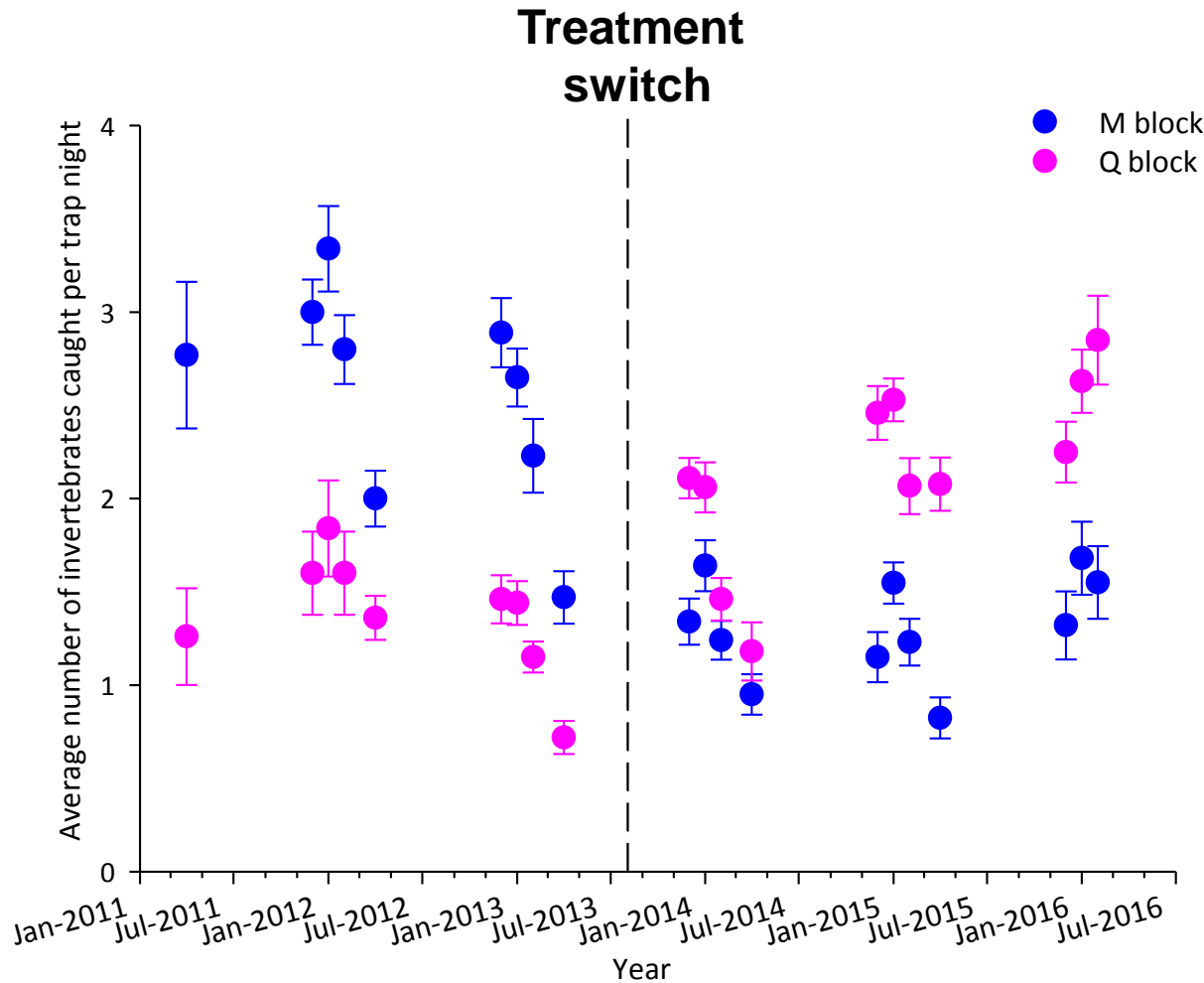
3400 ha



# Mouse density



# Invertebrate abundance

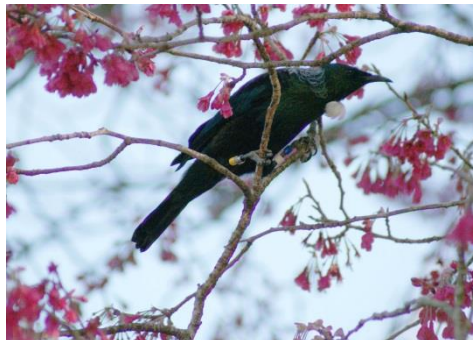
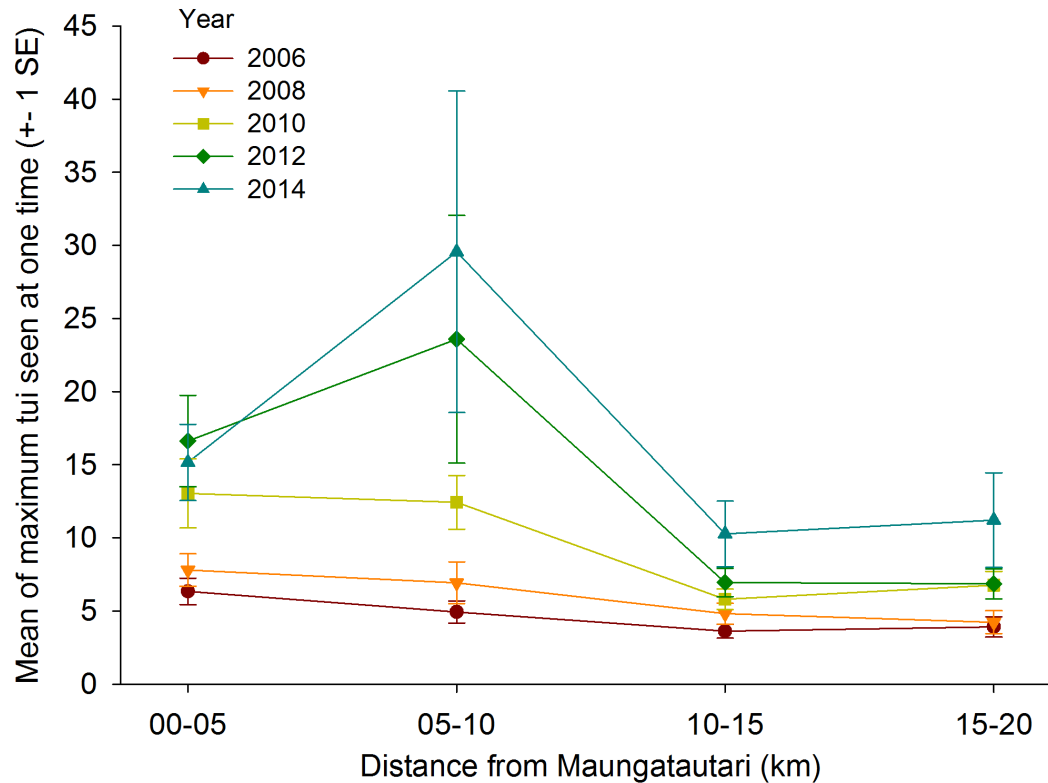


Similar patterns for:

- Beetles, spiders, weta, caterpillars
- Leaf litter samples

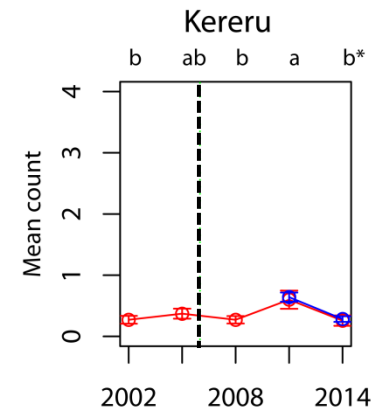
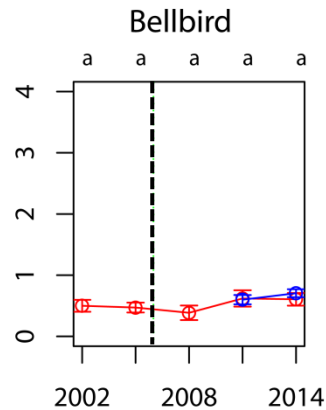
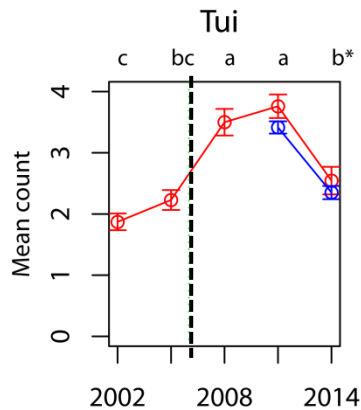
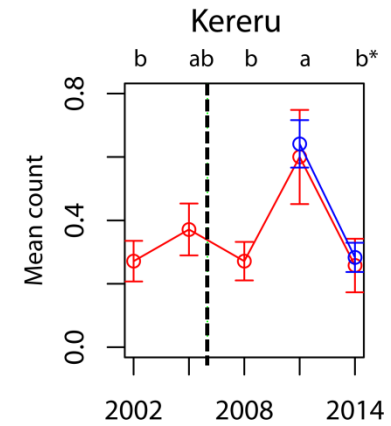
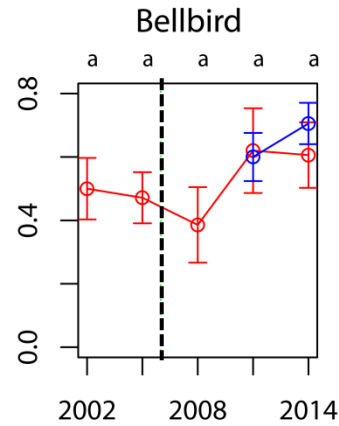
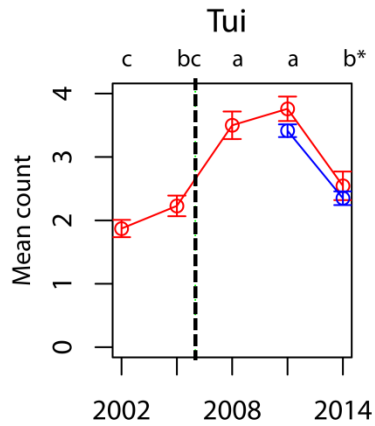


# Tui movement/spillover from M'tari



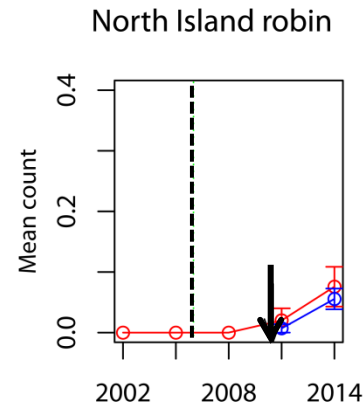
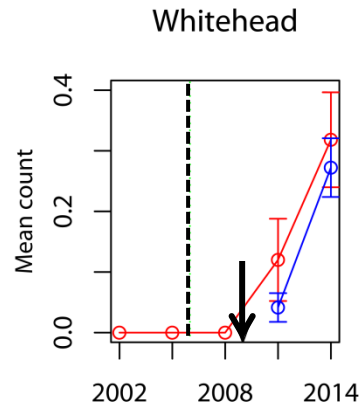
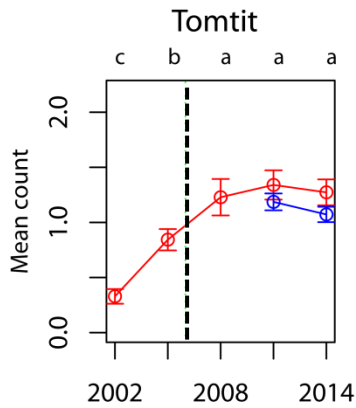
# Maungatautari 5mbc, 2002-14: mobile frugivores

-----  
= Mammal  
eradication

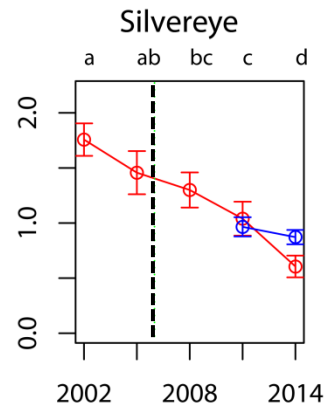
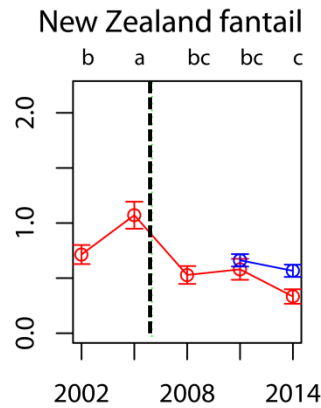
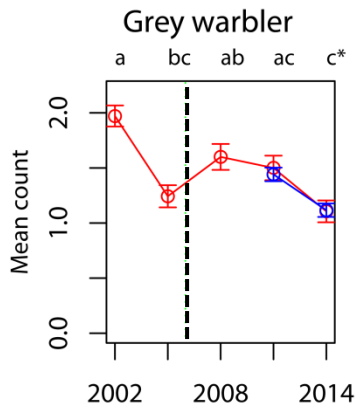


# Maungatautari 5mbc, 2002-14: insectivores

-----  
= Mammal  
eradication



↓  
= Translocation



# Conclusions

Pest levels (eg zero) known for some birds, lizards, inverts

Few density-impact functions known

Pest eradication impossible without fences

Competition and habitat also matter

There are winners and losers

## PLEASE MONITOR:

- Residual pest abundance with SOP indices
- Diverse biodiversity outcomes
- For 10 + years..... Rachelle

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John  
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- What can we learn from monitoring in fenced sanctuaries and mainland islands?
- Biodiversity monitoring database
- A meta-analysis of outcomes for sanctuaries

Rachelle  
Binny



# Predator Free New Zealand

**ORIGINAL PRESS RELEASE 25 JULY, 2016: New Zealand to be Predator Free by 2050**

"Prime Minister John Key has today announced the Government has adopted the goal of New Zealand becoming Predator Free by 2050."



## *Four interim 2025 goals:*

1. Suppress predators on a further 1 million hectares
2. Eradicate predators from at least 20,000 hectares without the use of fences
3. Eradicate predators from island nature reserves
4. Achieve a breakthrough science solution capable of eradicating at least one small mammal predator.

The Economist | World politics | Business & finance | Economics | Science & technology | Culture

**Conservation**

## New Zealand's war on predators

All latest updates

The biggest plan yet to rid the islands of animals threatening local flora and fauna

Aug 2nd 2016 | Science and technology | [Timekeeper](#) | [Like 2K](#) | [Tweet](#)



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The Norway rat is one of eight predators targeted for eradication in New Zealand. © Tom James/Metal Group/Getty Stock Photo

## New Zealand's 'mind-blowing' goal: Rat-free by 2050

# What can sanctuaries teach us?

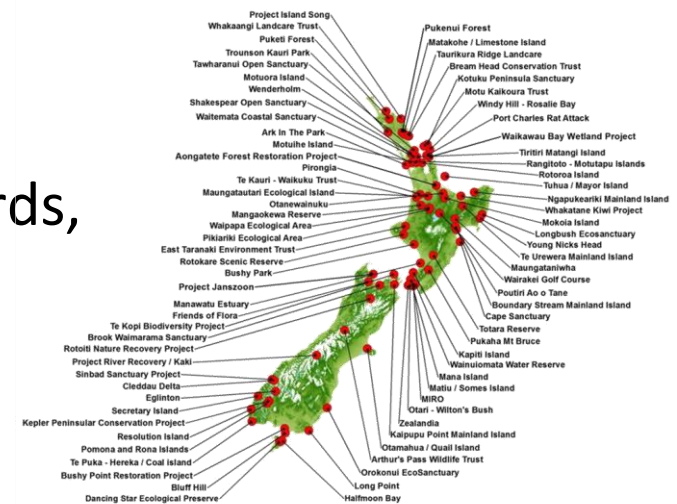
How do NZ's flora and fauna respond to pest control?

- Compare different control regimes; initially fenced sanctuaries and mainland islands
- Understanding biodiversity benefits is a crucial step towards achieving goals of PF2050



# Biodiversity monitoring database

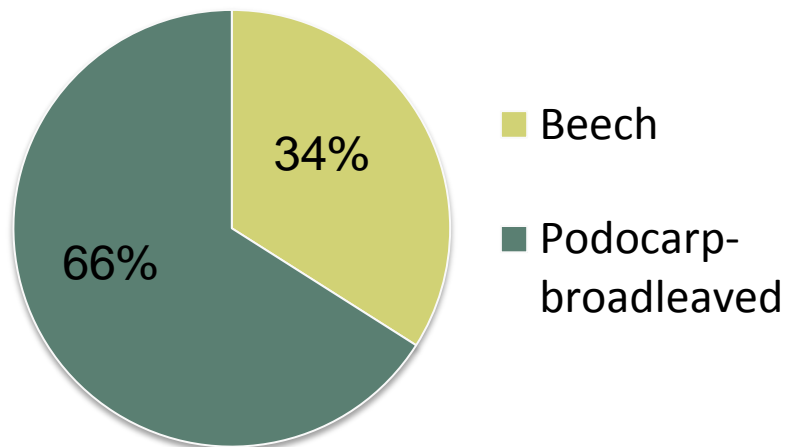
- Database of biodiversity monitoring data from managed sites
- 782,322 records
- 21 sites (3 DOC Mainland Islands, 18 other sanctuaries)
- 17 unfenced, 4 fenced
- 1995-2016
- 438 species (birds, invertebrates, lizards, vegetation and pests)



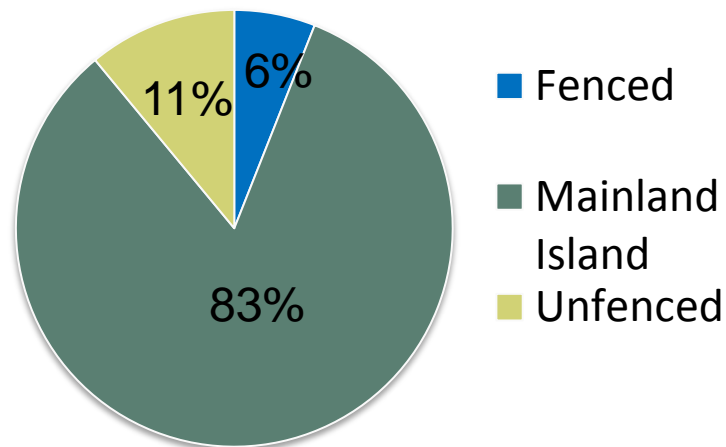


# Biodiversity monitoring database

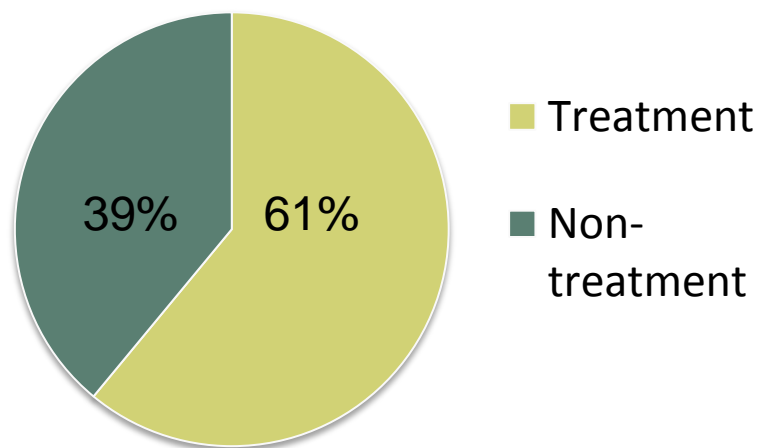
## Habitat



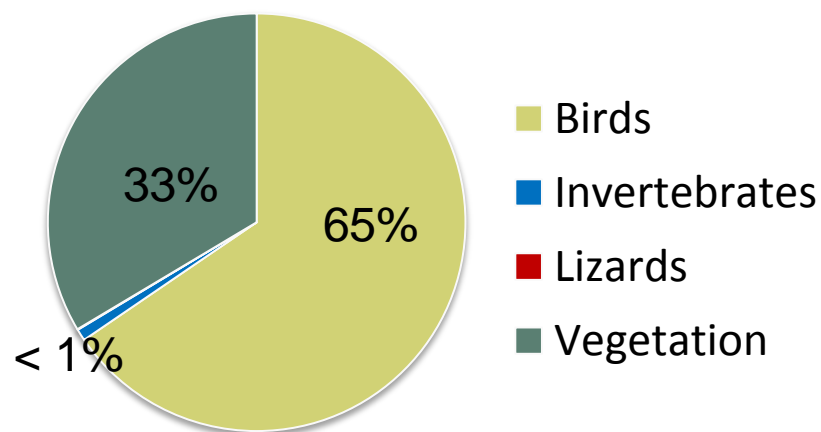
## Site Type



## Treatment type

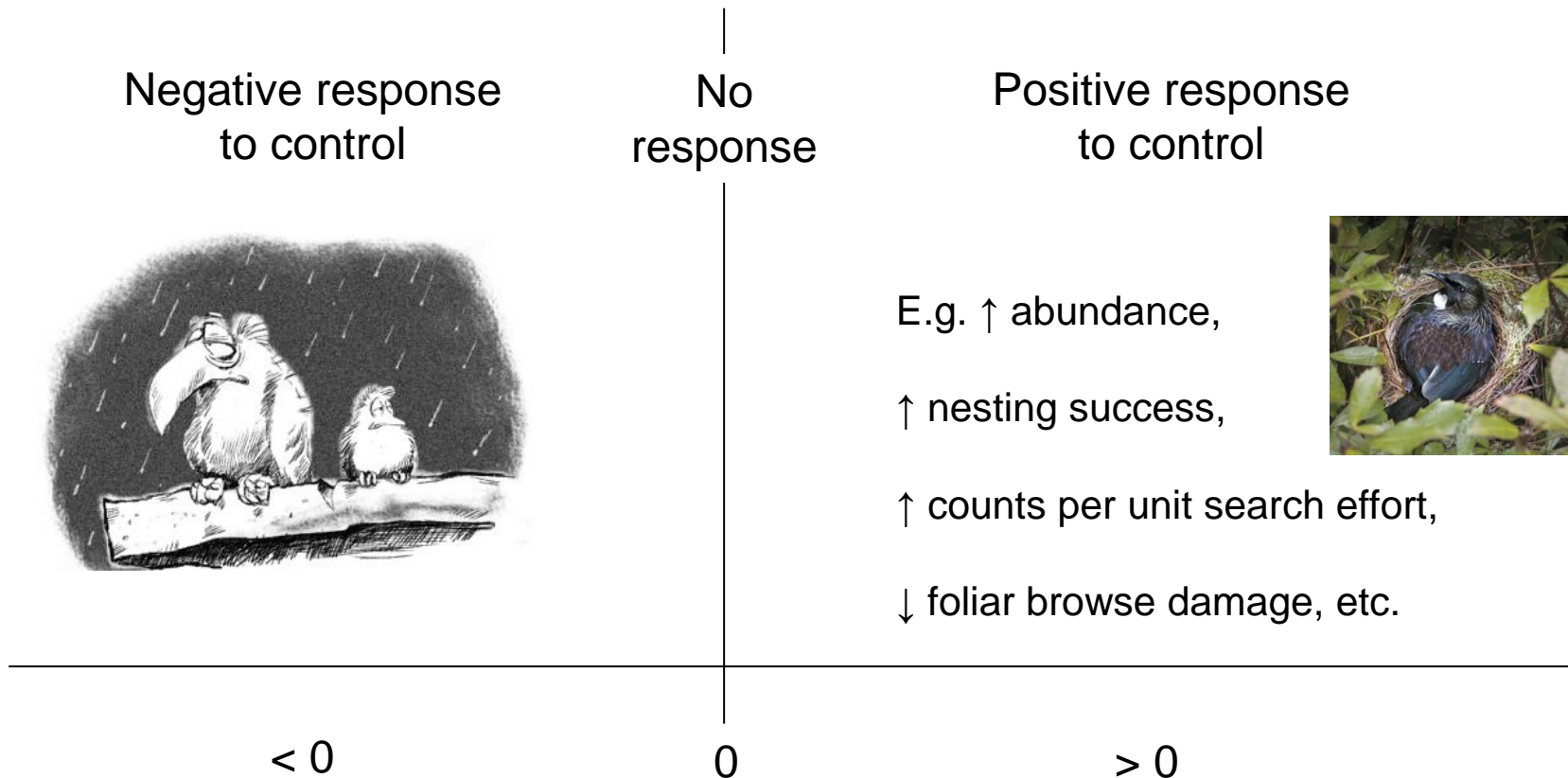


## Taxa

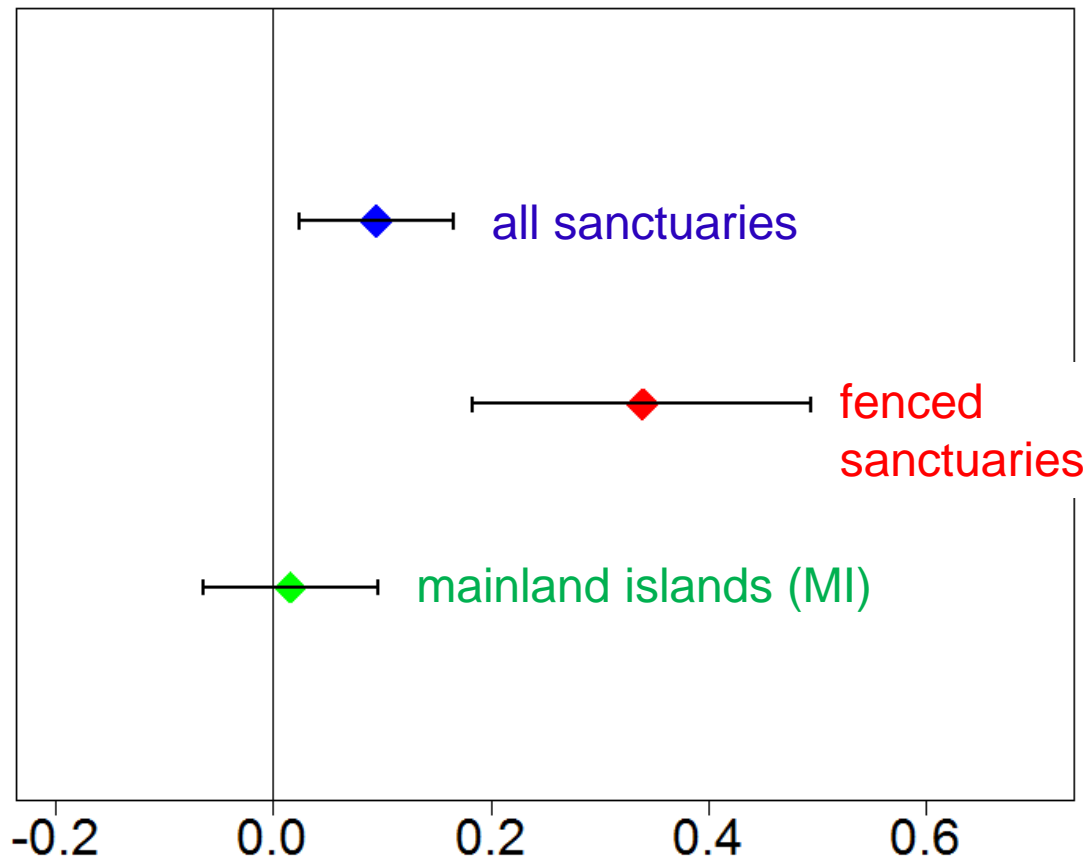


# Combining biodiversity data: meta-analysis

“Effect size”: outcome **with** pest control, c.f. **without**

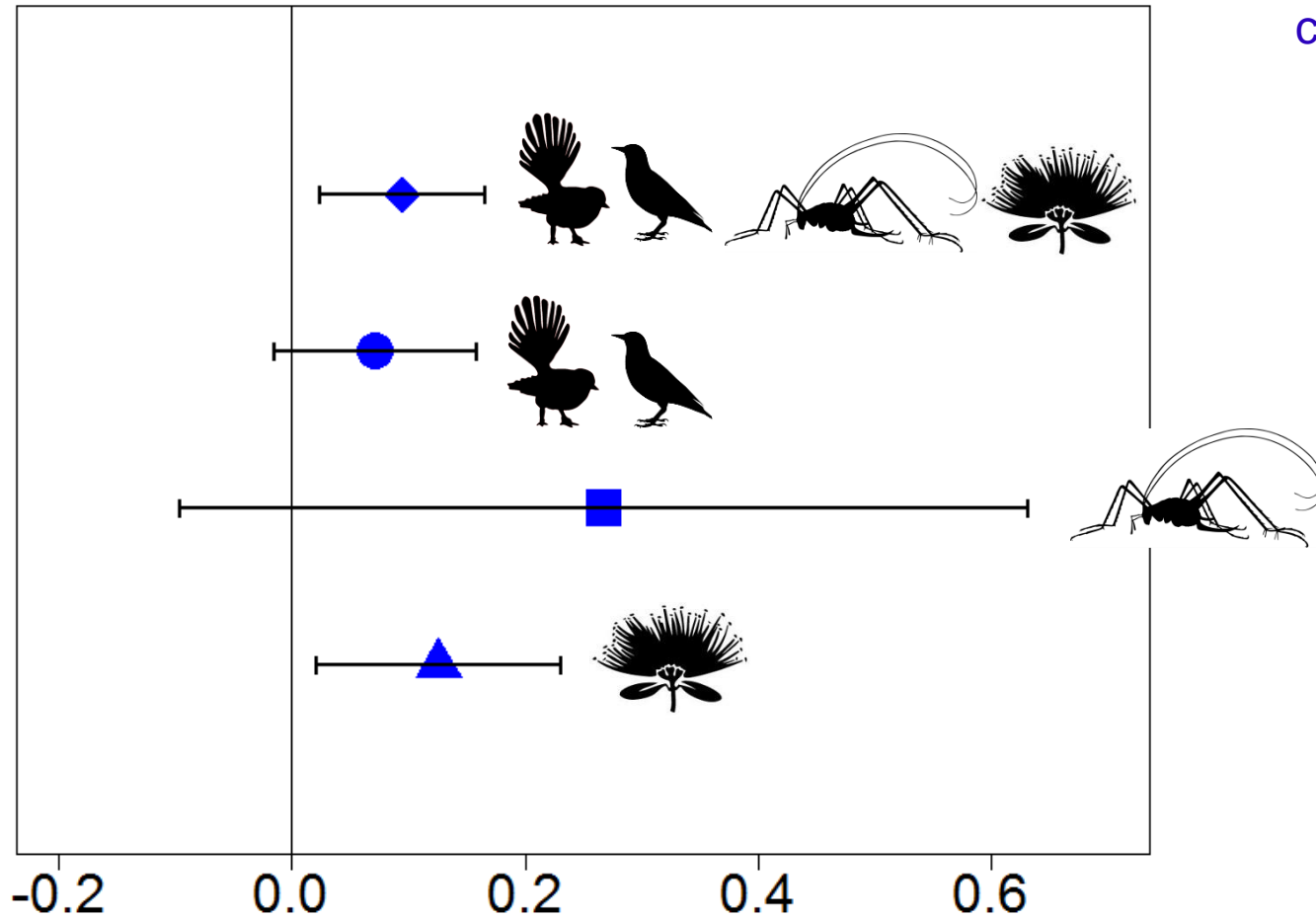


# Fenced vs. mainland islands

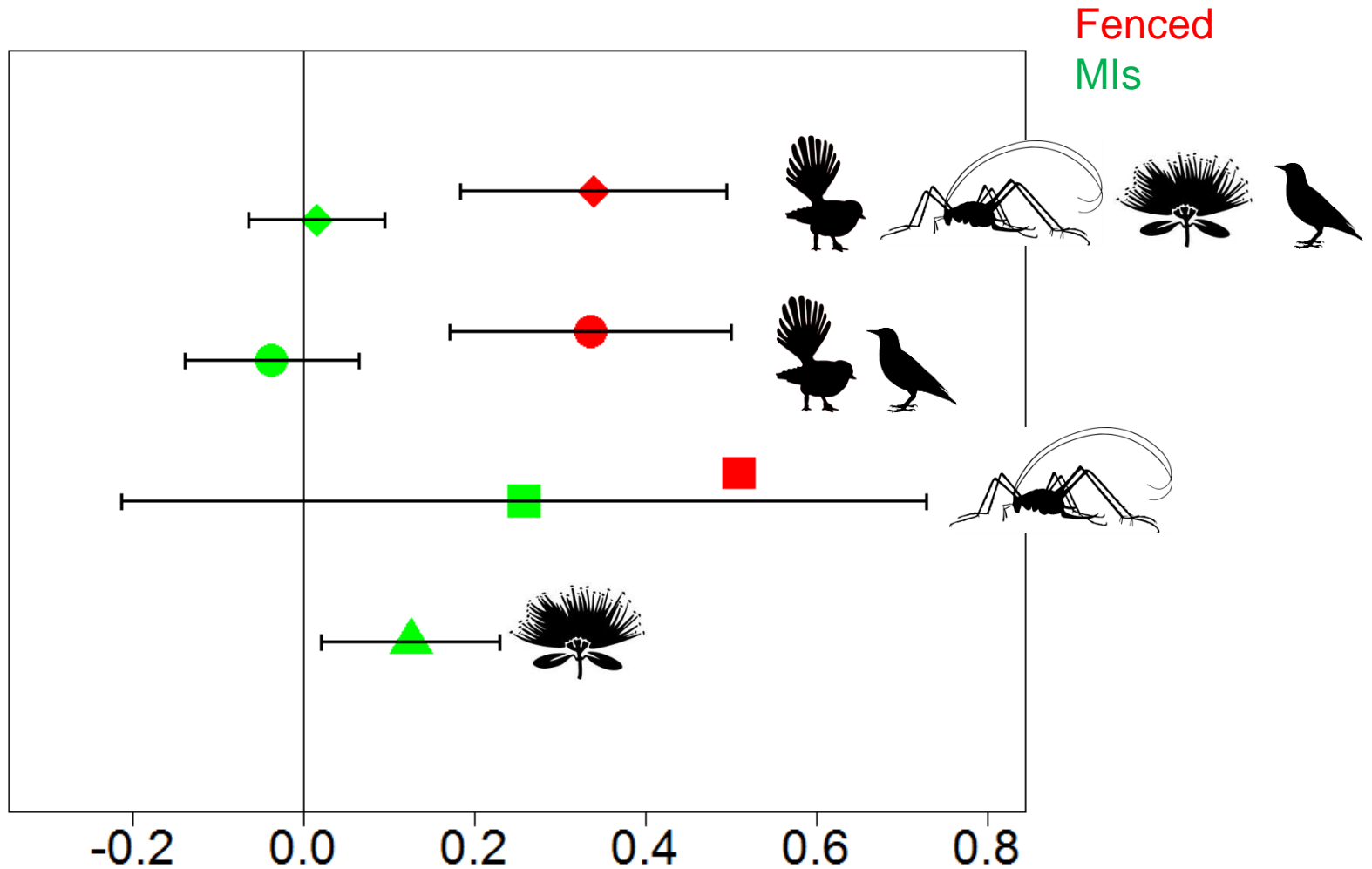


# Taxonomic groups

Fenced & MIs  
combined

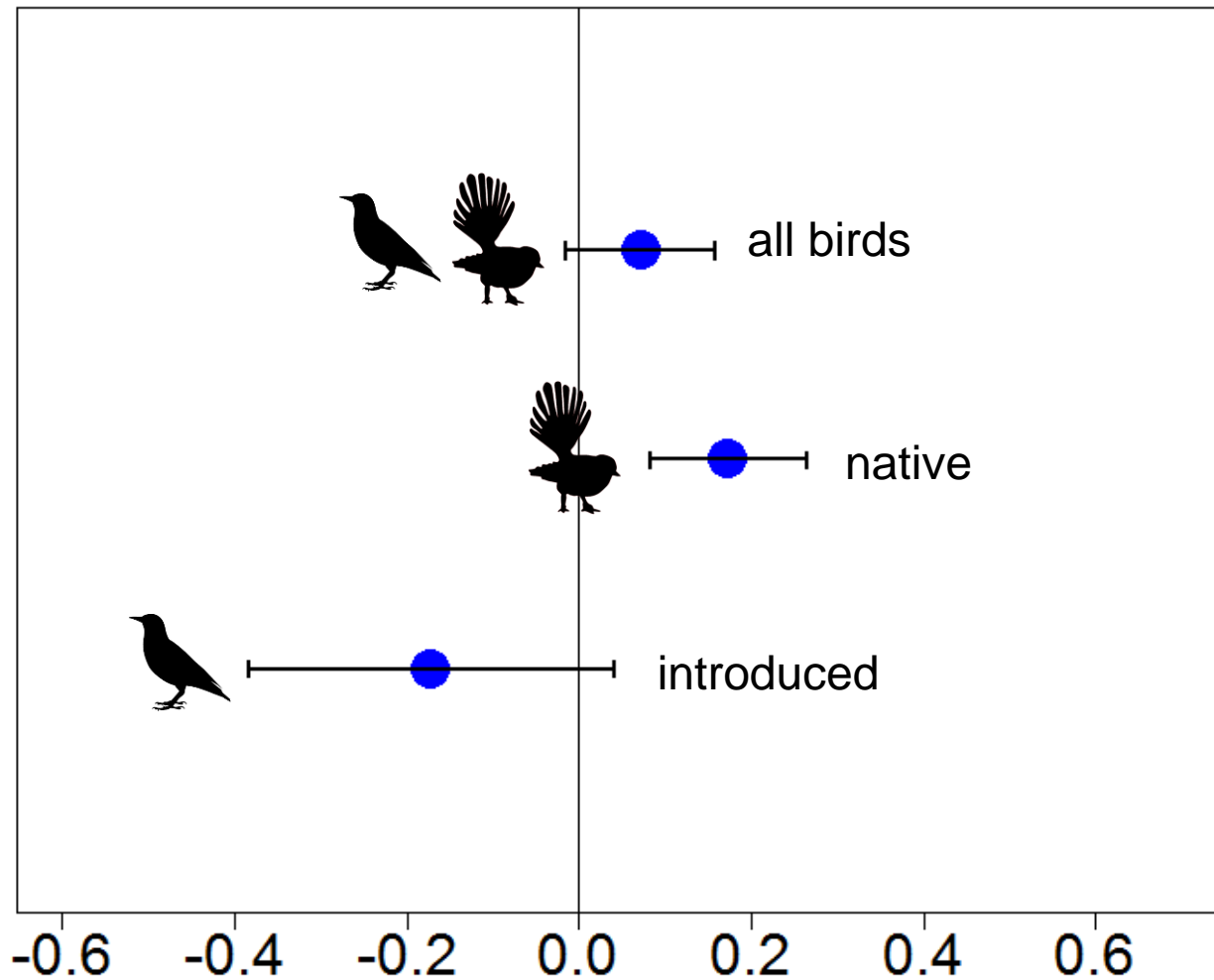


# Taxonomic groups by regime

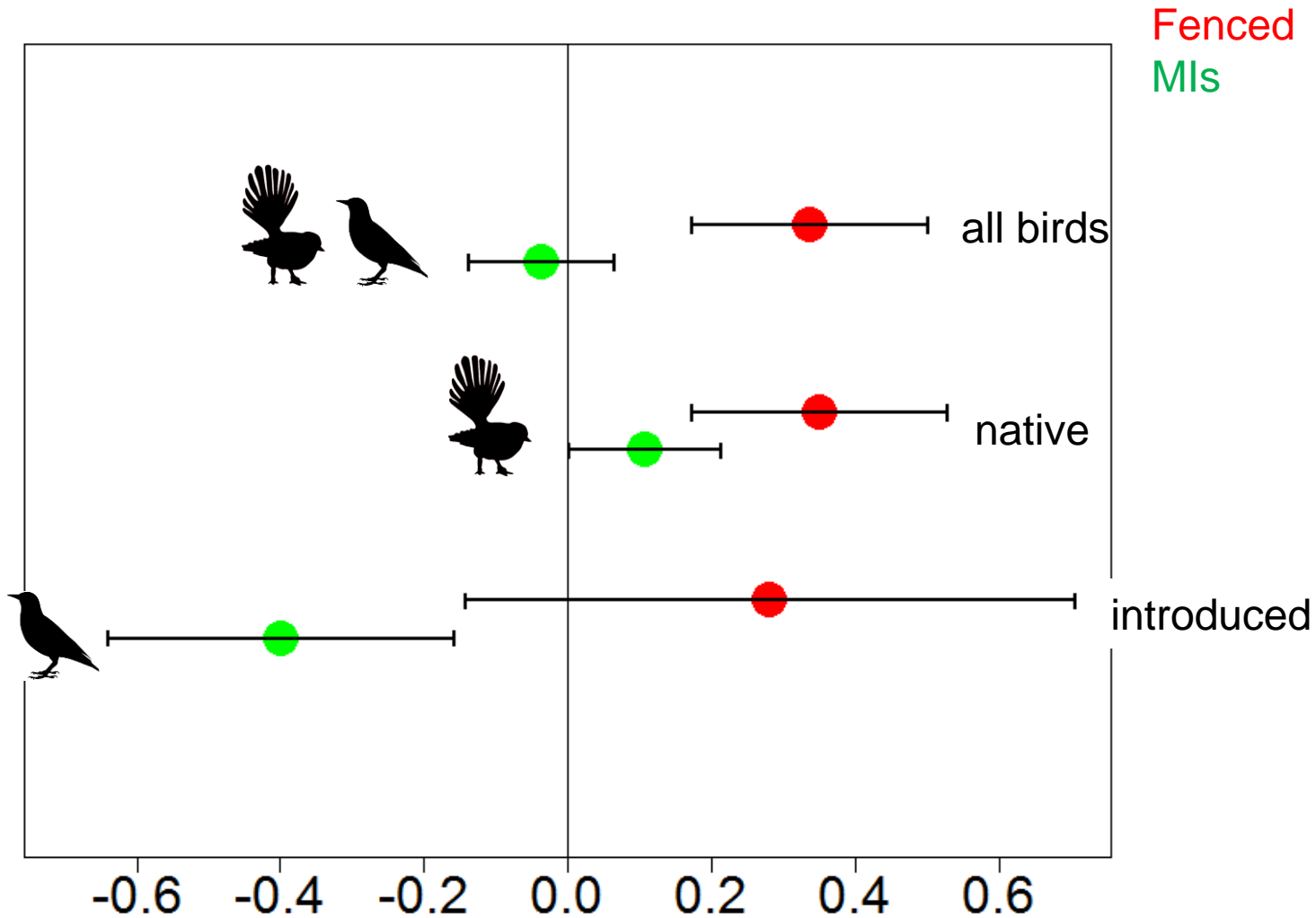


# Native vs. introduced birds

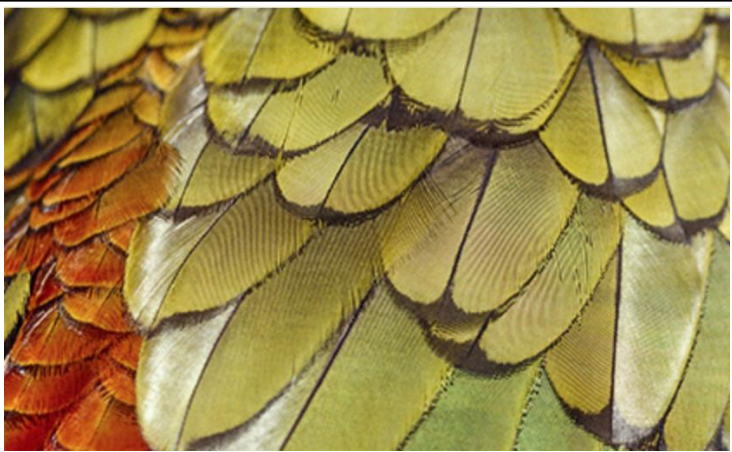
Fenced & MIs  
combined



# Native vs. introduced birds by regime



# Endemicity levels for NZ birds

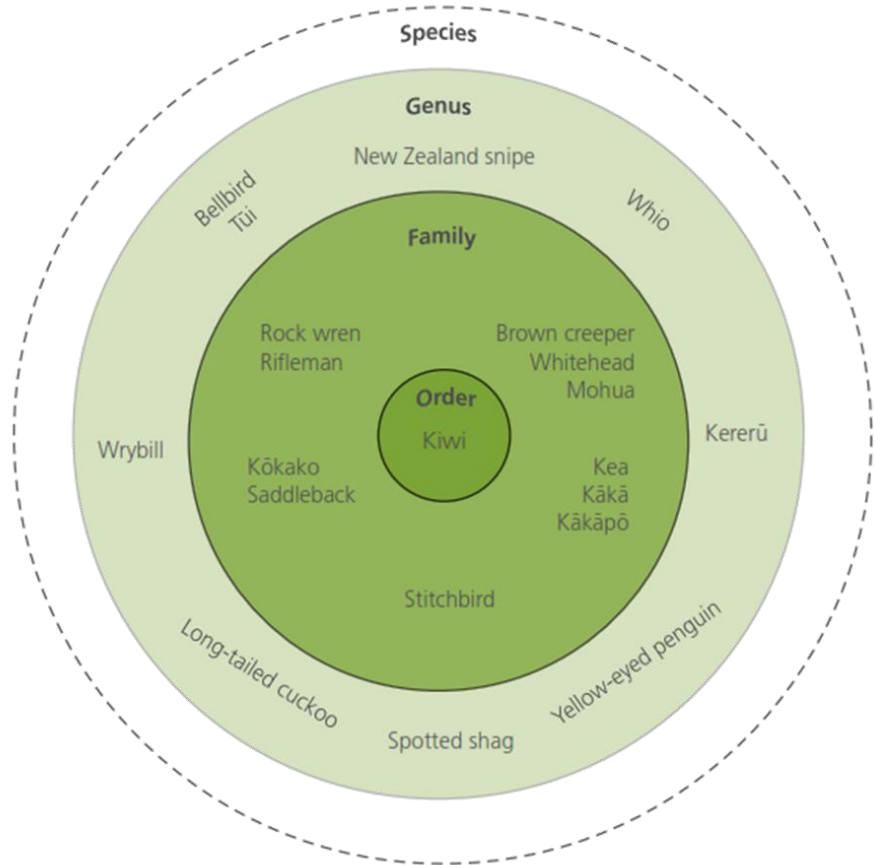


Taonga of an island nation:  
Saving New Zealand's birds

May 2017



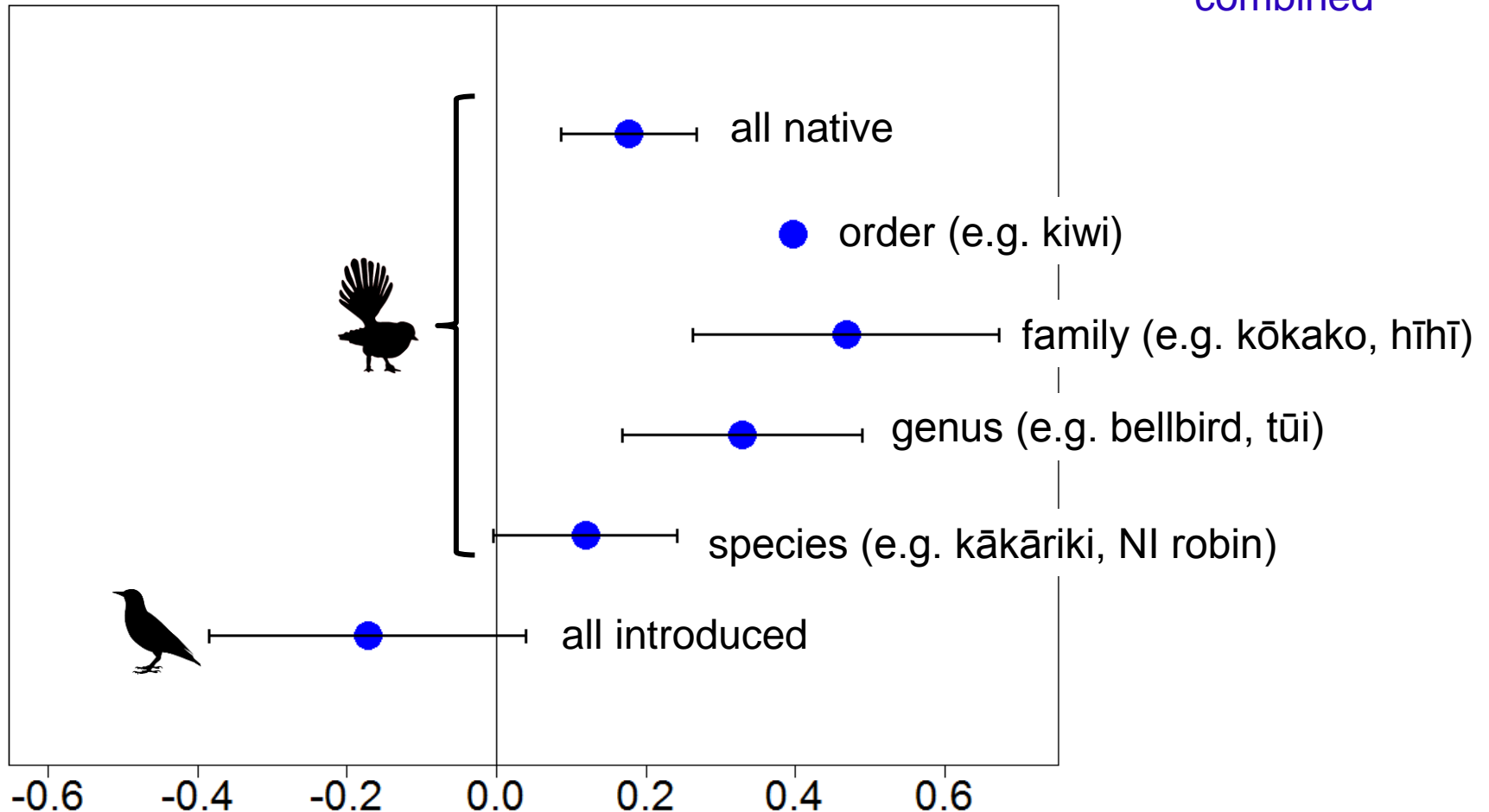
Parliamentary Commissioner  
for the **Environment**  
Te Kaitiaki Talao a Te Whare Pāremata



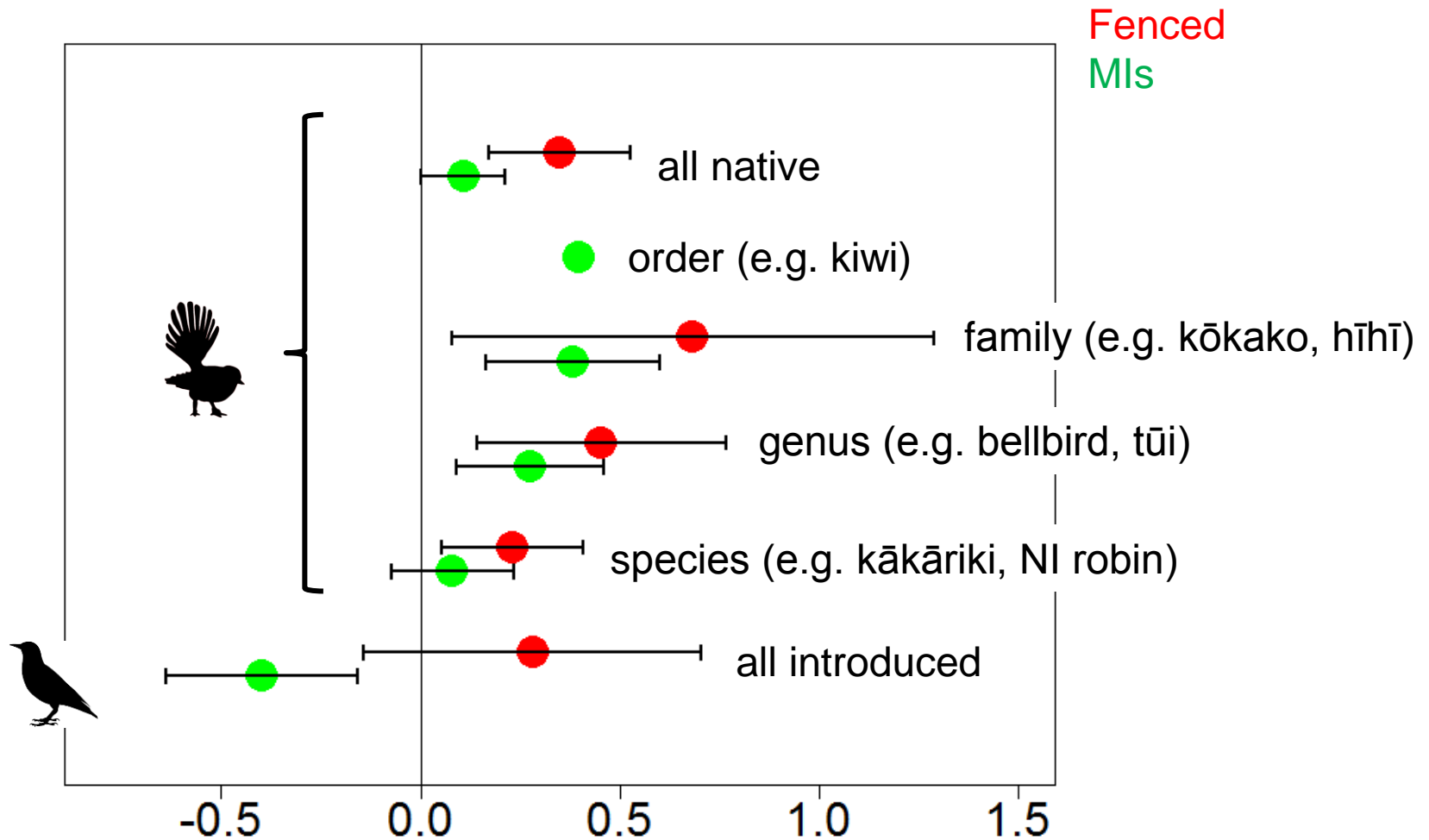


# Bird endemism

Fenced & MIs  
combined

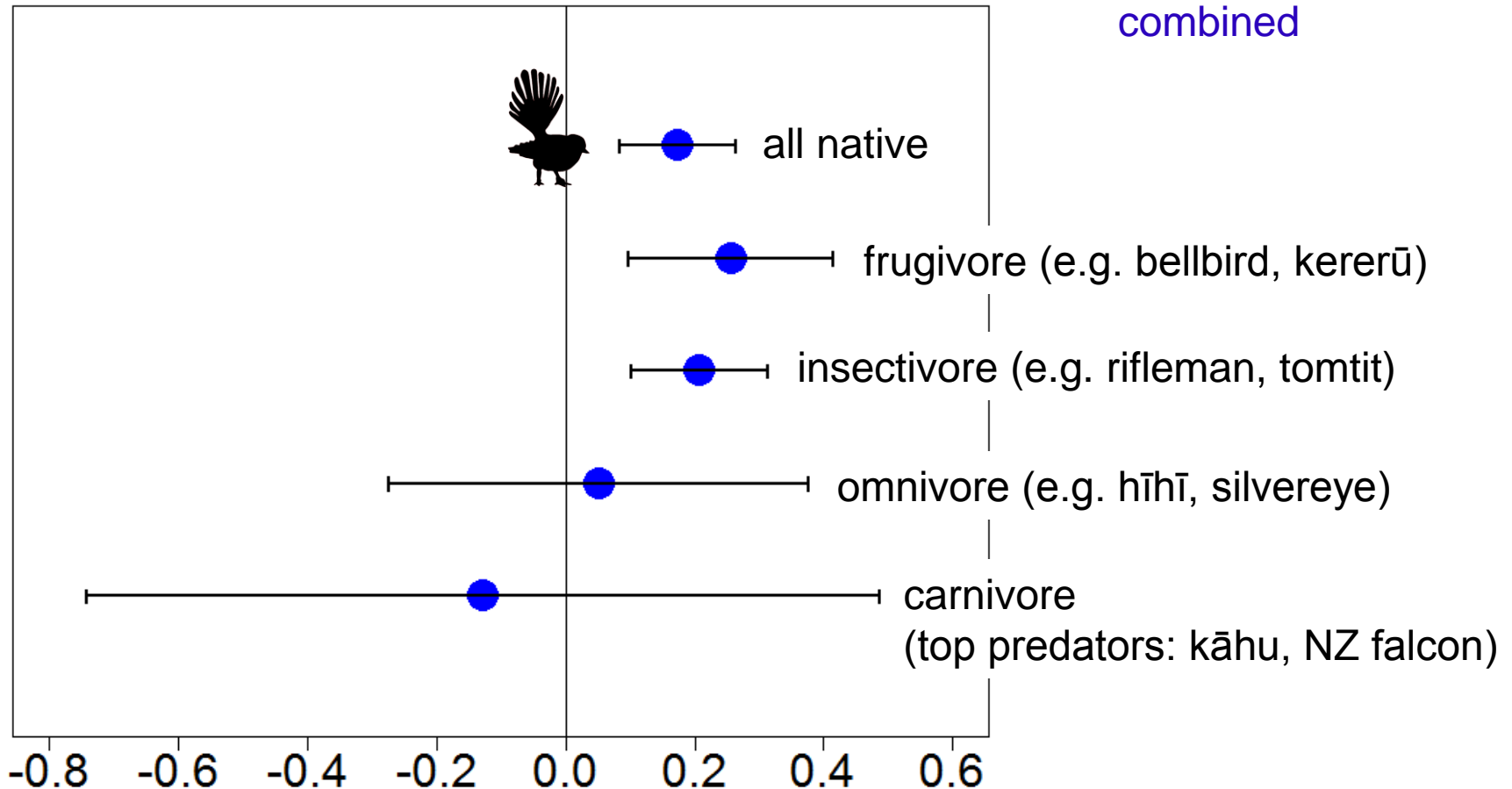


# Bird endemism by regime

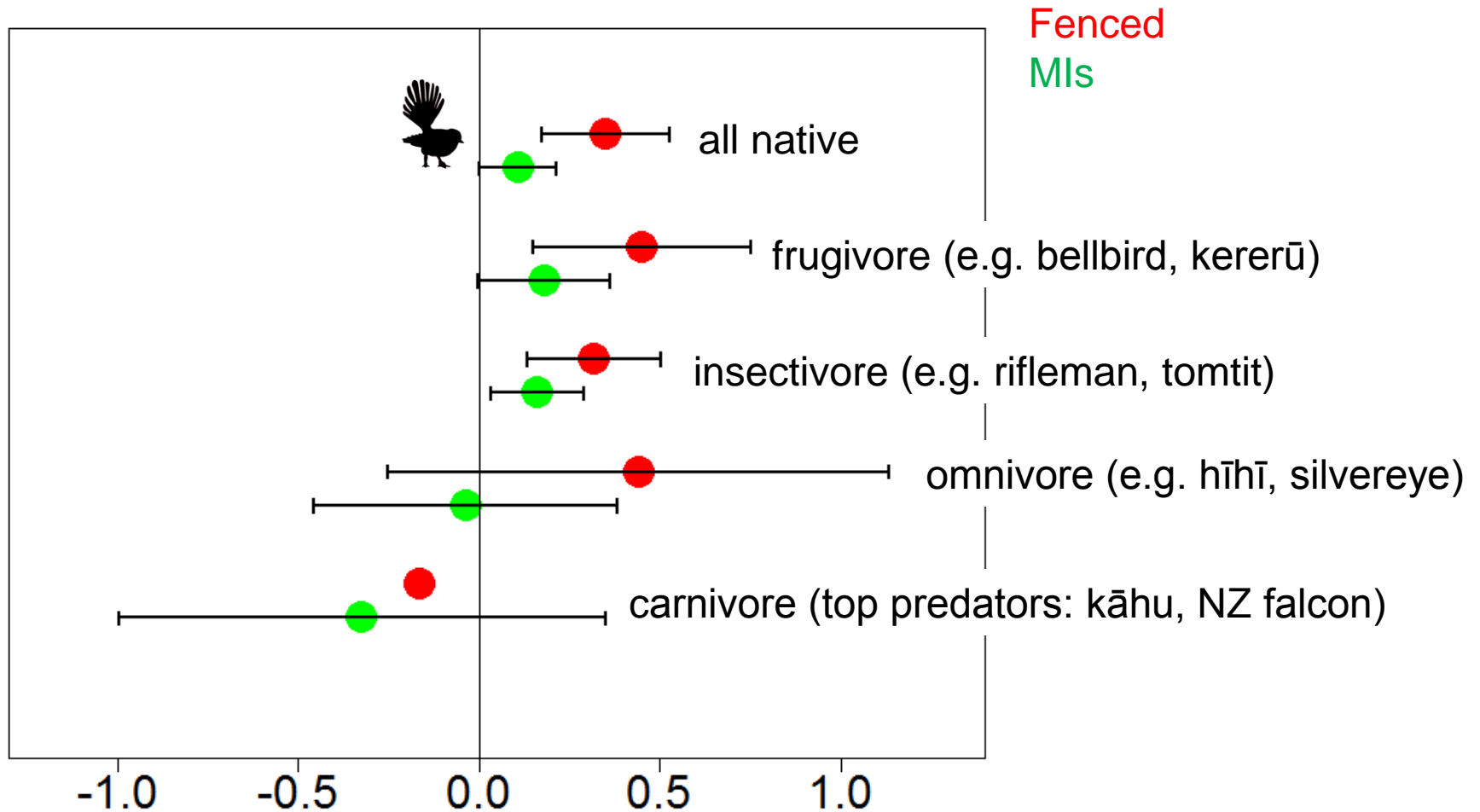


# Primary guild for native birds

Fenced & MIs  
combined

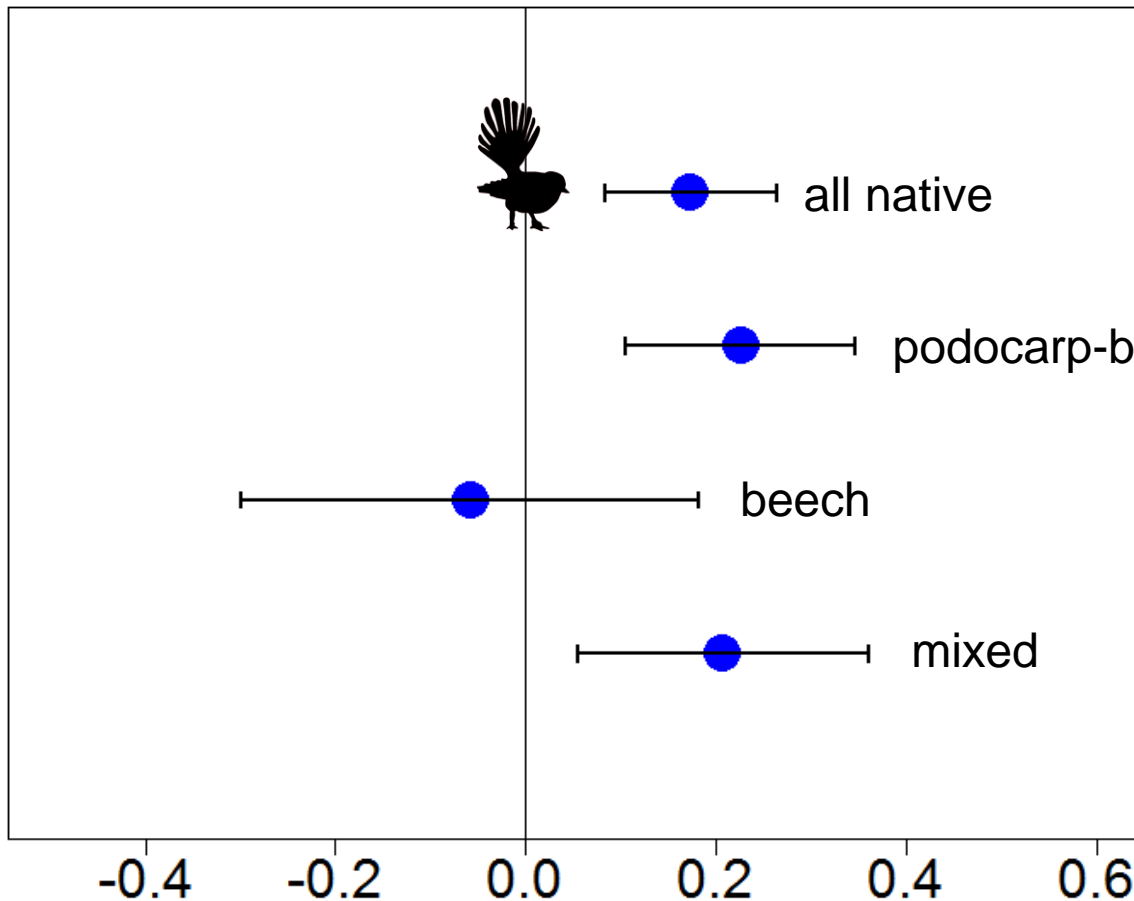


# Primary guild for native birds

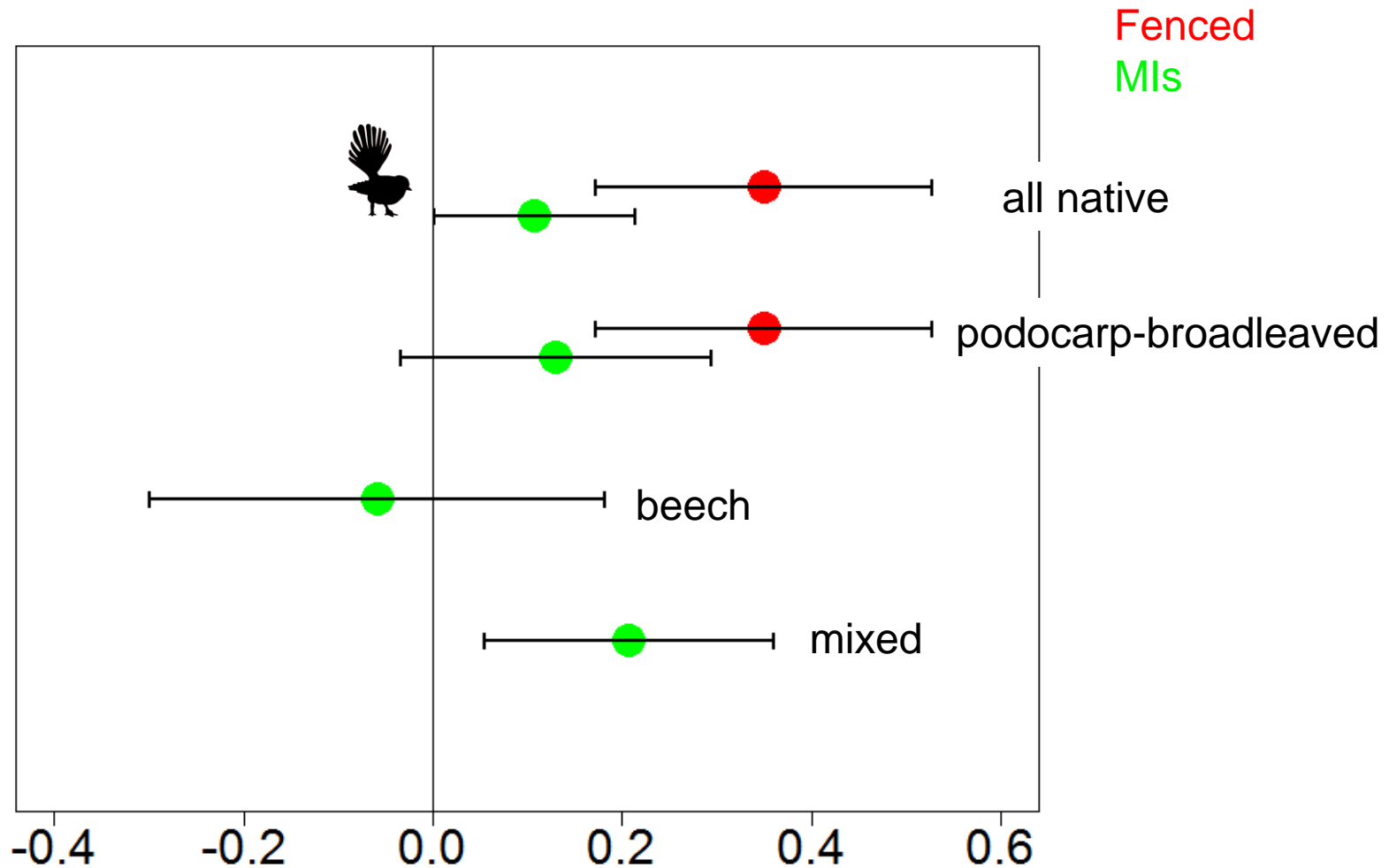


# Habitat for native birds

Fenced & MIs  
combined



# Habitat for native birds by regime

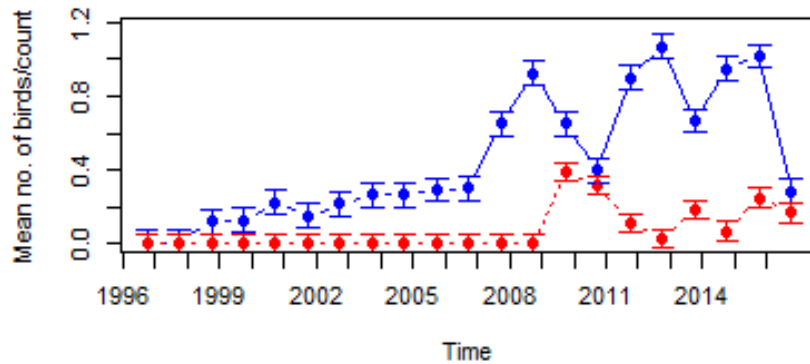


# Species (5 mbc)

Treatment  
Non-treatment

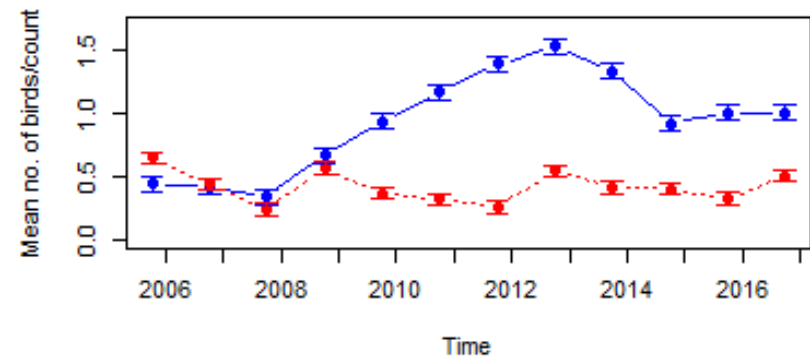
## Boundary Stream MI

### north island robin

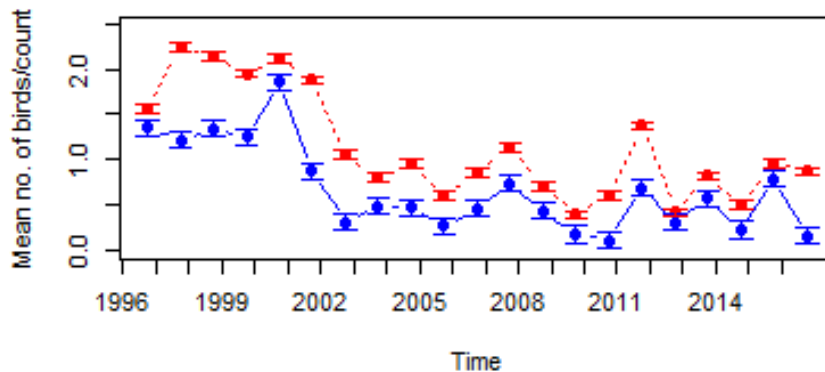


## Wainuiomata MI

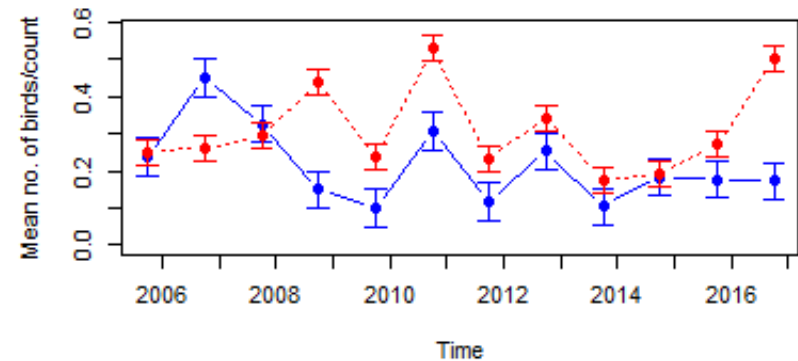
### rifleman



### grey warbler



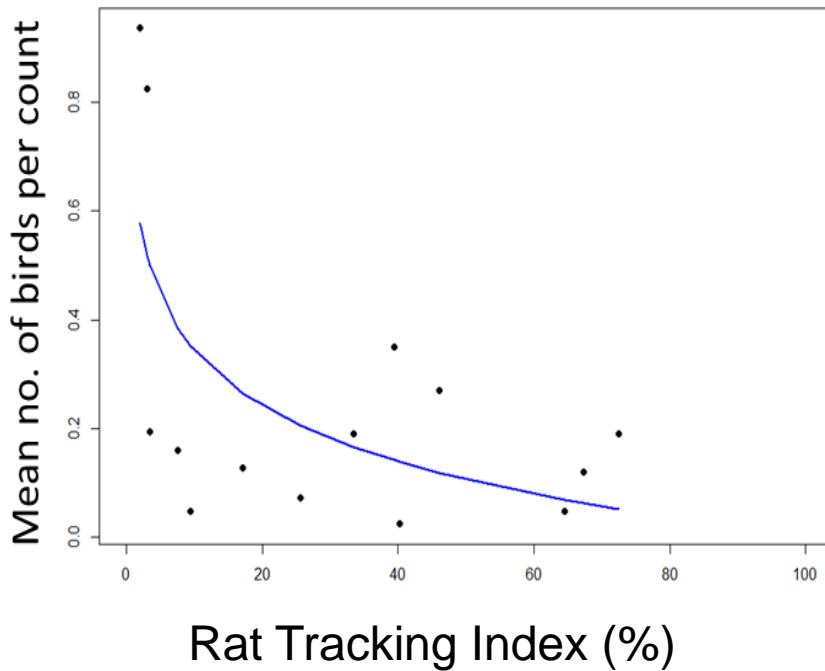
### whitehead



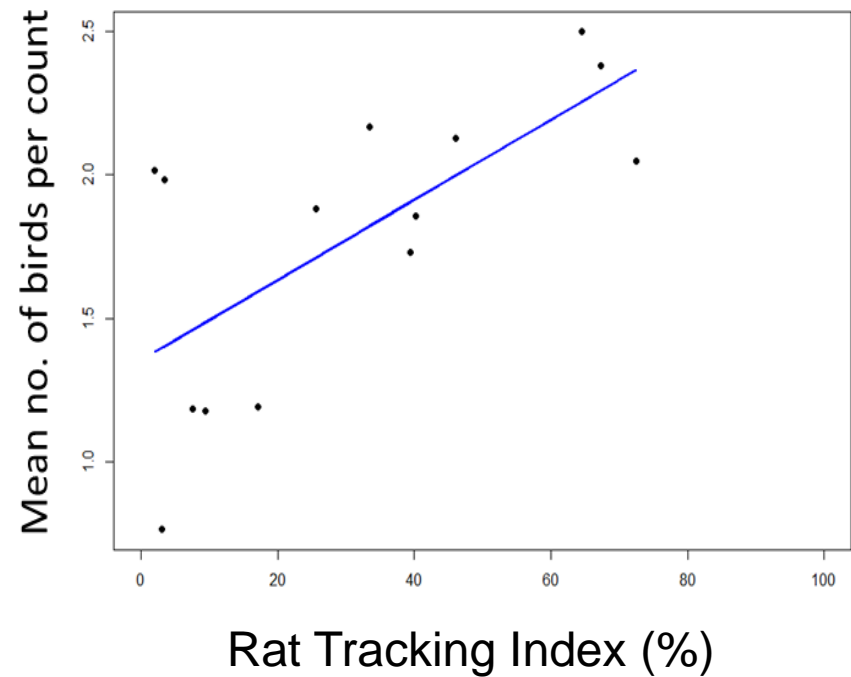
# Density-impact functions (Rotoiti)



Tui



Chaffinch





Station i  
site j  
spp k  
time t



observed indivs  
in observation area.

latent no. indivs at site j.

$$Z_{ijkt} \sim \text{Bin}(\text{round}(N_{ijkt}), \tau_{ijkt})$$

$$\ln(N_{ijkt}) \sim N(\mu_{ijkt}, \sigma^2)$$

$$Y_{ijk} = \ln(N_{ijk})$$

for now, fixed & known.  
forall i,t



$$\tau \sim \text{beta}(c, d)$$

$$\text{Priors: } \sigma^2 \sim \text{IG}(\alpha, \beta)$$

$$a, b \sim N(\theta_0, \tau_0^2)$$

ans=1:  
[ ]

ans=2:  
[ ]

$$M_{ijkt} = Y_{ijk(t-1)} + a + b Y_{ijk(t-1)} + X' \beta$$

Gompertz.



$$p(\theta | y) \propto p(y | \theta) p(\theta)$$

Full joint posterior: (j=1, k=1)

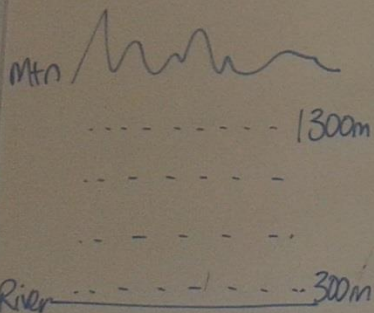
$$f(Y, \sigma^2, a, b, \tau | Z) \propto \prod_i \prod_t \text{Bin}(Z_{it} | \text{round}(N_{it}), \tau)$$

[obs. process]

$$\times \prod_{t=1}^{19} N(Y_{t+1} | [Y_t(1+b) + a + X' \beta], \sigma^2) \times \prod_{t=0}^{18} N(Y_{t+1} | [Y_t(1+b) + a + X' \beta], \sigma^2)$$

$$\left. \begin{matrix} M_{t+1} \\ Y_t(1+b) + a + X' \beta, \sigma^2 \end{matrix} \right\} \text{Likelihood.}$$

[biol. process]



$$\begin{aligned} & \times \text{IG}(\sigma^2 | 0.1, 0.1) \\ & \times N(a | 0, 10) \\ & \times N(b | 0, 10) \\ & \times \text{Beta}(\tau | 2, 20) \end{aligned}$$

Priors

M+1 if large  $\tau$  with real data

$$\sigma^2 | Y_t \sim \text{IG}\left(\frac{19}{2} + 0.1, 0.1 + \frac{1}{2} \sum_{i=1}^{19} (y_i - \mu)^2\right)$$

$$b = \alpha_0 + \alpha_1 \text{Pred} \quad \tau_{it} | Z_{it} \sim \text{Beta}(c+y, d+(n-y))$$

for density-dep. predation.

$$\begin{aligned} \sum_{i,t} Z_{it} &= n \text{ Observed} \\ \sum_t (N_t * n \text{ Stations}) &= n \text{ trials} \end{aligned}$$

- Hunter-Schmidt.

$$Z_{ijkt} \sim \begin{cases} \text{Bin}(\text{round}(N_{ijkt}), \tau_{ijkt}) & \text{if } N_{ijkt} > Z_{ijkt} \\ ? & \text{else} \end{cases}$$



① Truncated Y post dist?  $\rightarrow$  try larger  $N_t$

# Room for improvement?

Need consistent and long-term monitoring of biodiversity outcomes and residual pest abundance

- Standardised monitoring methods and measures ✓
- Data sharing & reuse
- Data management



# Conclusions

- Both increases and declines for species in sanctuaries
- How to measure success?
- Knowledge gaps: outcomes for communities and ecosystems
- Need **consistent** and **long-term** monitoring: diverse biodiversity measures and residual pest abundance using SOP indices

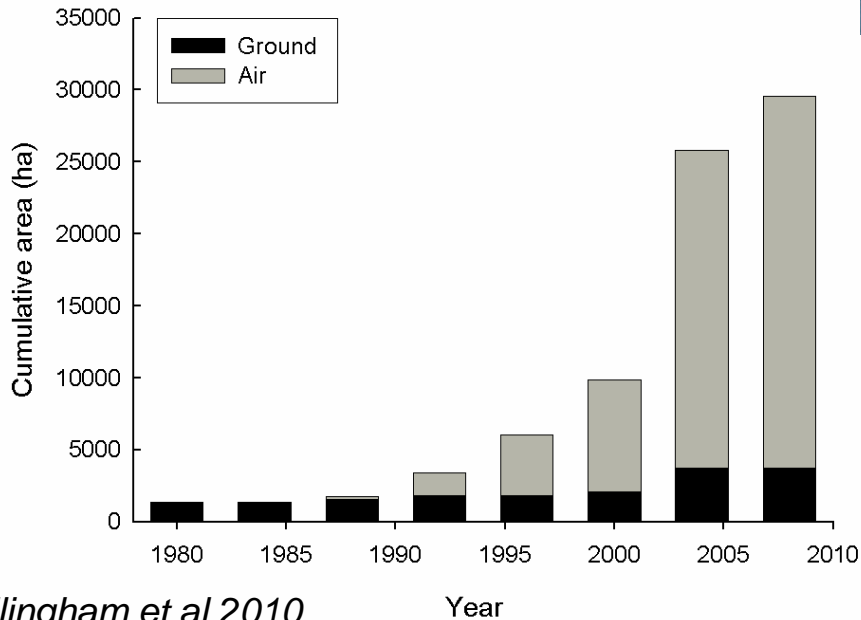


# What next?

- Offshore, pest-free islands



Ground ( <i>n</i> islands)	10	12	15	23	23	24	24	24
Air ( <i>n</i> islands)	0	0	1	20	28	36	41	47



Bellingham et al 2010

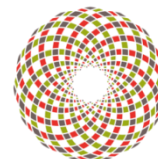
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Challenges



**Te Pūnaha Matatini**  
Data ■ Knowledge ■ Insight