

Biodiversity Monitoring and Reporting 101



Peter Bellingham
Landcare Research, Lincoln



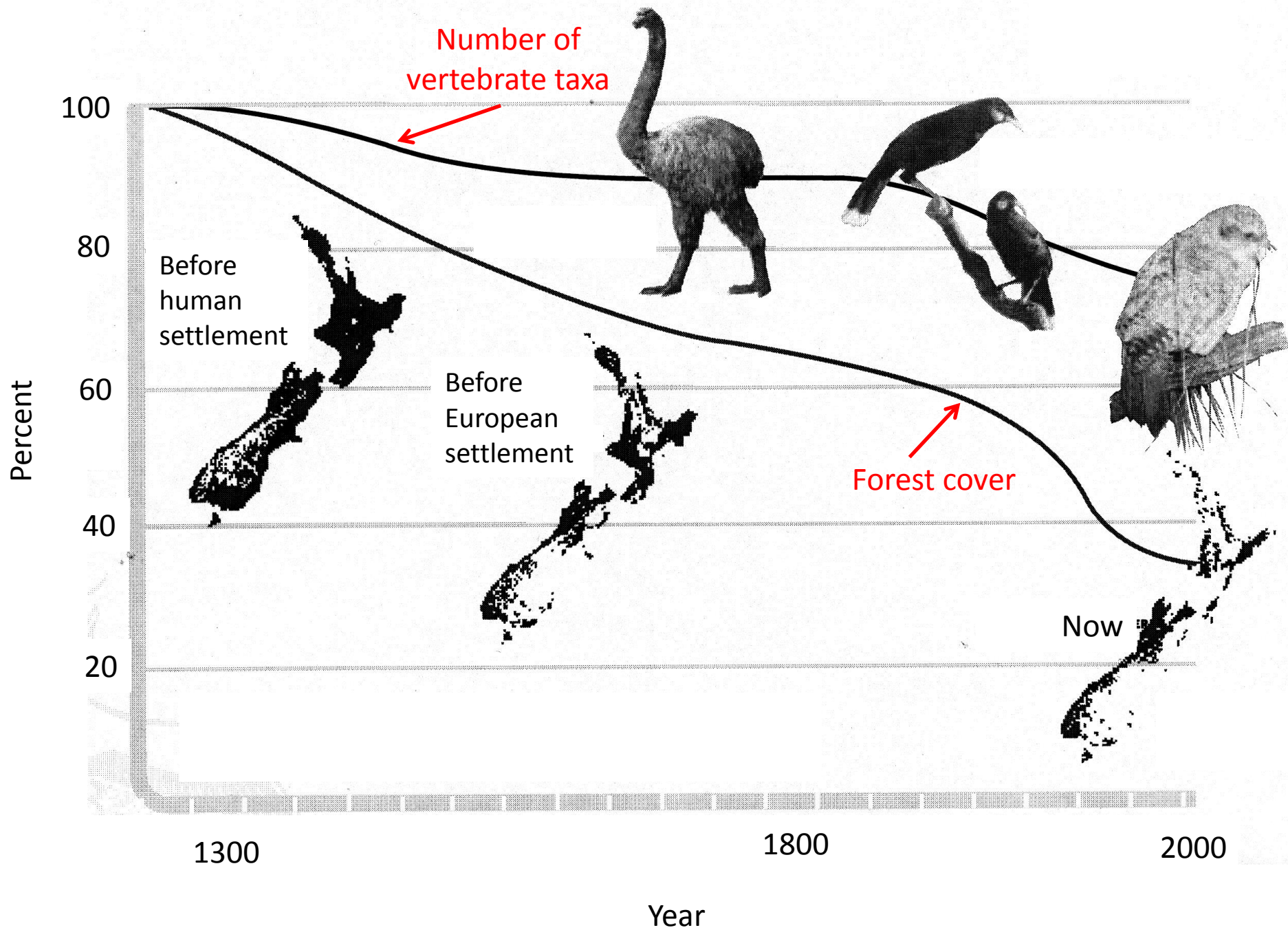
Landcare Research
Manaaki Whenua

Talk overview

- What has prompted a national assessment of status and trends in biodiversity
- A framework and biodiversity indicators
- Assessing ecological integrity
- Implementing biodiversity indicators throughout New Zealand
- New initiatives, new technologies

New Zealand's biodiversity

- Endemism (e.g., 86% of vascular plant flora); variable across taxa
- Extinction – notable in vertebrates, few in plants, unknown for others
- Chronic threats – biological invasions, habitat destruction
- Emerging threats – new invaders, climate change
- Turning the tide? – Conservation as “everyone’s business”



Why measure biodiversity?

- **Provide the evidence to show the difference that management makes**
- **Evidence base to improve practice**
- **The evidence base for sustainability credentials**
- **Certification (e.g., FSC), securing market advantage**
- **Evidence base for resource management decisions**
- **Meeting international obligations**
- **Systematic, integrated methods: away from “just-so” stories**
- **Consistent measures across all land uses**

Who, when, what, how, why?

Who's interested (now)?

- DOC
- Regional councils
- MfE and Statistics New Zealand
- MFAT
- MPI
- Tangata whenua, NGOs
- Others (e.g. OSPRI)

Who, when, what, how, why?

Why?

- DOC – to evaluate the effectiveness of management, to reveal emerging issues, SoE
- Regional councils – management and policy effectiveness
- MfE and Statistics New Zealand – SoE, EMaR
- MFAT – CBD reporting
- MPI – threats and pressures (old and new)
- Tangata whenua, NGOs – effectiveness of management, threats and pressures
- Others (e.g., OSPRI) – biodiversity outcomes of management

Imperatives

- Poor performance in meeting targets set by the national Biodiversity Strategy (2005 review)
- The growing audit culture: Auditor General, Treasury demands evidence of management effectiveness, not anecdote or selected evidence
- Prime Minister's Science Advisor: evidence-based policy
- New legislation (e.g., Environmental Reporting Act)

Ecological Integrity framework

- **Species occupancy** (*to avoid extinctions*): are the species present that you would expect?
- **Indigenous dominance** (*to maintain natural ecological processes*): are the key ecological processes maintained by native biota?
- **Ecosystem representativeness** (*to maintain a full range of ecosystems*): are the full range of ecosystems in New Zealand protected somewhere?

DoC and terrestrial biodiversity monitoring and reporting

Research sites:

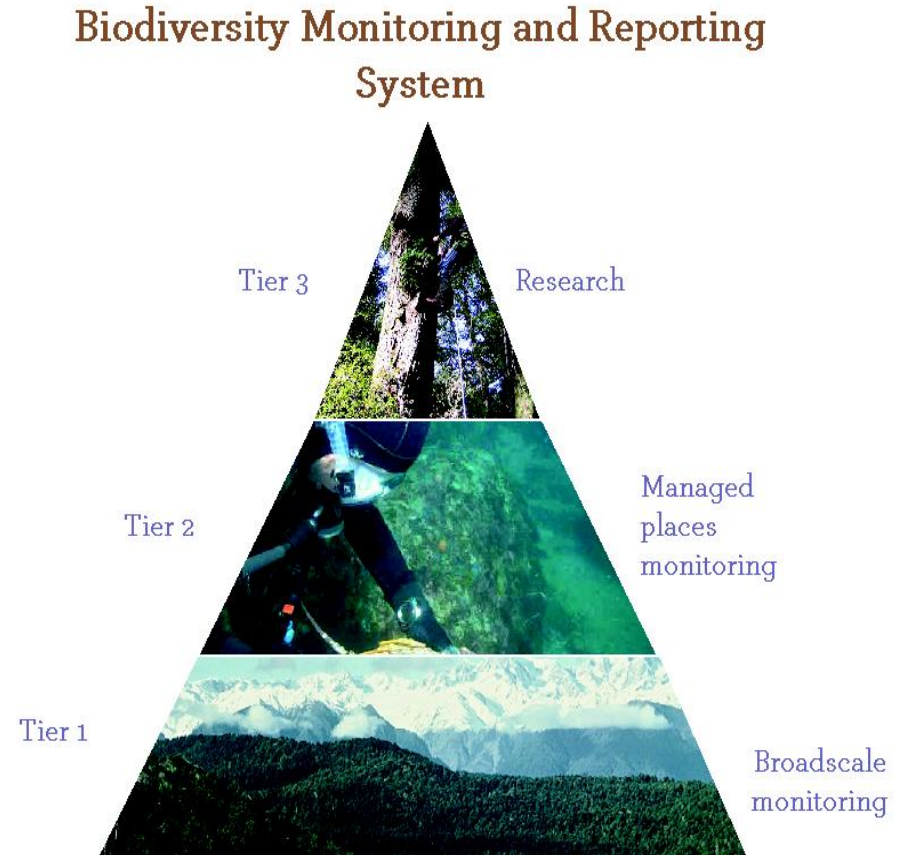
- Long-term ecological research sites

Monitoring at managed sites:

- Focus on sites that managed to optimise benefits for conservation, including rare ecosystems and rare taxa

National monitoring:

- National-scale status and trends that provide the context to interpret local changes



DoC and terrestrial biodiversity monitoring and reporting

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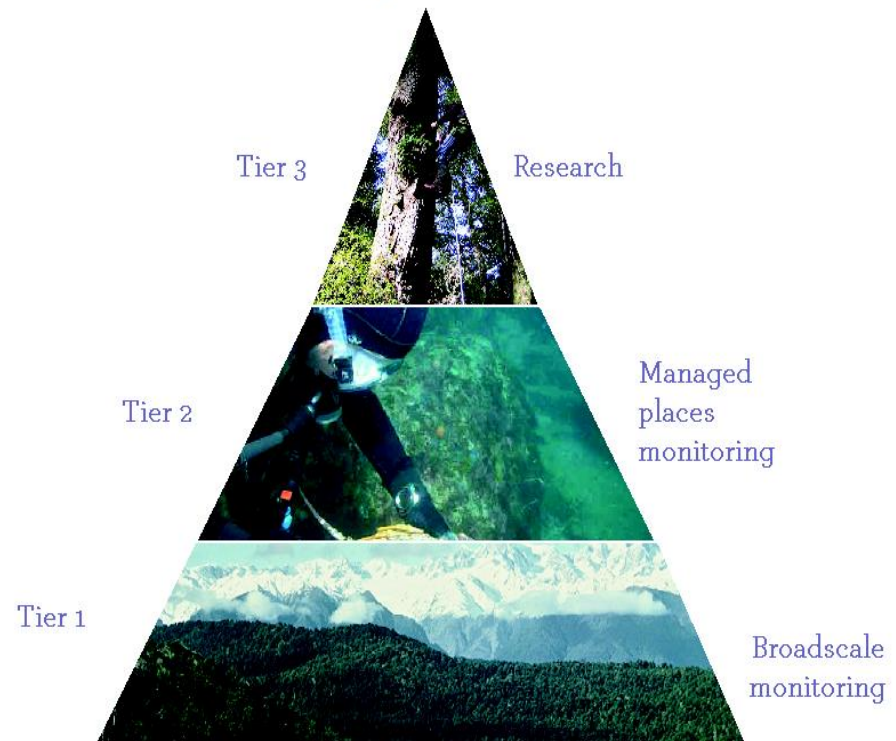
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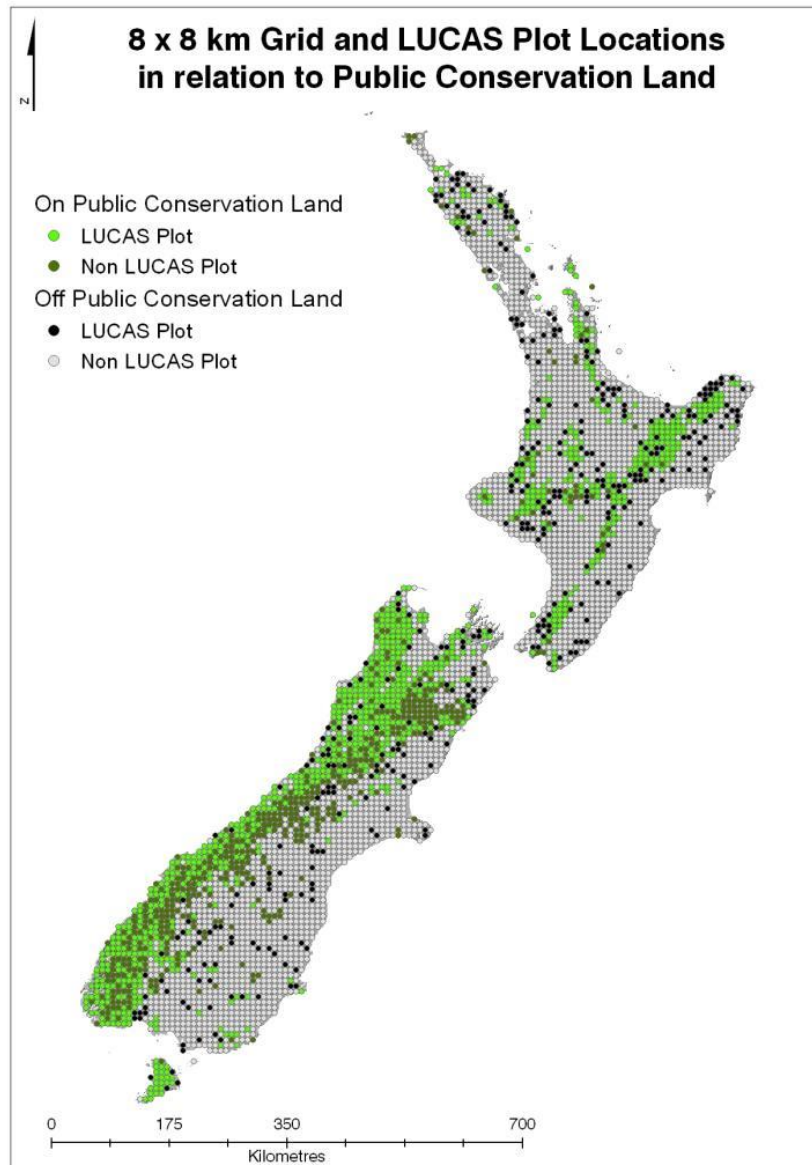
National monitoring:

- National-scale status and trends that provide the context to interpret local changes

Biodiversity Monitoring and Reporting System



A nationwide assessment of public conservation land



- Builds on a LUCAS assessment for reporting carbon (for UNFCCC)
- Biodiversity indicators at the same scale
- Focus on the widespread, and (currently) common taxa
- Coincident measures at point

Terrestrial biodiversity indicators used nationally by DOC

Point-based indicators

Dependencies on repositories for:

- Vegetation data (2 RC measures and 3 DOC measures) – data included in the NVS databank;

- Weed distribution data (1 RC measure);

- Pest mammal data (e.g., trap catch indices, faecal pellet indices) (1 RC measure and 1 DOC measure);

- Bird data (1 RC measure and 1 DOC measure)

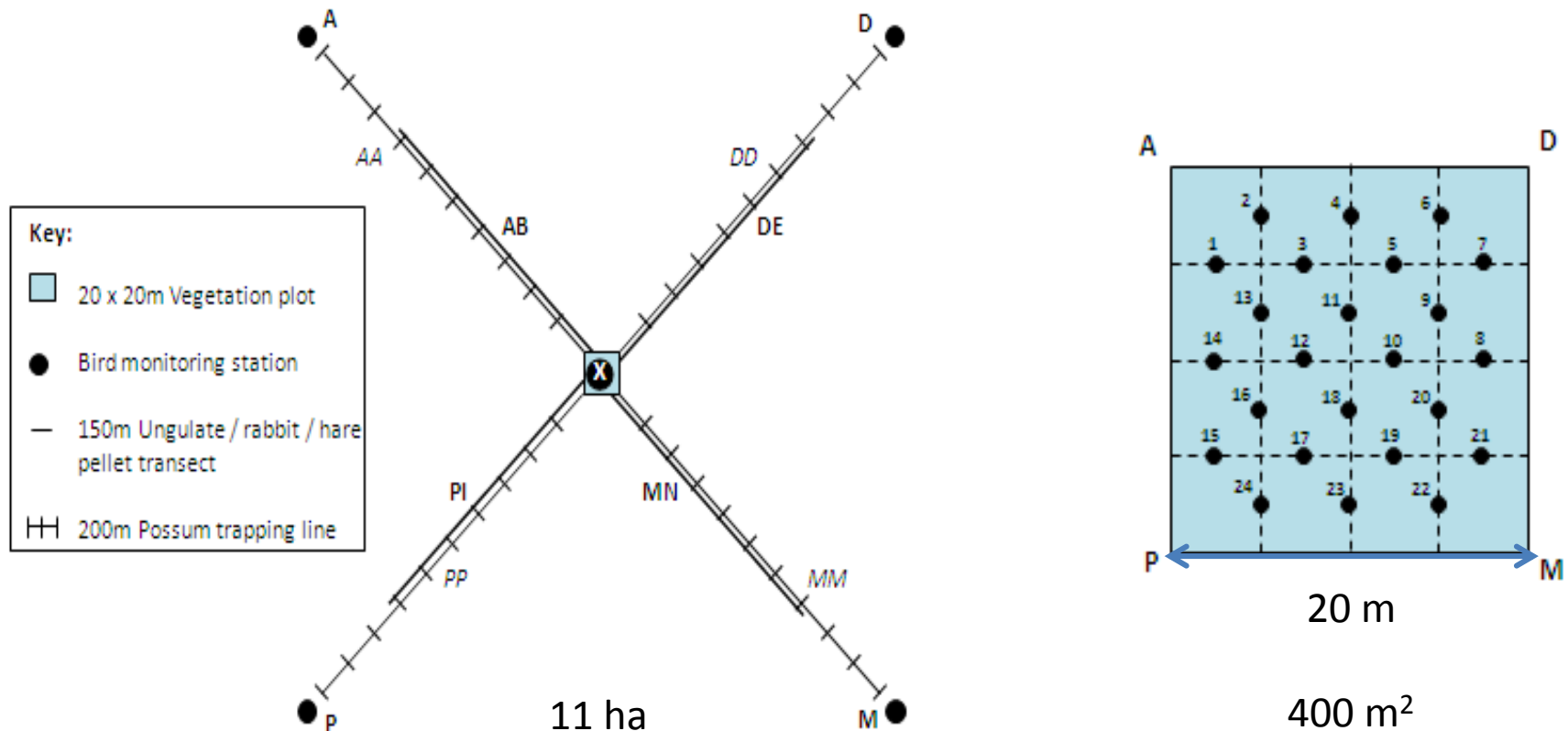
Indicators and measures

Ecological integrity attribute	Indicator	Measure
Indigenous dominance	Non-native plant and mammal dominance	Non-native plant dominance
		Mammal invasions
Species occupancy	Composition	Size-class structure of canopy dominants
		Representation of plant functional types
		Bird community composition and abundance

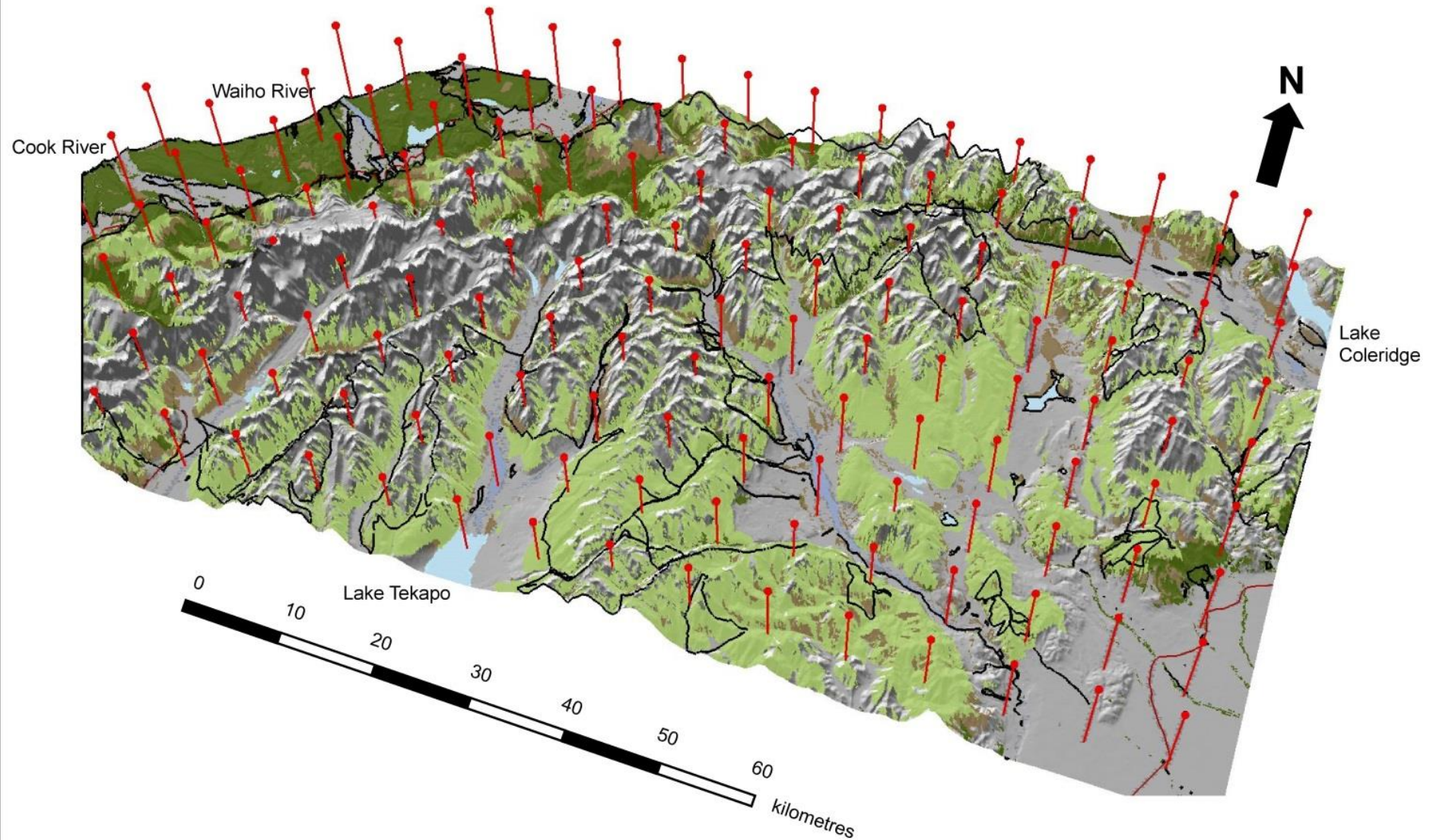
Sampling design:

multiple measures sampled at each point

Birds, Vegetation, Pest mammals measured simultaneously



Sample points on an 8-km grid







Indigenous dominance



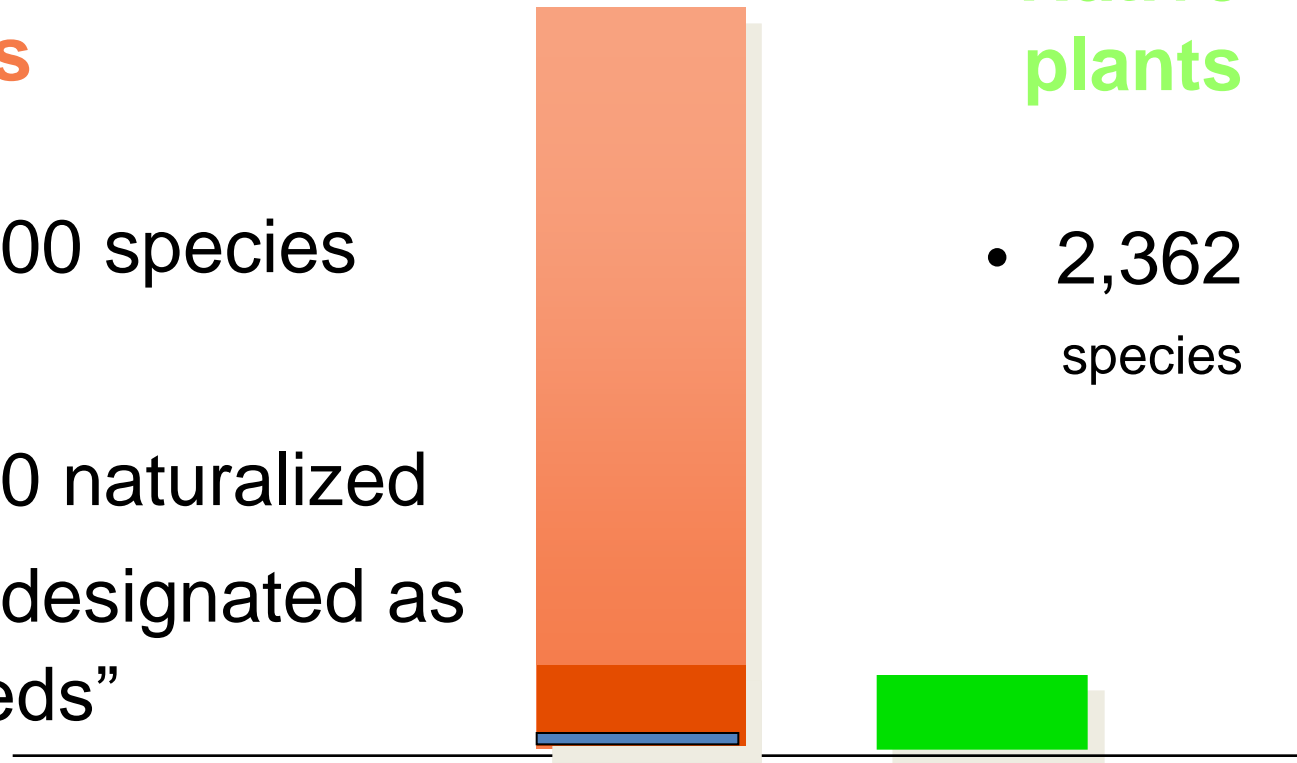
Plant invasions

Introduced plants

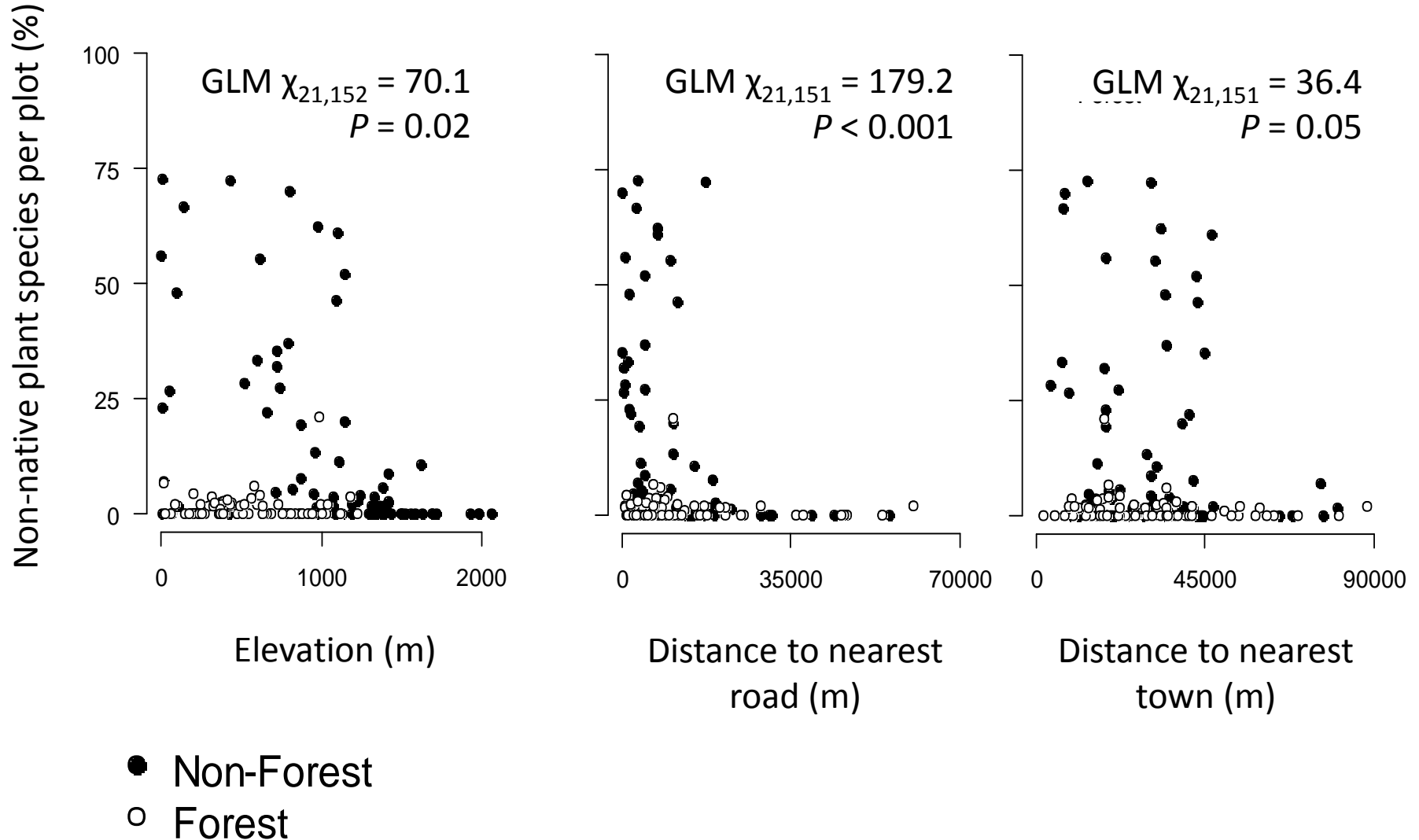
- 25,000 species
- 2,500 naturalized
- 250 designated as “weeds”

Native plants

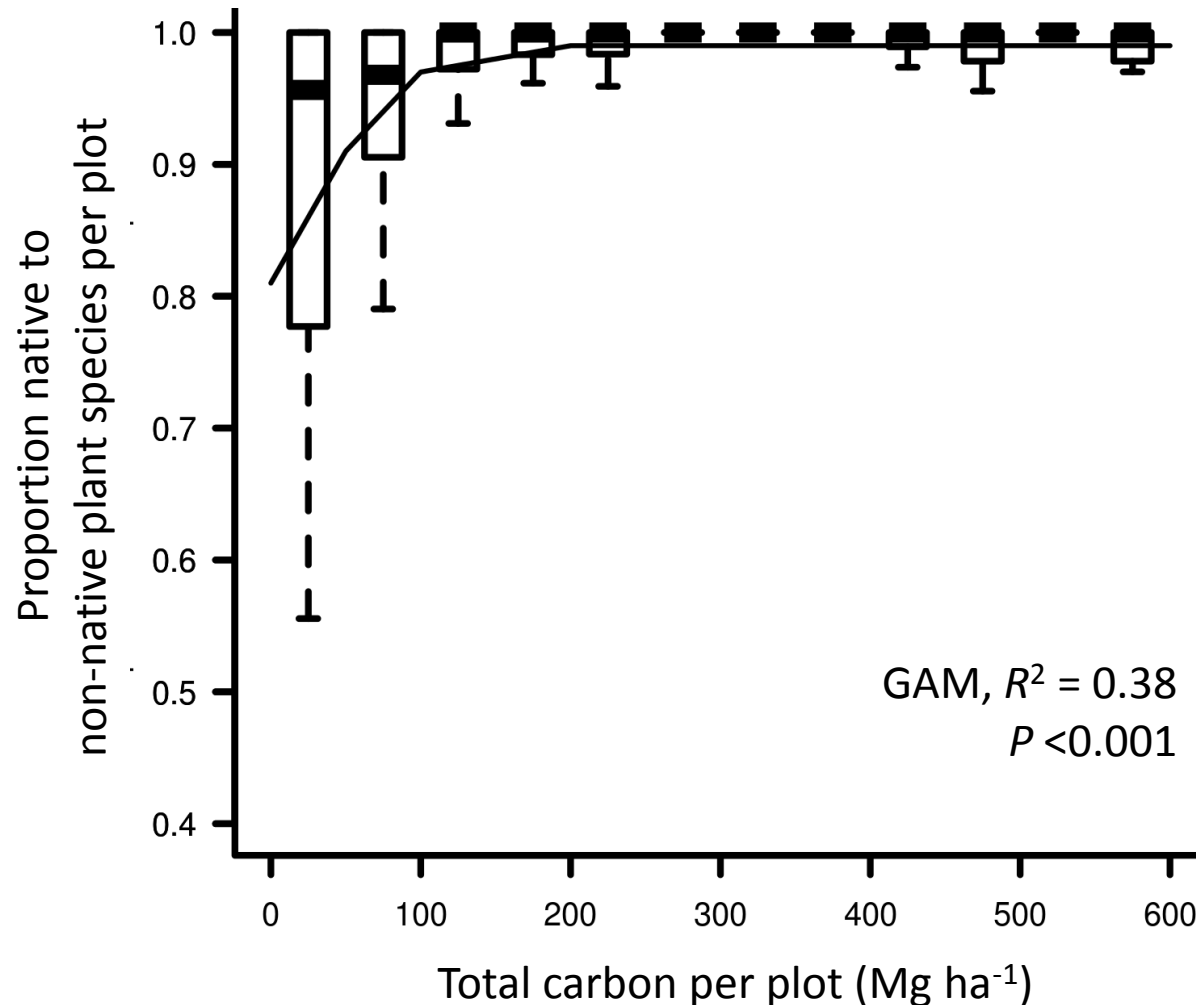
- 2,362 species



Non-native plant invasions



Native to non-native plant richness with respect to carbon stocks (biomass) in forests



Two widespread non-native plants

Non-forested ecosystems



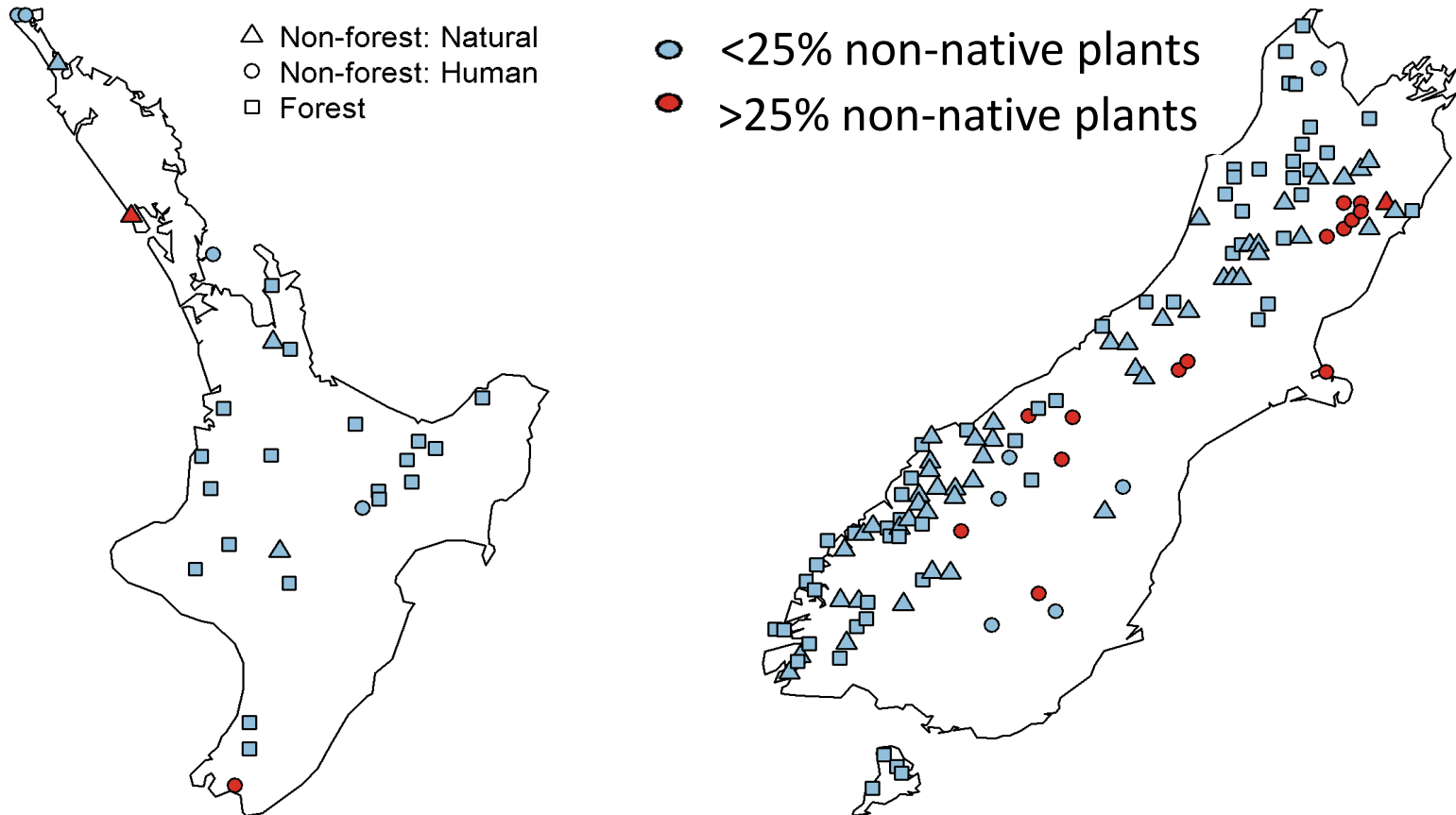
Browntop (*Agrostis capillaris*)

Forests



Wall lettuce (*Mycelis muralis*)

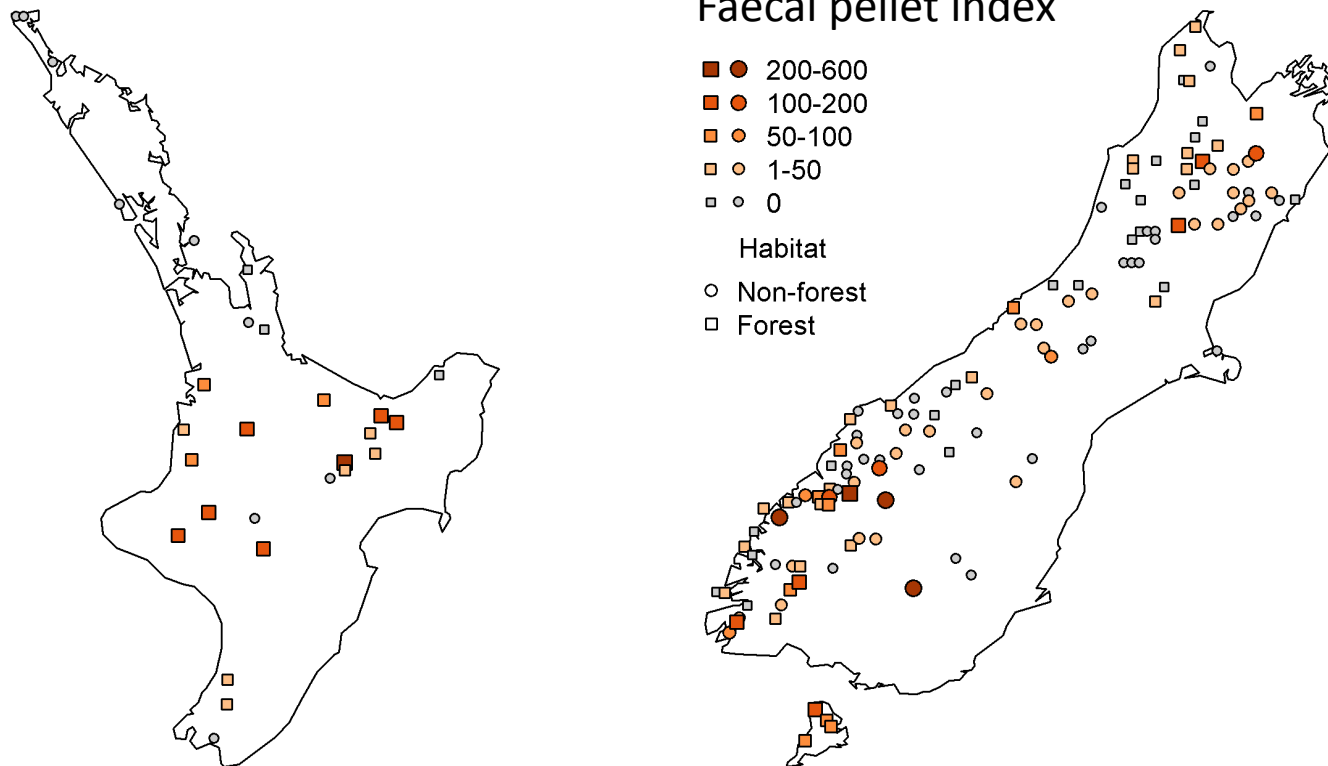
Non-native plants: forests and non-forested ecosystems



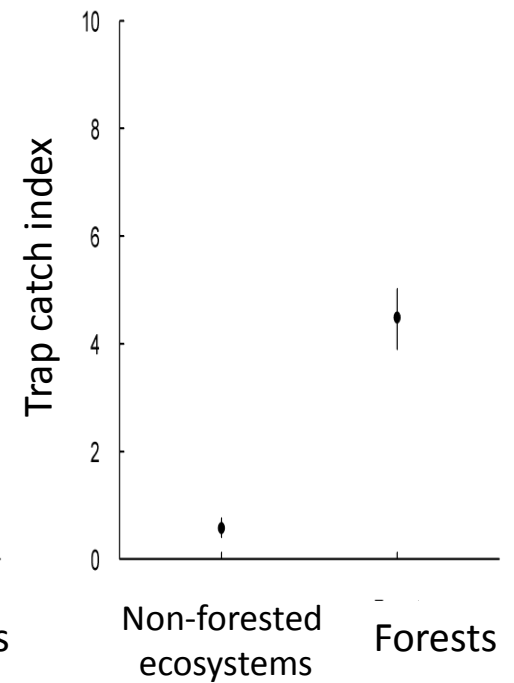
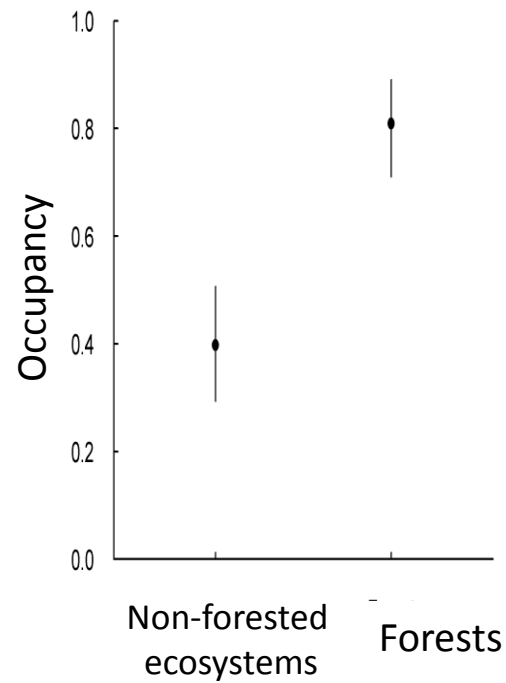


30 species of land mammals

Abundances of deer and goats throughout New Zealand



Brush-tail possums

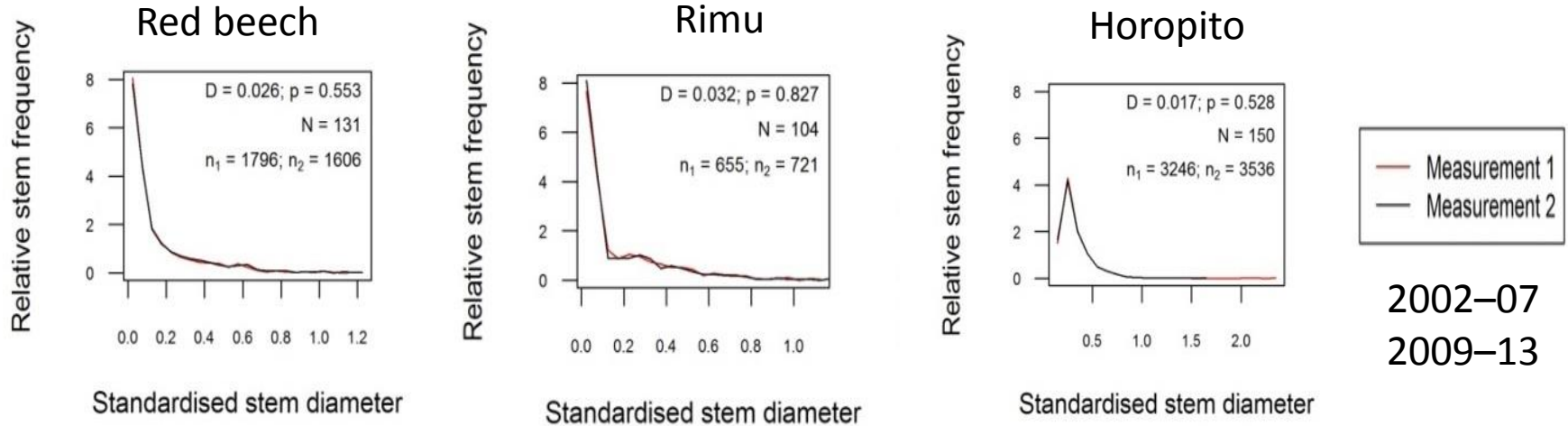


Species occupancy

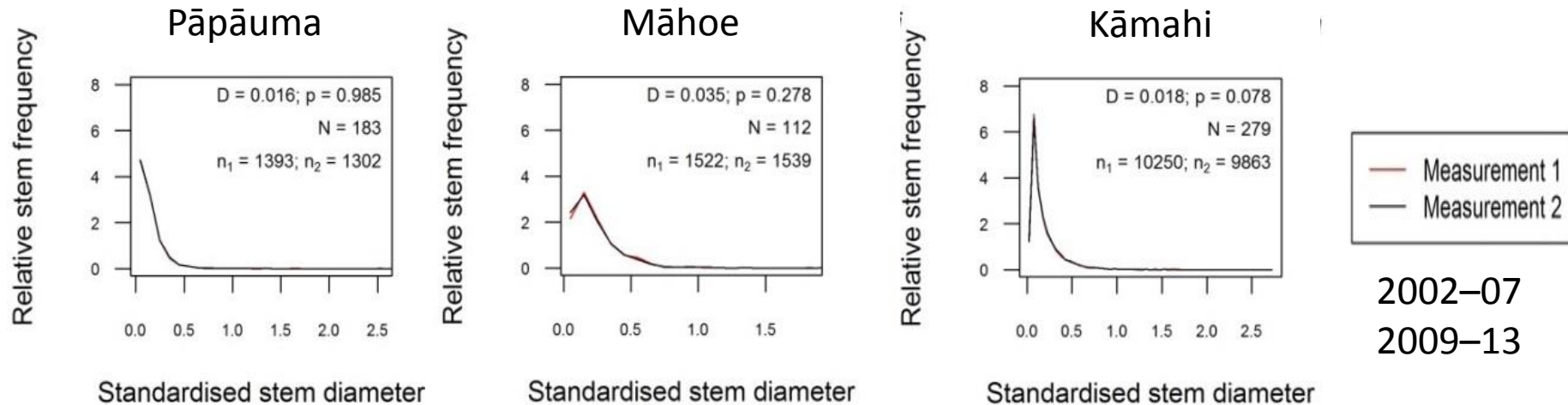




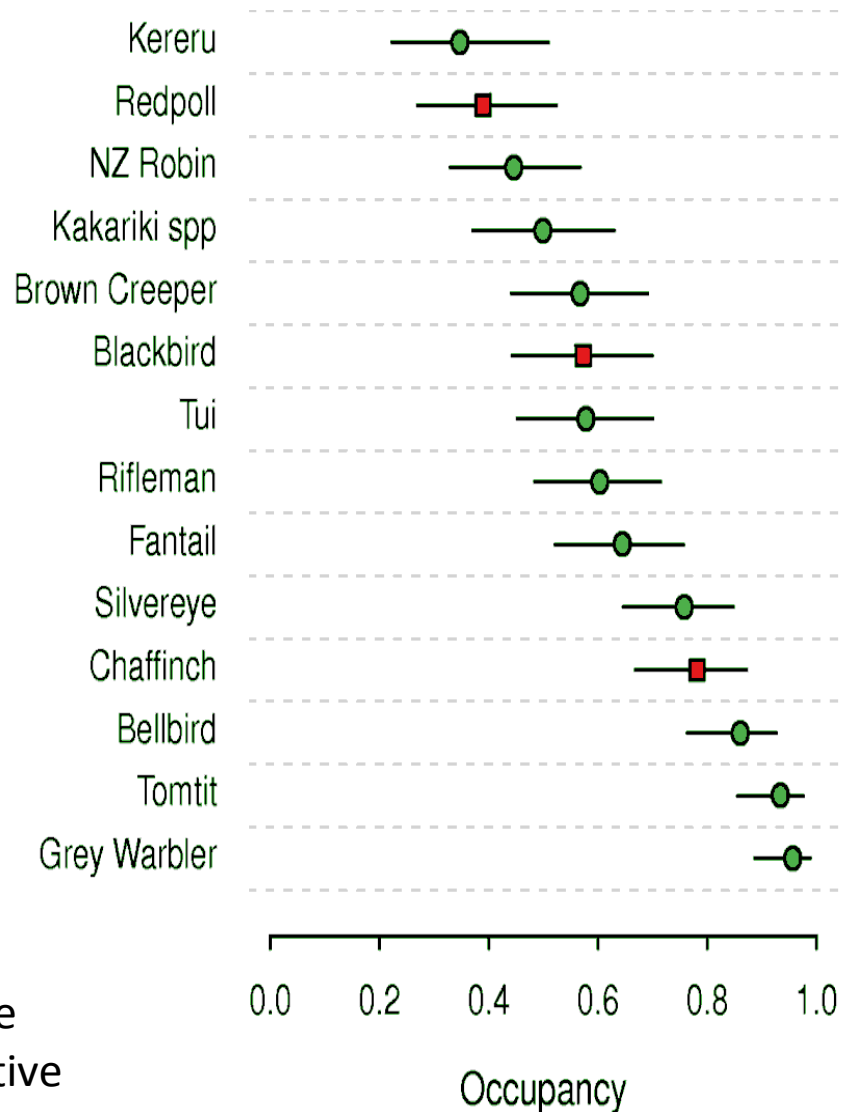
Continuous regeneration of trees that are unpalatable to introduced mammals



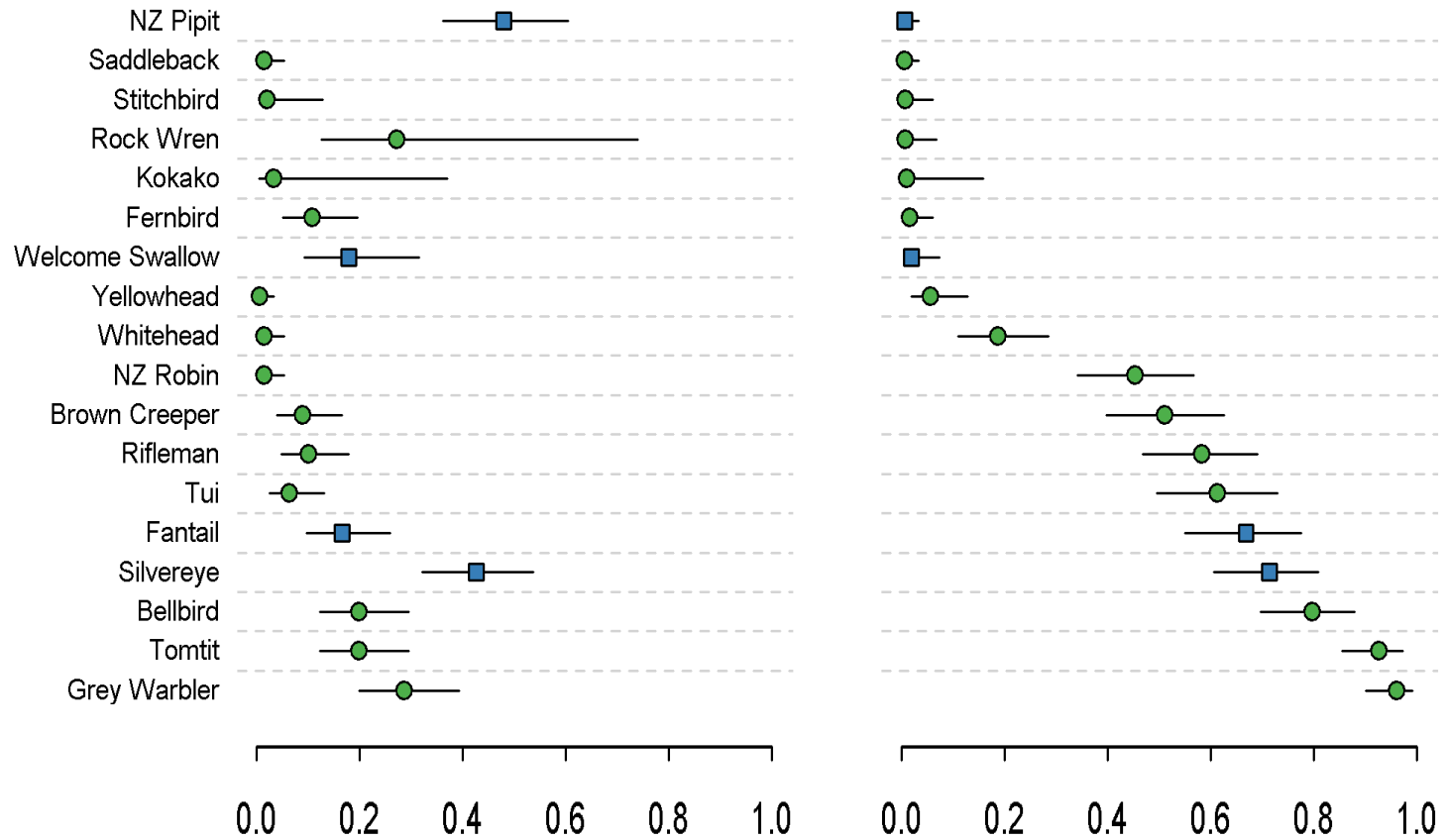
Continuous regeneration of trees that are palatable to introduced mammals



Bird species in forests nationally



Native birds: non-forested ecosystems vs. forests



Green = endemic

Blue = non-endemic

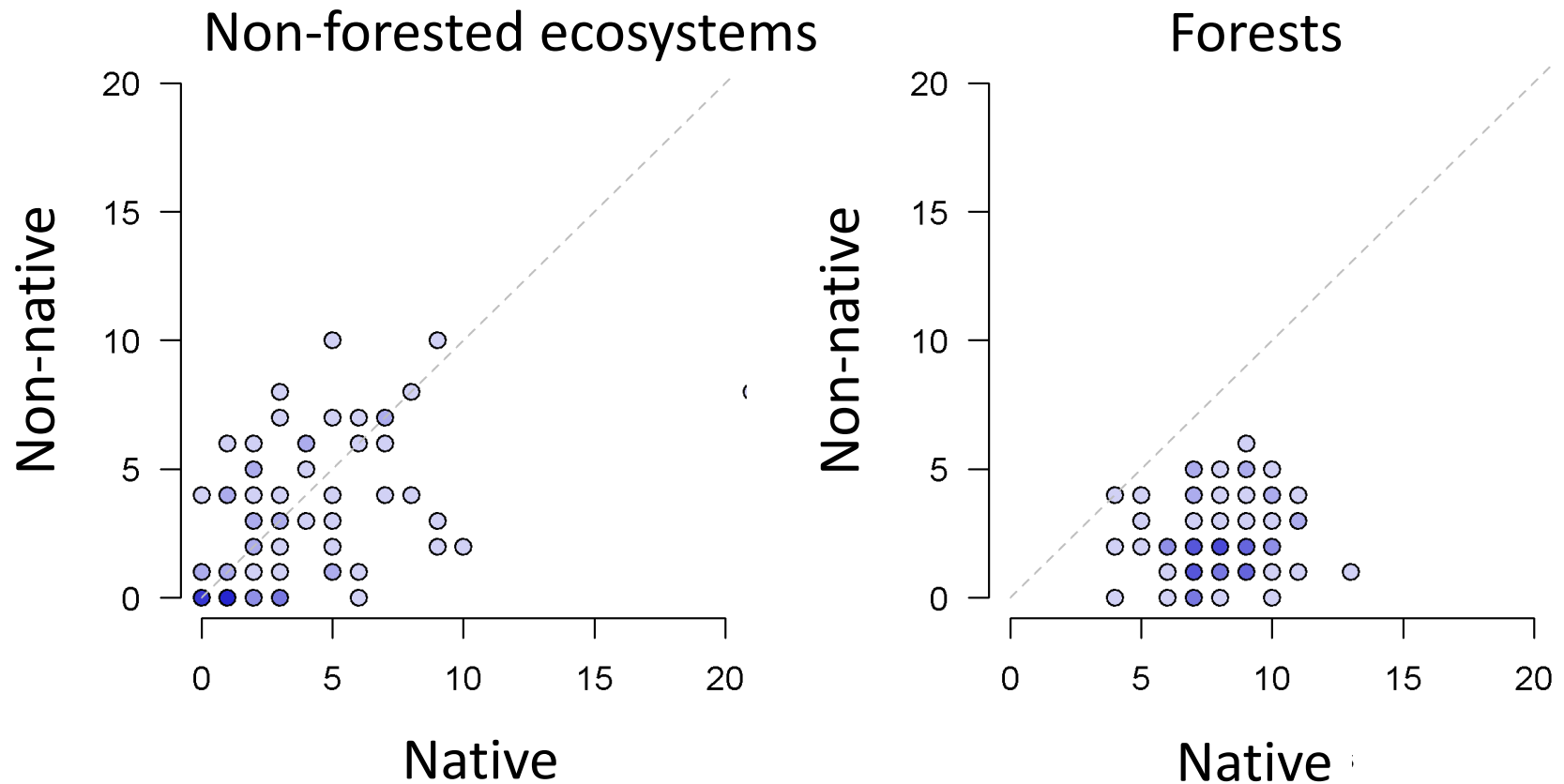
Non-forested ecosystems

Forests

Occupancy

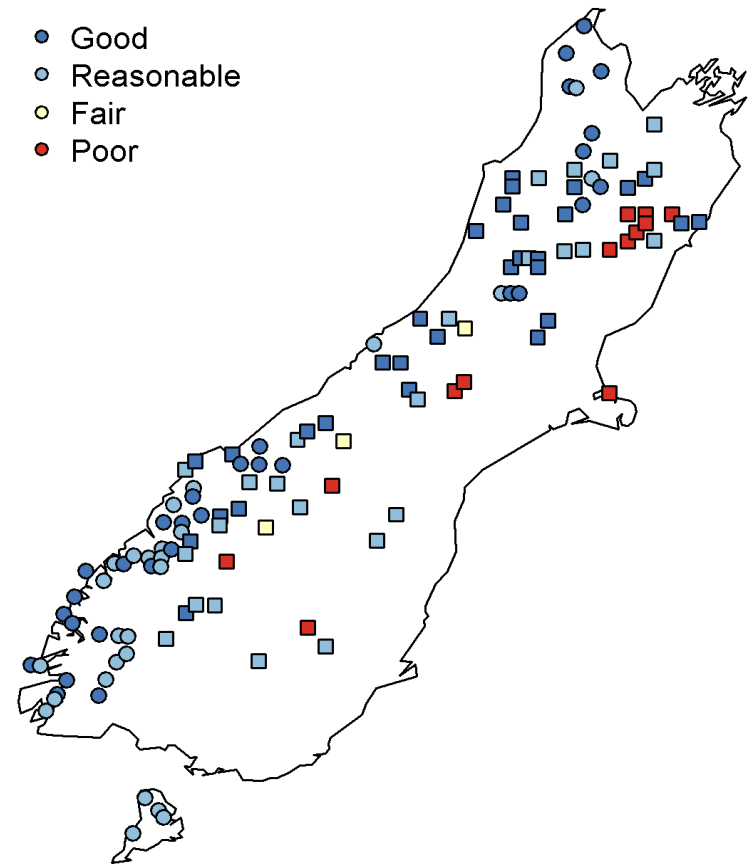
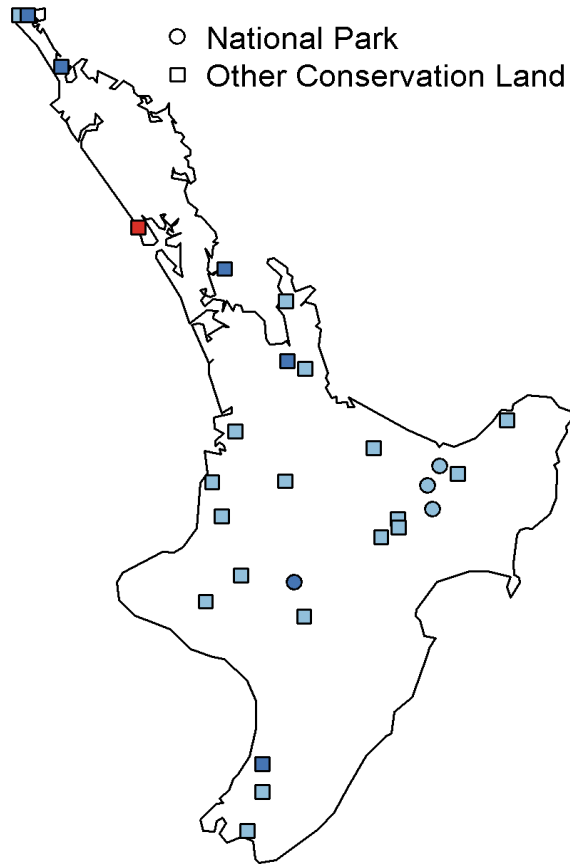
Dominance by native vs. non-native birds

α -richness (per plot), n species



The darker the symbol the more plots with the same data

Aggregated index of invasions: non-native mammals, birds, and plants





Westland National Park

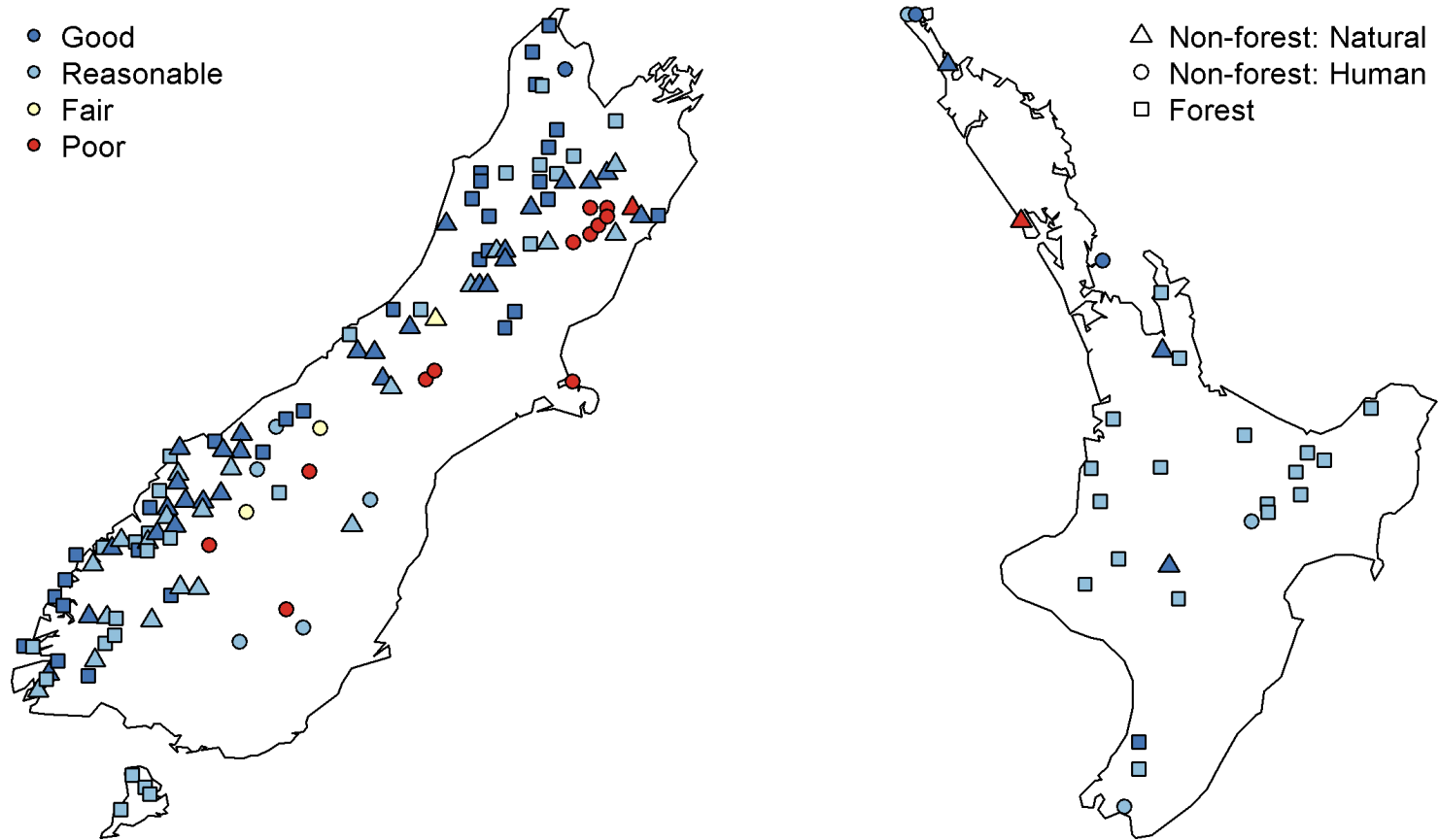


Kahurangi National Park



Clarence River valley, Marlborough

Ecological Integrity (EI) across Public Conservation Lands based on Tier 1 monitoring plots



ECOLOGY

Valuing Common Species

Kevin J. Gaston

Ecologically common species play key roles in terrestrial and marine ecosystems, yet are also the main victims of habitat loss, ecosystem degradation, and overexploitation.

154

8 JANUARY 2010 VOL 327 SCIENCE www.sciencemag.org

Published by AAAS

“Ecologically common species play key roles in terrestrial and marine ecosystems, yet are also the main victims of habitat loss, ecosystem degradation, and overexploitation”

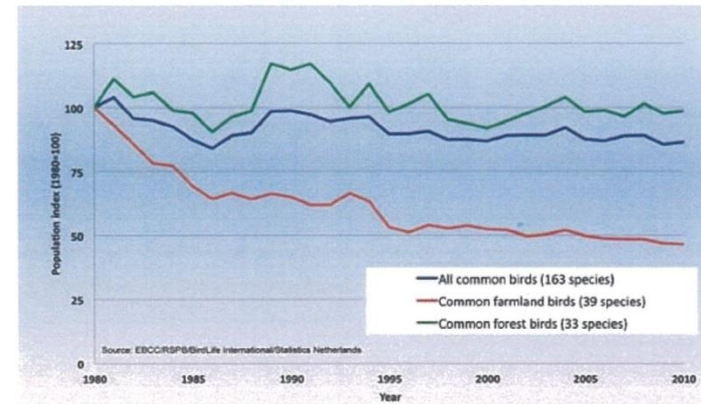
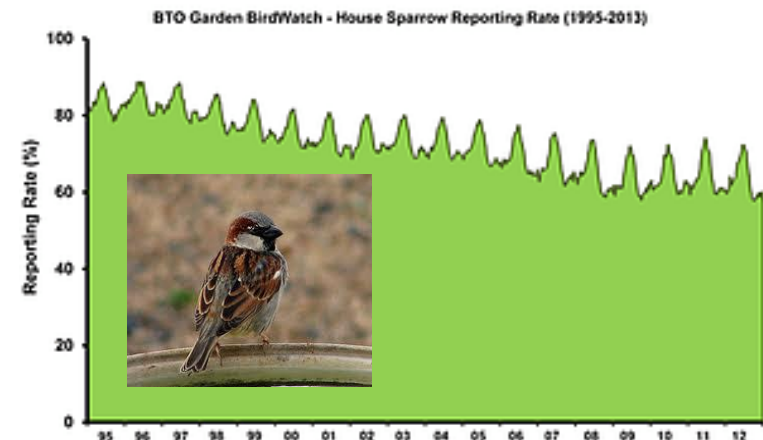
**European birds over 30 years**

Figure 2: Population trends of widespread birds in Europe (WBI) for all birds, farmland birds and forest birds.

House sparrows in England over 18 years

Valuing Common Species

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Ecologically common species play key roles in terrestrial and marine ecosystems, yet are also the main victims of habitat loss, ecosystem degradation, and overexploitation.

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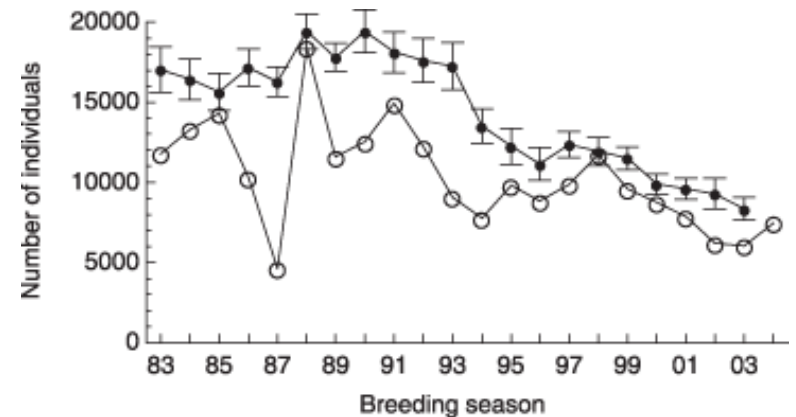
Seagull is NZ's latest endangered species

MICHAEL WRIGHT

Last updated 05:00 30/10/2014

KIRK HARGREAVES/FAIRFAX NZ

NUMBERS CRASHING: The red-billed gull, the mainstay of Kiwi beaches, is "nationally vulnerable".



Mills *et al.* (2010, *J Animal Ecology*)

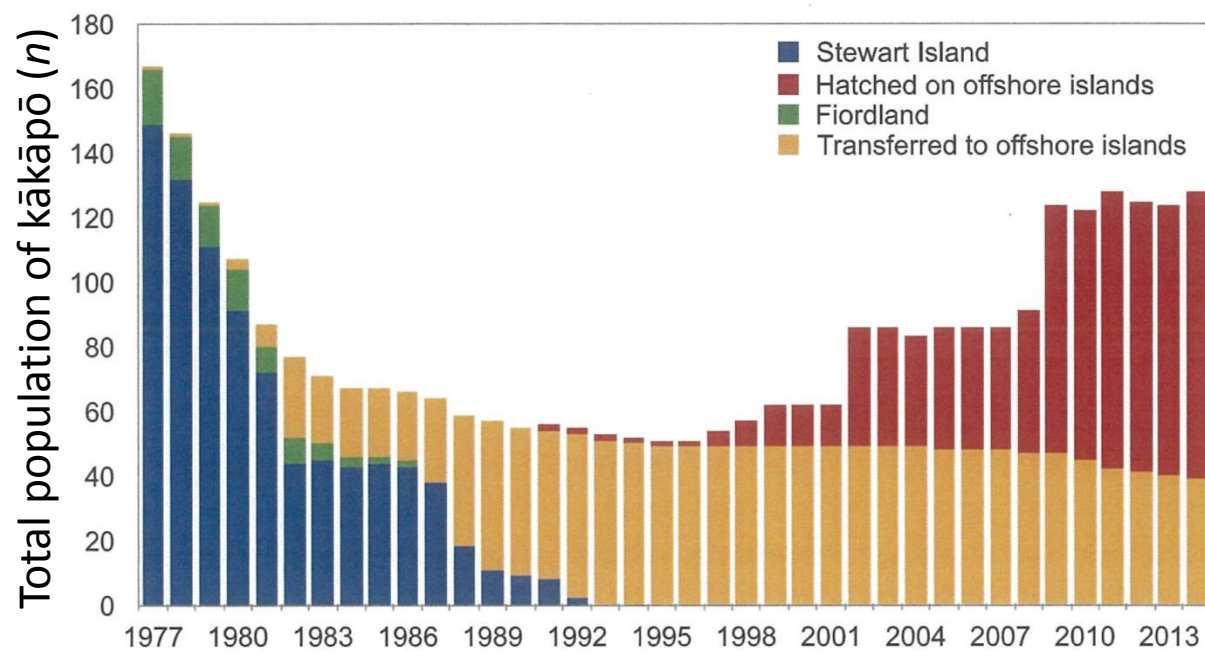


Figure 7. Estimated population of kākāpō.

DoC and terrestrial biodiversity monitoring and reporting

Research sites:

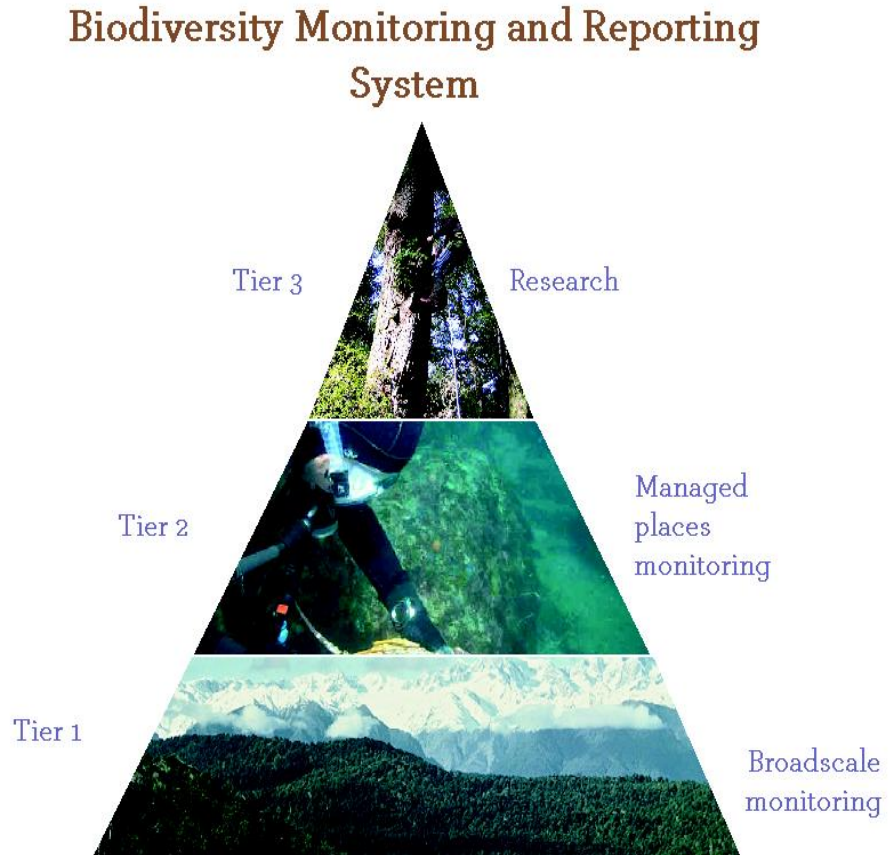
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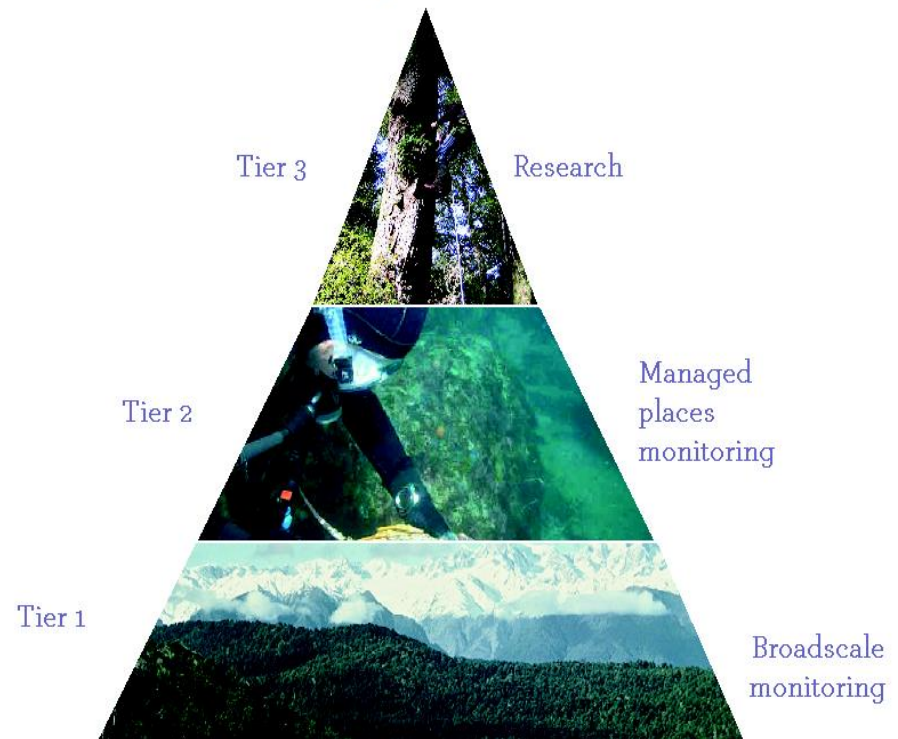
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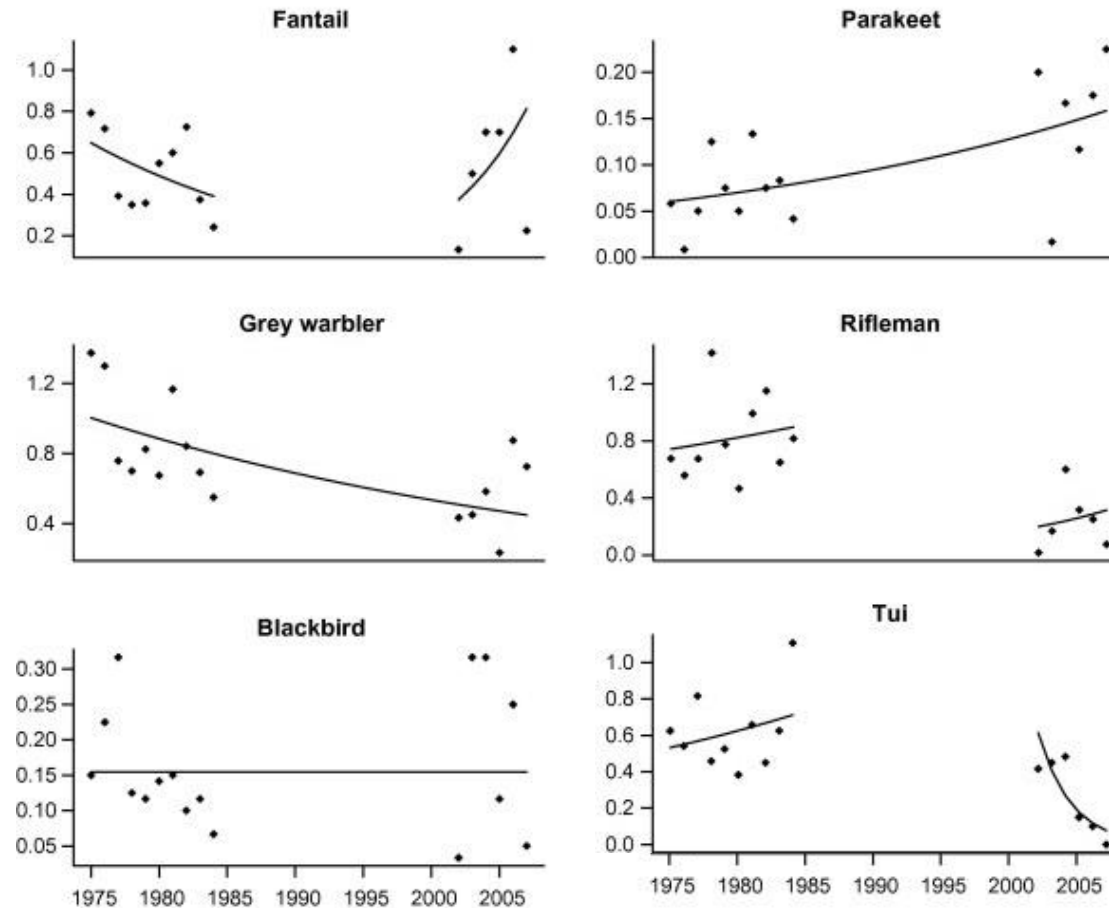
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Biodiversity Monitoring and Reporting System



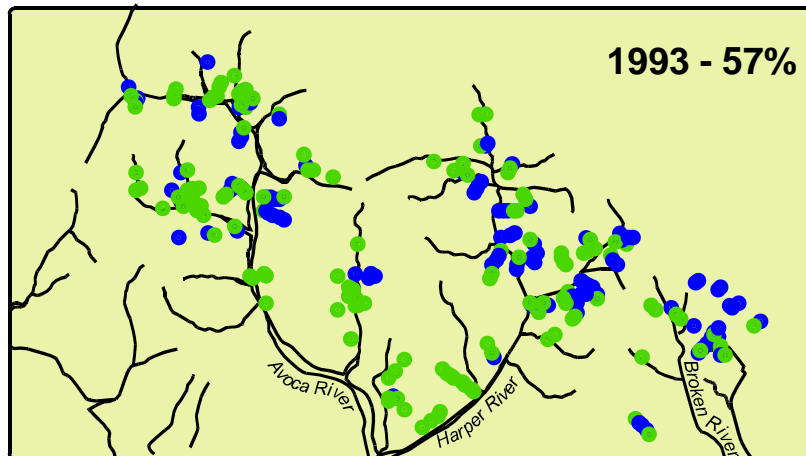
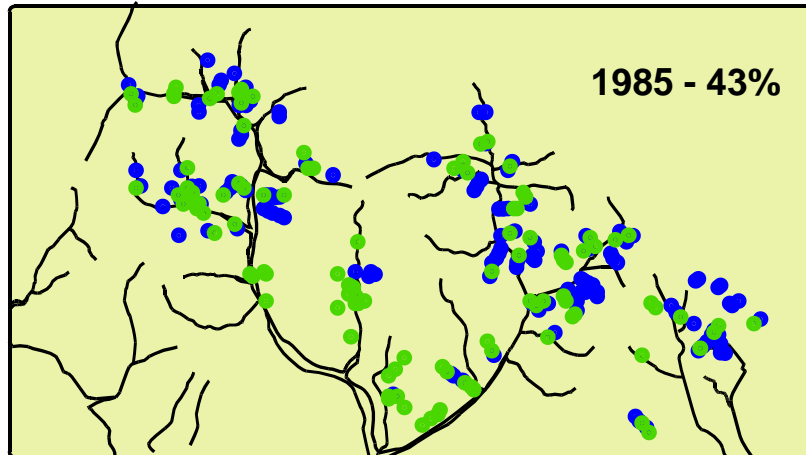
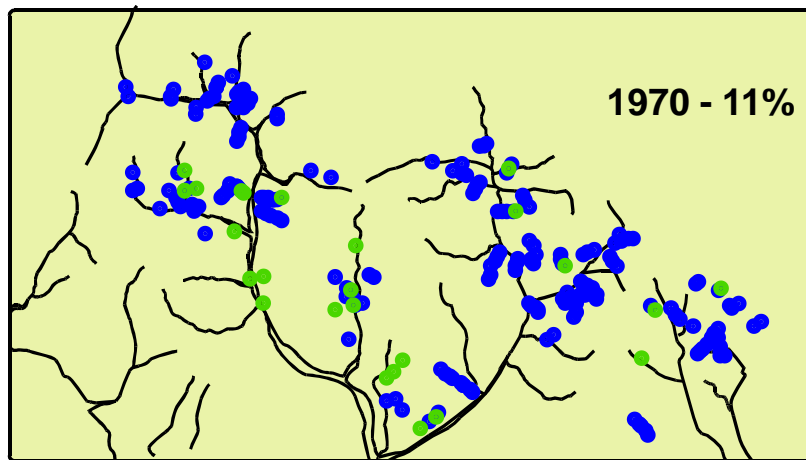
Long histories of change in biodiversity at local sites throughout New Zealand



*Some declines, some increases
in widespread forest birds in a
wasp-invaded beech forest
(Nelson Lakes National Park)
over 30 years*

*Elliott and others
Biological Conservation (2010)*

23 years of invasion by
a European herb
(*Hieracium lepidulum*)
in mountain beech
forests (Craigieburn
Forest)



- Plots invaded
- Plots not invaded

Biodiversity reporting across public conservation land

- Multiple indicators reporting ecological integrity
- Underpins DOC's annual reports, 2012 to present.
- Auditor-General's office changes DOC's status, after the 2012 report, from "on notice" to "good"

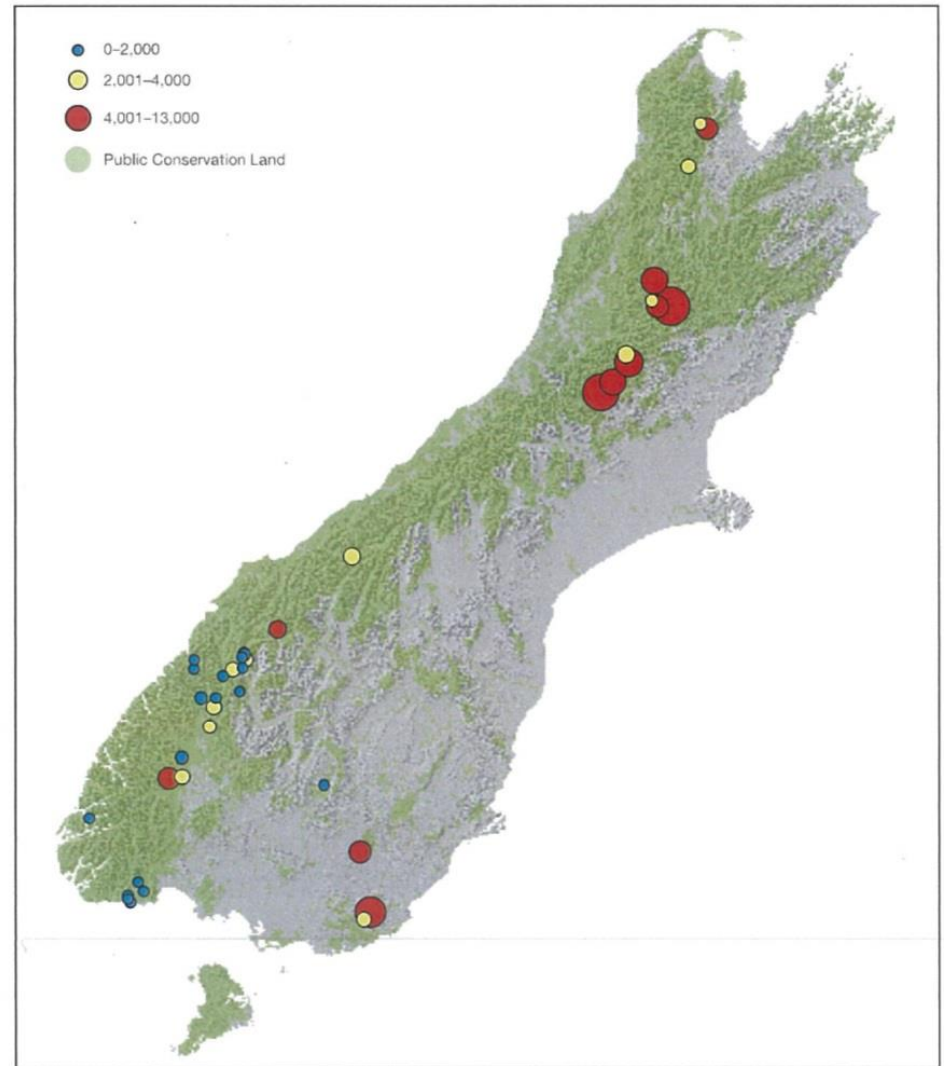


Figure 11. Beech seedfall (seeds/m²) measured at selected sites across the seed rain network February–July 2014.

A whole-of-New Zealand approach



Regional councils' terrestrial biodiversity monitoring

To determine:

- Status and trends
- Threats and pressures
- Effectiveness of policy and management
- Community engagement

Advanced as the basis for biodiversity in EMaR



Indicator	Developed	Implemented	Indicator	Developed	Implemented
Status and trend			Effectiveness of policy and management		
M1 Land cover			M12 Change in rare ecosystems		
M2 Vegetation		2 councils	M13 Threatened species habitat		
M3 Birds		2 councils	M14 Consents compliance		
M5 Rare ecosystems			M15 Pest-free ecosystems		
Threats and pressures			M16 Plants and birds at risk		
M6 Weeds			M17 Catchment protection		
M7 Pest mammals		R&D issues	Community engagement		
M8 Land cover change		R&D issues	M18 Protection		
M9 Loss to fire, herbicide		R&D issues	M19 Community restoration		Data issues
M11 Climate			M20 Community pest control		Data issues

Large-scale biodiversity indicators

Spatial indicators

Dependencies on:

- LCDB and its iterations (4 RC measures);

- LENZ (2 DOC measures)

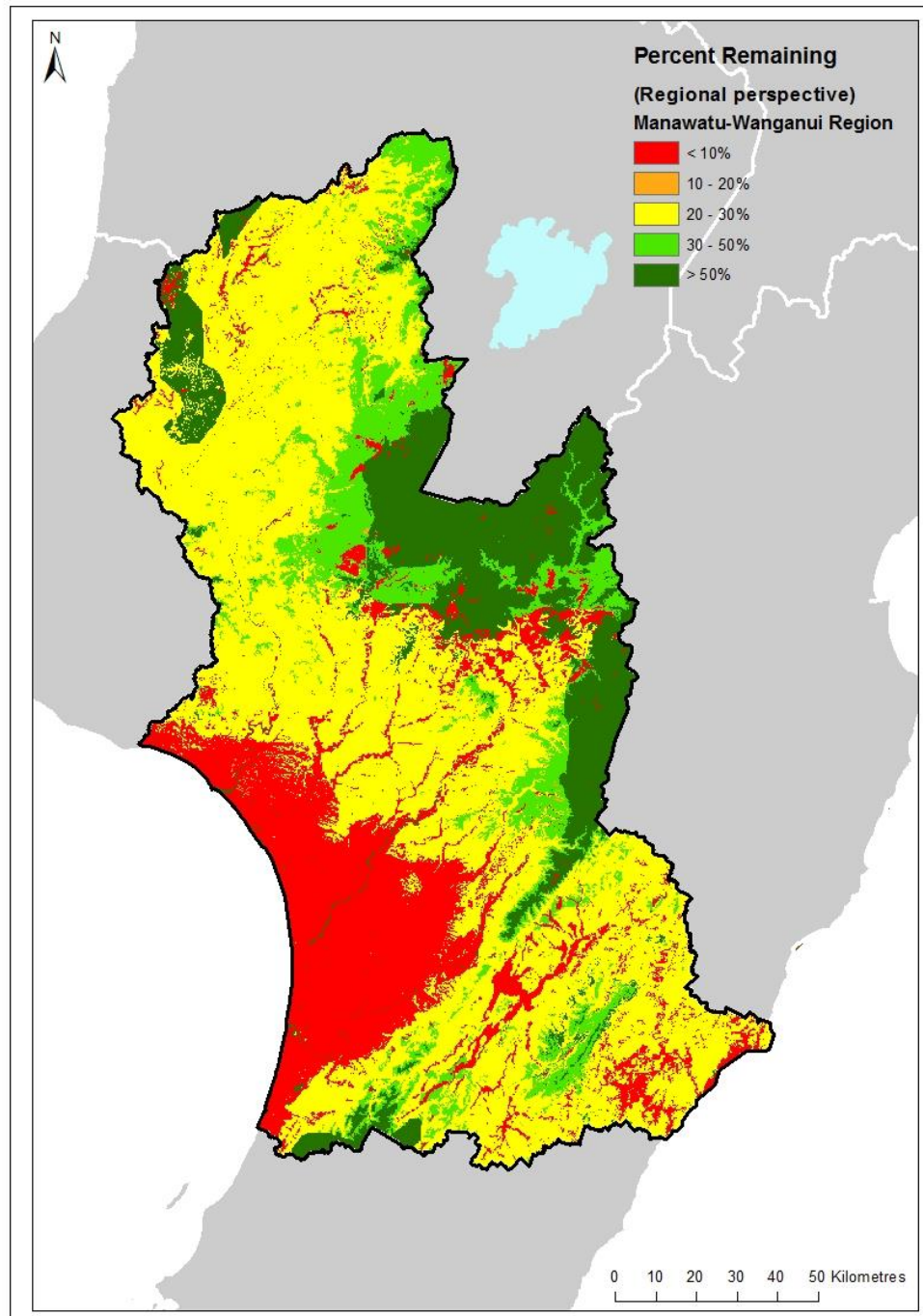
- GIS layers delineating ecosystems of interest (naturally uncommon ecosystems, wetlands) (1 RC measure and 2 DOC measures)

- Protected areas spatial layers (PANZ) (1 RC measure)

- Areas subject to pest control or community restoration projects (2 RC measures)

Land area under indigenous vegetation (Measure 1)

Indigenous land cover (by ha) of cover classes, habitat types, across LENZ and Ecological District units, regions.



Area and type of biodiversity protection achieved on private land (Measure 18)

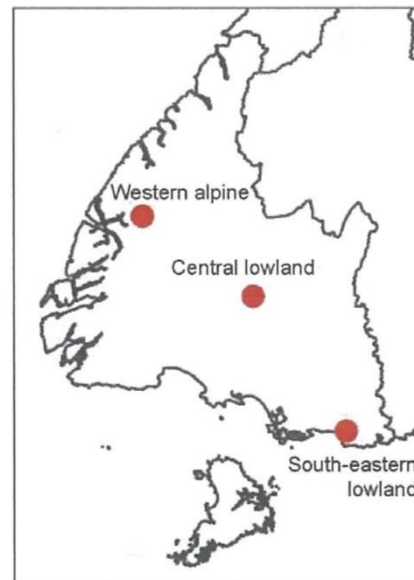
New areas (ha) protected through initiatives on private land



Change in precipitation and temperature (Measure 11)

Analysis of mean and extreme (i) annual temperature, (ii) seasonal temperature, (iii) frost frequency, (iv) annual precipitation, (v) seasonal precipitation

Location	Δ Mean temperature ($^{\circ}\text{C}$)			Δ N _{freezing} (days)	Δ N ₂₅ (days)	Δ Total precipitation (mm)		
	Annual	Summer	Winter			Annual	Summer	Winter
Western alpine	-0.17	-0.16	-0.02	8.3	-0.5	-1063	693	-233
Central lowland	0.07	0.42	-0.13	0.3	-5.2	-115	4	-42
South-eastern lowland	0.3	0.67	0.25	-10.4	-2.4	-57	-4	7

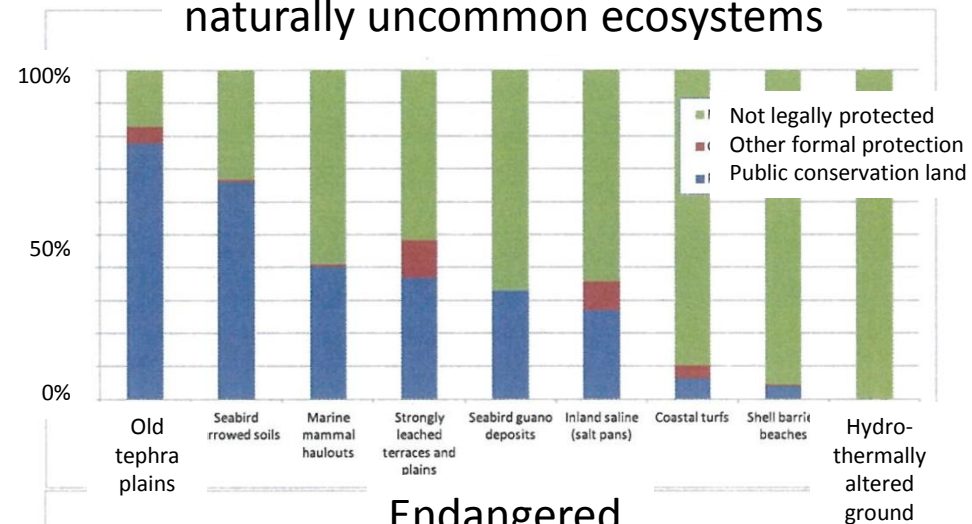


Rare ecosystems (Measure 12 of RCs, Measure 6.1.4 of DOC)

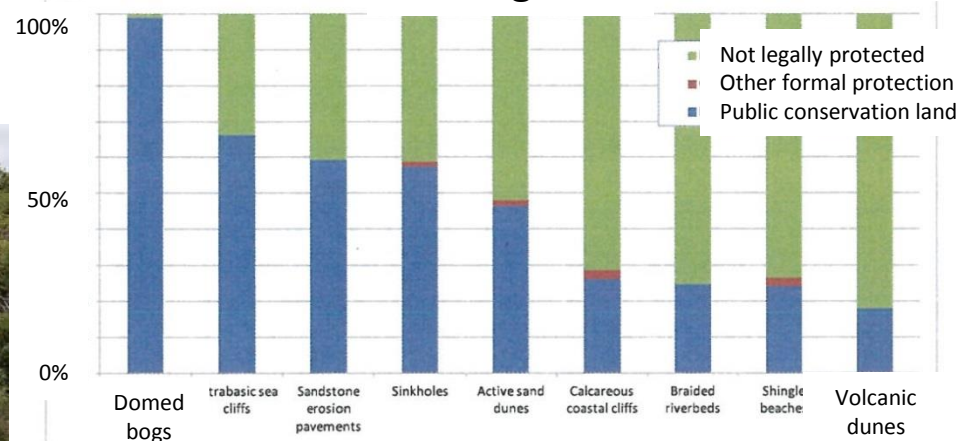
Depends on mapping of the rare ecosystems; ground-truthing required for many of these



Critically endangered naturally uncommon ecosystems

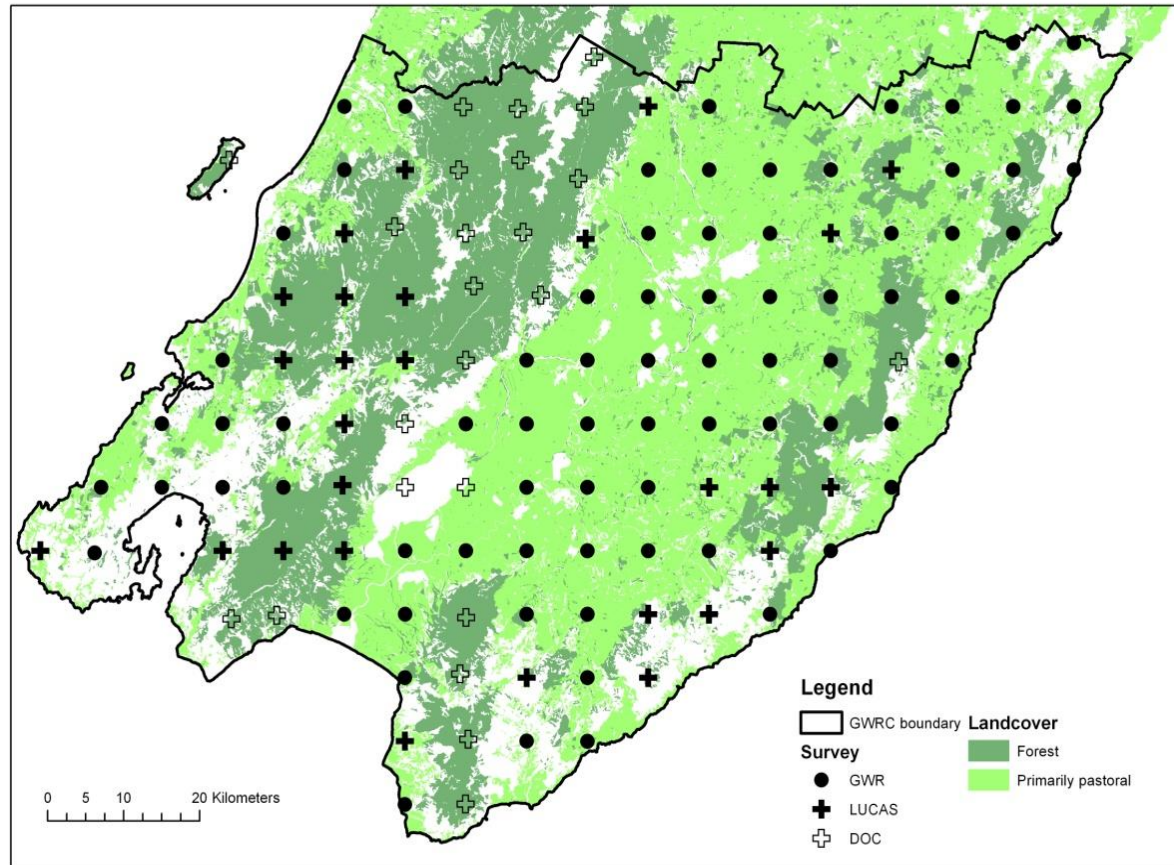


Endangered



Greater Wellington Regional Council: implementing biodiversity indicators

Point-based samples



Sampling in primary production landscapes





Co-creating an online tool for sustainability assessment, monitoring, reporting and learning.



Ecosystems
Consultants



Forestry partners





6-year MBIE-funded project,
initiated in 2012

- *Recognises three drivers for sustainability reporting*
 - Regulatory
 - Market
 - Business improvement
- *Nested design to support reporting multiple scales*
 - Farm
 - Industry and/or region
 - National
 - International
- *Locally and international relevant*
 - Using existing indicators where they exist (e.g. DOC and regional councils, FAO SAFA)
 - Developing and testing new indicators to address key gaps

Essential Biodiversity Variables

H. M. Pereira,^{1,*†} S. Ferrier,² M. Walters,³ G. N. Geller,⁴ R. H. G. Jongman,⁵ R. J. Scholes,³ M. W. Bruford,⁶ N. Brummitt,⁷ S. H. M. Butchart,⁸ A. C. Cardoso,⁹ N. C. Coops,¹⁰ E. Dullo,¹¹ D. P. Faith,¹² J. Freyhof,¹³ R. D. Gregory,¹⁴ C. Heip,¹⁵ R. Höft,¹⁶ G. Hurtt,¹⁷ W. Jetz,¹⁸ D. S. Karp,¹⁹ M. A. McGeoch,²⁰ D. Obura,²¹ Y. Onoda,²² N. Pettorelli,²³ B. Reyers,²⁴ R. Sayre,²⁵ J. P. W. Scharlemann,^{26,27} S. N. Stuart,²⁸ E. Turak,²⁹ M. Walpole,³⁰ M. Wegmann³⁰

A global system of harmonized observations is needed to inform scientists and policy-makers.

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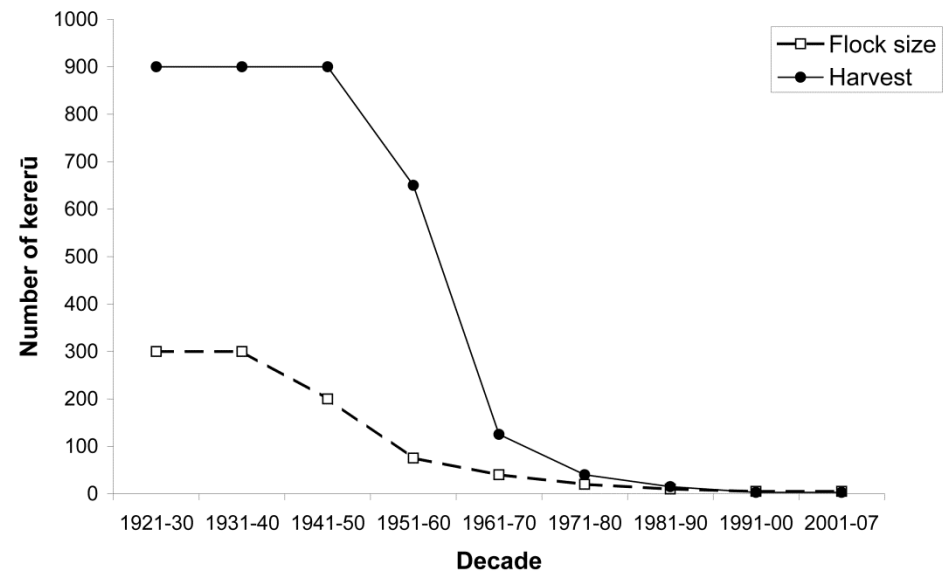
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Essential biodiversity variable class	Essential biodiversity variable example	Meets Aichi Targets (ex CBD)	DOC's indicators
Genetic composition	Allelic diversity	12, 13	A few species
Species populations	Abundances and distributions	4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15	Vegetation, birds, invasives
Species traits	Phenology	10, 15	Seeding
Community composition	Taxonomic diversity	8, 10, 14	Vegetation, birds
Ecosystem structure	Habitat structure	5, 11, 14, 15	Vegetation (better links to remote data)
Ecosystem function	Nutrient retention	5, 8, 14	Plant functional types (and soils)

Terrestrial biodiversity indicators based on mātauranga Māori

Example: An 80-year estimate of kererū populations in Te Urewera
based on Tūhoe Tuawhenua mātauranga



Belowground biodiversity and ecosystem functioning

Richard D. Bardgett¹ & Wim H. van der Putten^{2,3}

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“Soil biodiversity

- Regulates the structure and functioning of terrestrial ecosystems;
- Has a key role in determining the ecological and evolutionary responses of terrestrial ecosystems to current and future environmental change”



OUR VISION: Simple, cost-effective, and comprehensive biodiversity assessment

1. Commercially available sampling kit



2. End-user samples soil and ships to lab



3. Laboratory-based analyses



4. Bioinformatics identifies DNA sequences



5. Automatically generated end-user report

Next-Generation Biodiversity Assessment*

Preliminary plot-level report to land-owner

R. Holdaway, I. Dickie, J. Wood, K. Orwin, C. MacLeod

March 31, 2014

Information on Next Generation Biodiversity Assessment (<http://tinyurl.com/NextGenBiodiversity>) plot H4, sampled as part of initial, "proof-of-concept" survey of 30 plots within the Wairau river catchment spanning 5 different land use types (indigenous forest, pine plantations, low-producing grassland, high-producing grassland, and vineyards). This information is provided as a courtesy to land-owners by the Next-Generation Biodiversity Assessment team, led by Landcare Research with collaboration from the Bio-Protection Research Centre, Lincoln University.

1 How to read this report

This report is divided into sections for different types of data (e.g., soil chemistry, soil ecosystem function, plant community composition, bird community composition). In each section a header gives general information, followed by a graph showing the actual measurement results for this plot compared to other plots of similar land use (i.e., other high-prod. grassland plots) and the average values by land use type for all other plots in the area. For plant and bird community data a full list of observed species is presented as a table, with additional indicators (diversity, proportion native) following in a figure. If you have received this document in electronic form, any blue text is a clickable link to further information on the internet. For most species-level information, these links go to NatureWatch NZ, while many other links go to Wikipedia or other sources. Links are provided for information, but do not indicate endorsement of any particular service or website.

Comparison to other plots
(see legend)

Measure (units)

Value

Ranking
within
landuse
across
all
plots

Phase 1: Proof-of-concept in a model catchment (Wairau Valley, Marlborough)

5 land use types along
an intensification gradient



Indigenous forest



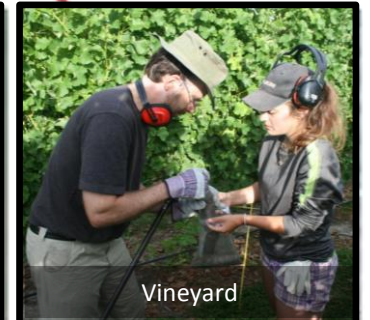
Low-producing grassland



Pine plantation



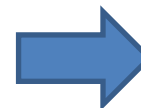
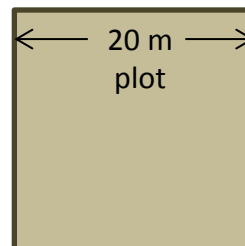
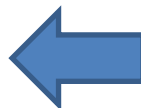
High-producing grassland



Vineyard

- Based on national grid of 20x20m plots used by DoC, MfE and regional councils
- Traditional plot-based measurements (plants, birds) alongside molecular methods

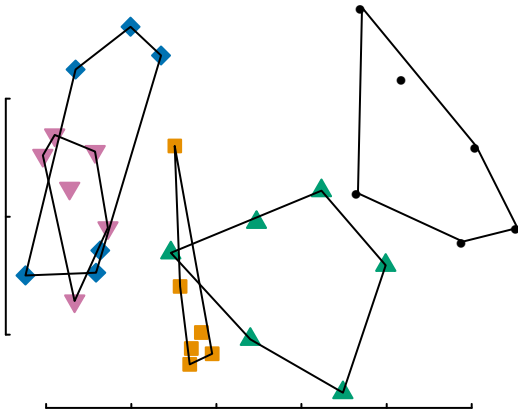
Field-based
Bird and plant surveys



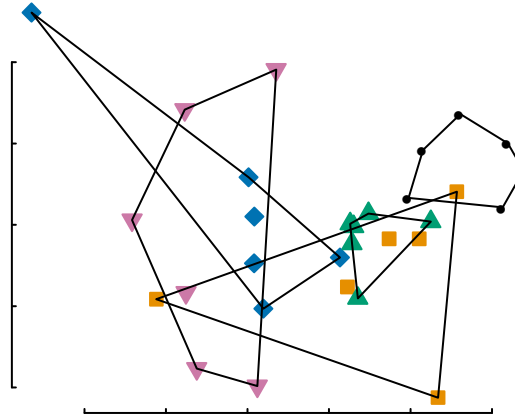
Soil cores for molecular analysis



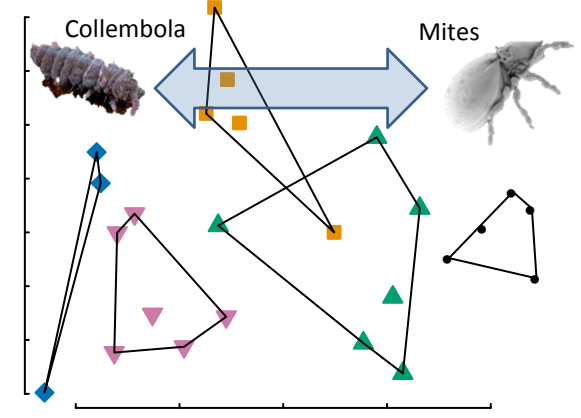
Plants (Field measurement)



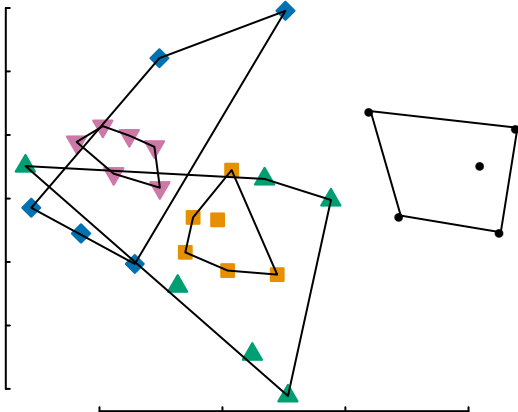
Birds (Field measurement)



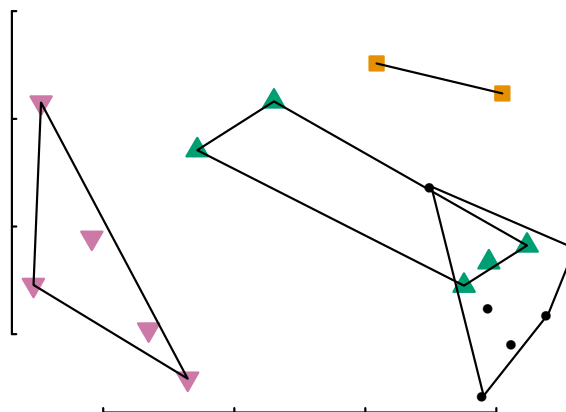
Invertebrates (DNA)



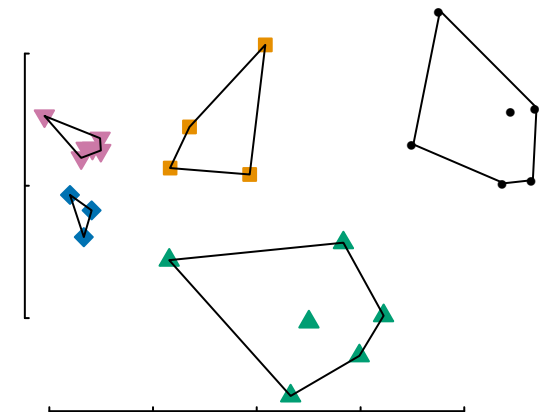
Plants (DNA)



Birds (DNA)



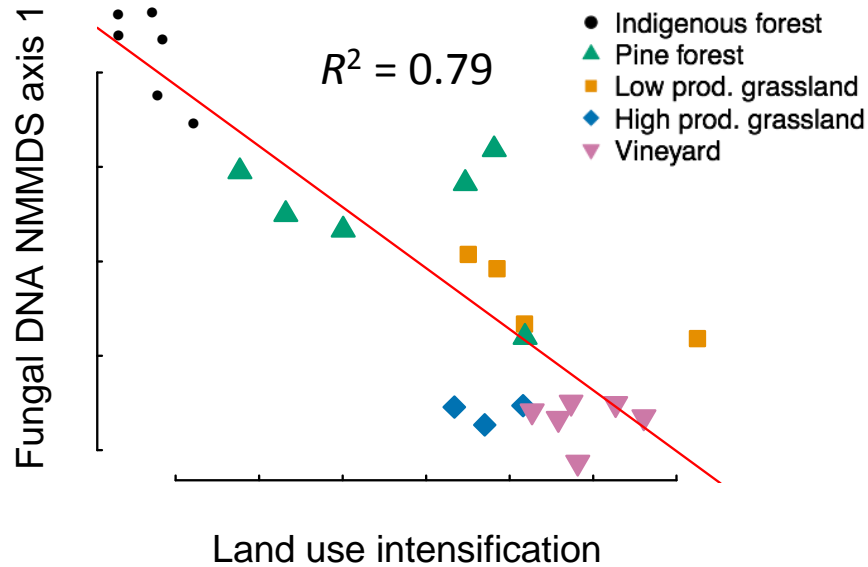
Fungi (DNA)



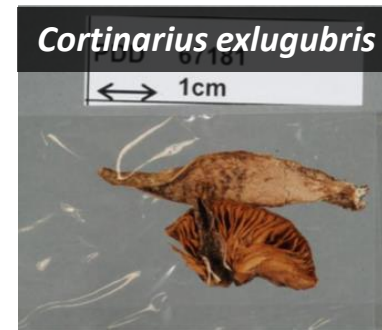
- Indigenous forest
- ▲ Pine forest
- Low prod. grassland
- ◆ High prod. grassland
- ▼ Vineyard

- DNA recreates most of information from field methods at lower cost (e.g., plants, birds)
- Vast increase in new information (Bacteria, Archaea, Insects, Nematodes, Fungi)
- Next objectives: increase reliability, improve reference databases (only 2% insects match)

COMMUNITY-LEVEL RESOLUTION \longleftrightarrow SPECIES-LEVEL RESOLUTION



Species of conservation concern, e.g.



Pathogens, e.g.



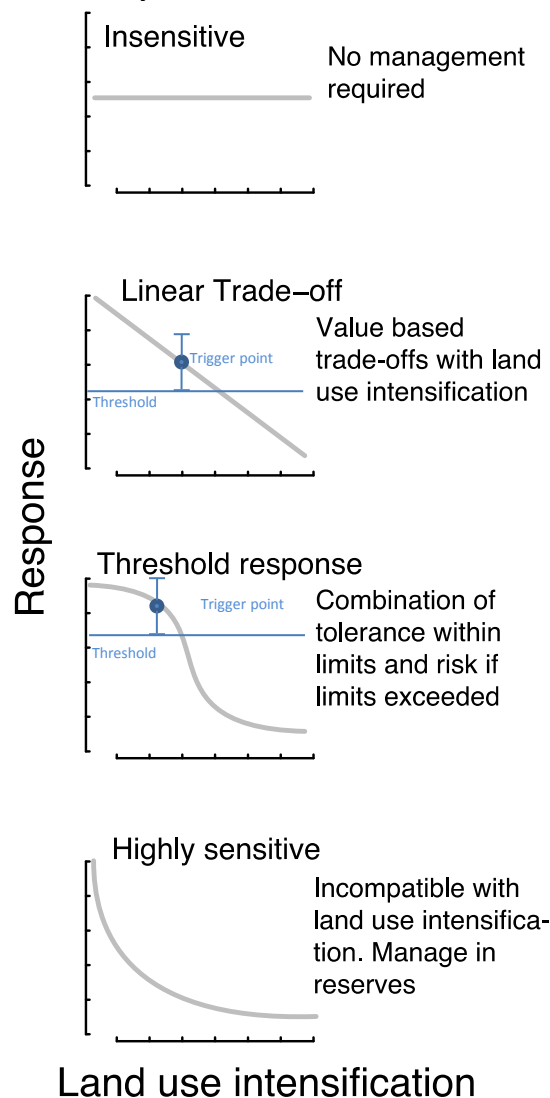
Table 1: Plant species and percent cover

Species	Common.name	Cover	Status	Growth.form
<i>Lolium perenne</i>	perennial ryegrass	61.20	introduced (EnvWeed)	grass
<i>Vitis vinifera</i>	grape	24.60	introduced (EnvWeed)	
<i>Schedonorus arundinaceus</i>		22.40	introduced (EnvWeed)	grass
<i>Trifolium repens</i>	white clover	11.20	introduced	herb
<i>Chenopodium album</i>	fat-hen	4.50	introduced	herb
<i>Dactylis glomerata</i>	cocksfoot	4.50	introduced (EnvWeed)	grass
<i>Galium aparine</i>	cleavers	4.50	introduced	herb
<i>Holcus lanatus</i>	yorkshire fog	4.50	introduced (EnvWeed)	grass
<i>Agrostis stolonifera</i>	creeping bent	2.70	introduced	grass

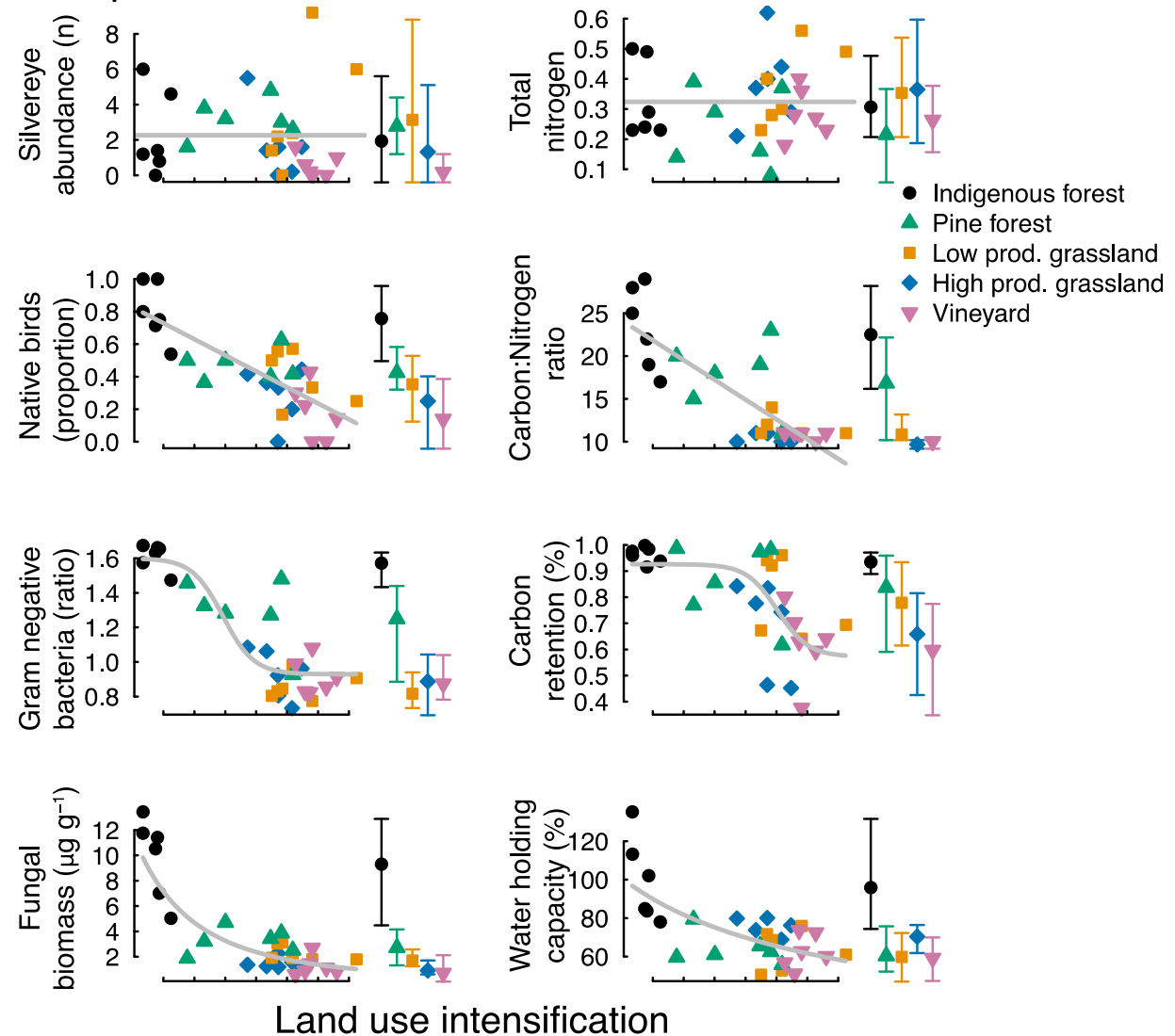
Feeds into reports, which highlight taxa of concern (e.g. weeds)

- From community composition to detection of pathogens and conservation species
- Integrated pathway from field sampling through analysis and report generation
- Reporting at national, regional, and site-scales within and across land use
- Links directly to central government, industry, land-owners integrating and improving on current practice

Theory

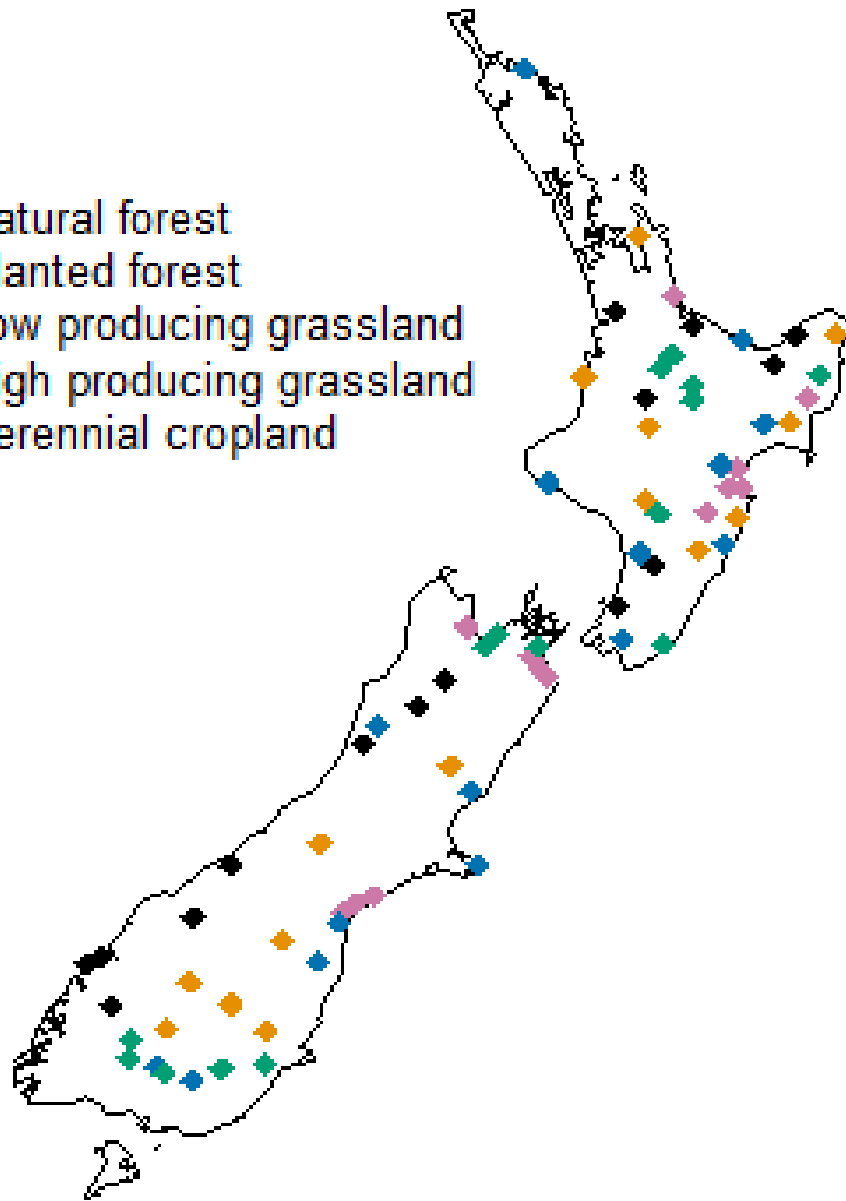


Examples from field data



- Different response curves have different implications for management
- Full range of responses – each indicating different management strategies
- High within land use variance – key direction for future work

- Natural forest
- Planted forest
- Low producing grassland
- High producing grassland
- Perennial cropland



New Zealand's Biological Heritage

A National Science Challenge



A national framework for bioheritage assessment across natural and productive landscapes

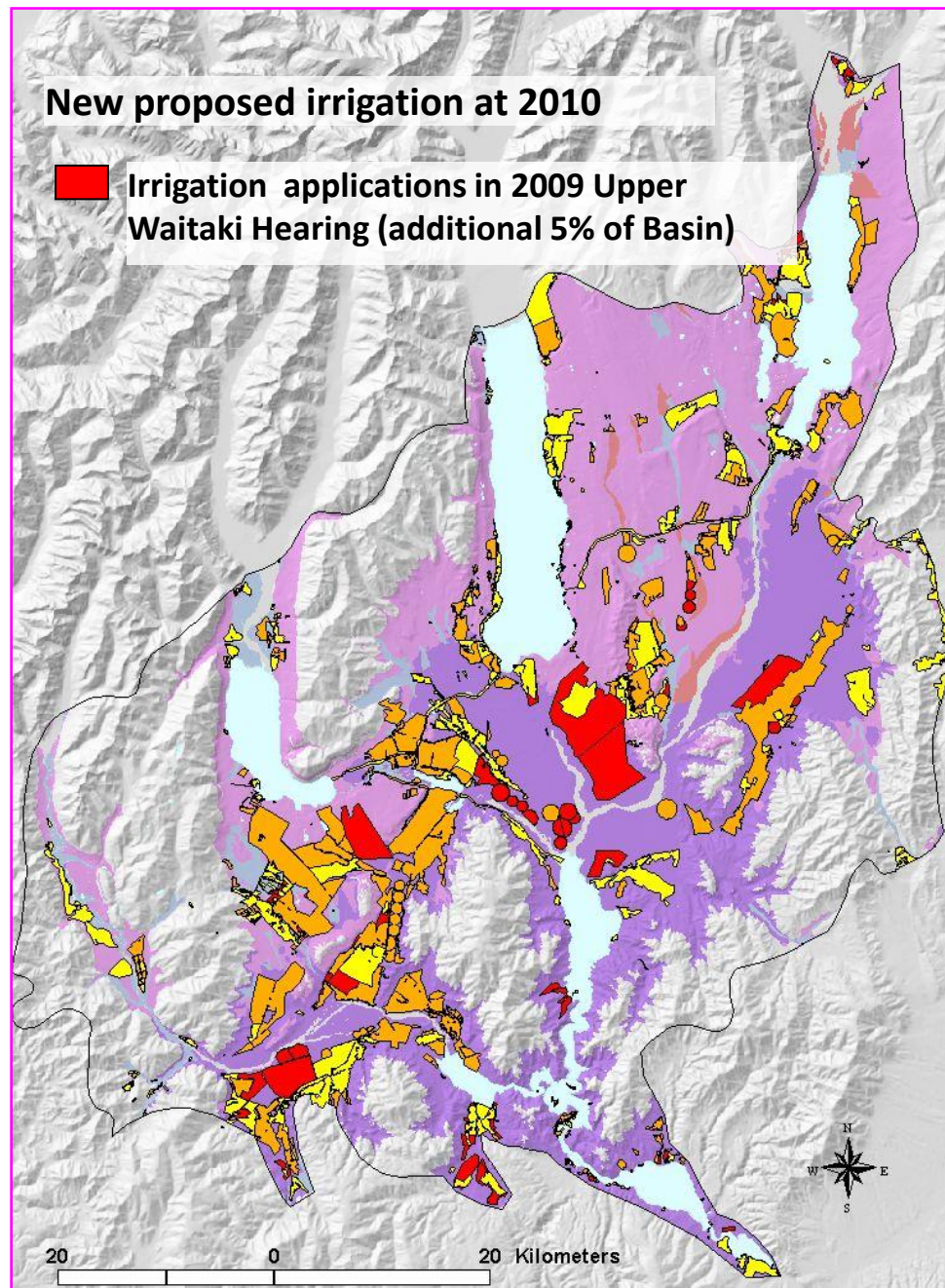
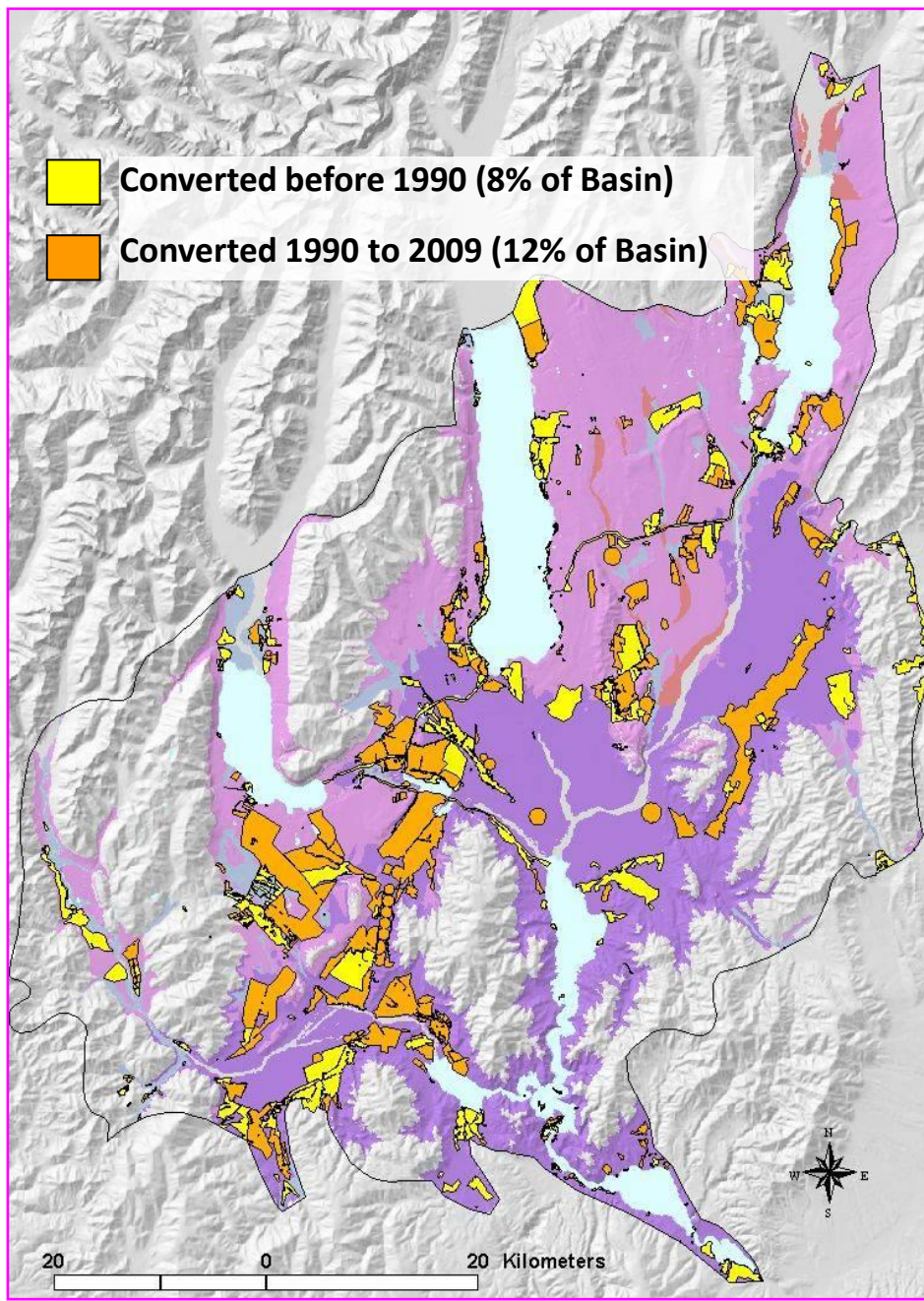
- This project, contributing to Challenge Programme 1 (Real-time bioheritage assessment), will develop a New Zealand-wide framework and platform for biological heritage measurement and monitoring using environmental DNA (eDNA) data. It will in turn allow accurate detection and monitoring of biosecurity incursions while also underpinning environmental monitoring and reporting at different scales.

Poutiri Ao o Tane Project Hawke's Bay



Multi-agency collaboration

Indigenous grassland loss - Mackenzie Basin





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