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Manaaki Whenua Landcare Research

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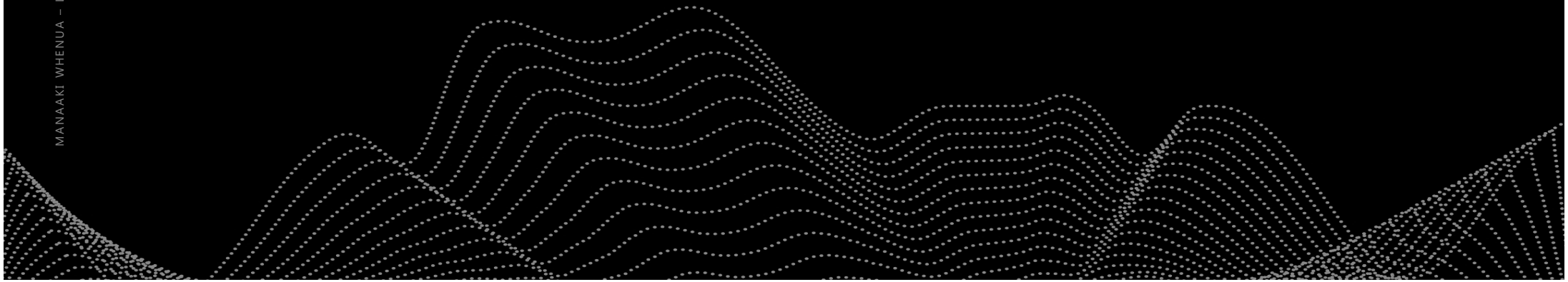
A pilot study on unifying terrestrial ecosystem typologies in Aotearoa New Zealand

James McCarthy



Talk outline

1. Introduction to ecosystem typologies
2. Work toward a New Zealand national ecosystem typology
3. Description of terrestrial typologies currently in use
4. Work done to create an integrated terrestrial typology – Northland pilot study

What is an Ecosystem Typology?

A structured classification system that groups ecosystems based on shared characteristics.

Why do we need ecosystem typologies?

Ecosystem typologies are foundational for:

- Biodiversity conservation
- Land-use planning
- Environmental monitoring
- Ecological research and understanding

Yet, existing typologies often:

- Lack ecological resolution
- Not scalable or transferable
- Inconsistent across regions

"The lack of harmonized ecosystem classification and mapping frameworks limits the ability to compare ecosystem conditions across regions and to monitor changes over time."

– IPBES Global Assessment Report, 2019

Ecosystem typology ≠ map

Typology	Map
Conceptual classification	Spatial representation
Defines ecosystem types	Shows where types occur
Independent of location	Location-specific
Supports consistency	Supports application
Can exist without spatial data	Requires spatial data

The current status of typologies

Many typologies are:

- Expert-driven and subjective
- Incomplete
- Based on coarse land cover or vegetation types
- Poorly aligned with ecological processes

This limits their utility for:

- Generating maps
- Monitoring ecosystem change
- Integrating across disciplines or realms/domains

A national ecosystem typology for New Zealand: project team

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NIWA Taihoro Nukurangi

ESR Science for Communities He Pūtaiao, He Tāngata

GNS SCIENCE TE PŪ AO

LINCOLN UNIVERSITY TE WHARE WĀNAKA O AORAKI

Ministry for the Environment Manatū Mō Te Taiao

Department of Conservation Te Papa Atawhai

Regional Councils

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How to achieve a national ecosystem typology

Terrestrial

Wetlands

Rivers

Lakes

Groundwater

Estuarine & Marine

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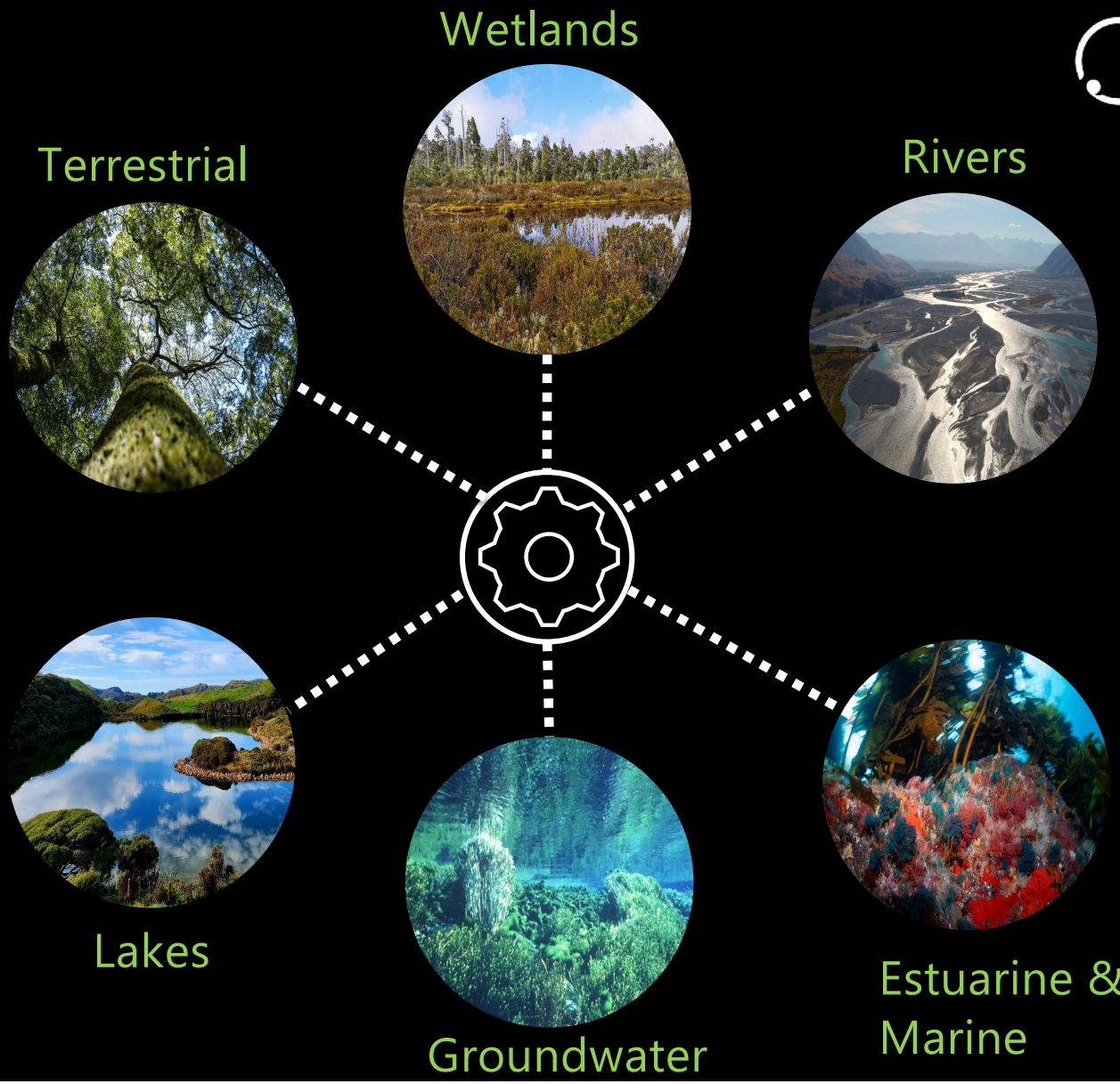
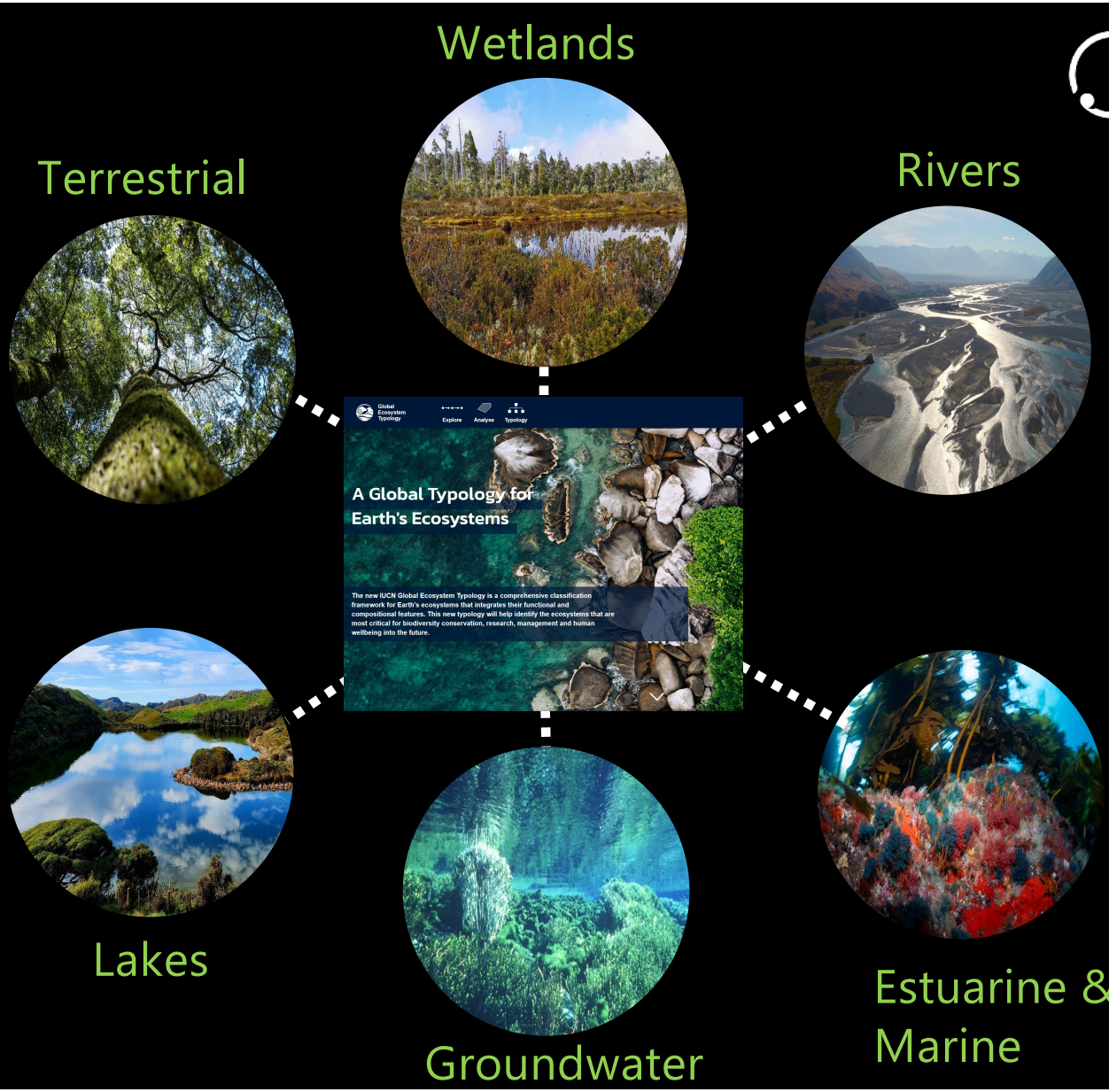
How to achieve a national ecosystem typology

- Unify with a common framework



How to achieve a national ecosystem typology

- Unify with a common framework



How to achieve a national ecosystem typology

- Unify with a common framework

Terrestrial

Wetlands

Rivers

- Hierarchical
- Mappable
- Updateable
- Comprehensive
- Reproducible
- Robust …

Lakes

Groundwater

Estuarine & Marine

How to achieve a national ecosystem typology

- Unify with a common framework
- No typology met all the principles

Terrestrial

Wetlands

Rivers

- Hierarchical
- Mappable
- Updateable
- Comprehensive
- Reproducible
- Robust …

Lakes

Groundwater

Estuarine & Marine

Toward a functional, scalable typology

Integration of advances in:

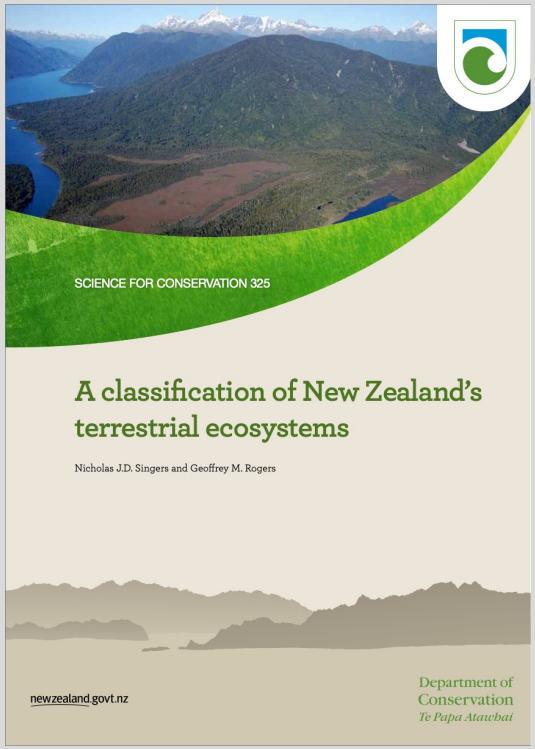
- Vegetation databases and plot-survey coverage
- Statistical and computational approaches
- Emerging technologies (e.g. remote sensing, machine learning)

Enable a new generation of typologies that are:

- Empirically grounded
- Operational and ready for application
- Scalable across regions
- Aligned with global ecosystem frameworks and functional understanding
- Informative for decision-making and conservation planning

New Zealand's current terrestrial typologies

- Two main terrestrial typologies in use
- Each has strengths – but also limitations
- Integration is needed for national consistency
- Pilot study in a single region to explore how they align



Expert-based system

- Potential ecosystem composition – no human disturbance
- Goal to map potential extent of ecosystems
- Guide management priorities
- Most regions mapped (excluding Canterbury and Westland)

Expert-based system – ‘zonal’ ecosystems

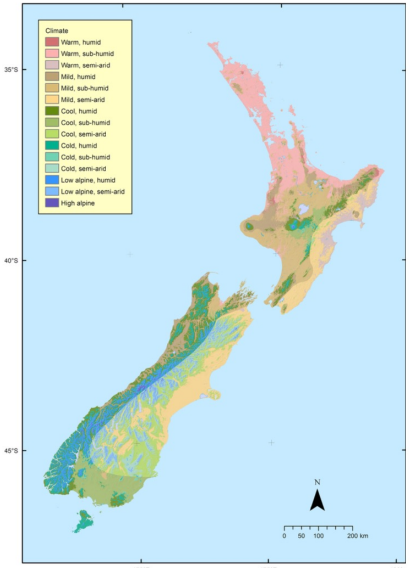


Table A2.1. Zonal ecosystems.

PRIMARY ECOSYSTEM DRIVER: TEMPERATURE	SECONDARY ECOSYSTEM DRIVER: MOISTURE	TERTIARY ECOSYSTEM DRIVERS: LANDFORMS AND SOILS	ECOSYSTEM UNIT CODE	ECOSYSTEM UNIT NAME
Subtropical: Mean summer temperature >22.5°C and frost free [Subtropical forests]	Sub-humid	Coastal hillslopes and hillcrests	SF1	Kermadec pōhutukawa forest
Warm temperate: Mean summer temperature 17.5–22.5°C [Warm forests]	Semi-arid	Coastal hillslopes and hillcrests	WF1	Tītoki, ngaio forest
		Recent alluvial terraces with free-draining stony and alluvial soils	WF2	Tōtara, matai, ribbonwood forest
		Hillslopes and hillcrests	WF3	Tawa, tītoki, podocarp forest
	Sub-humid	Coastal hillslopes and hillcrests	WF4	Pōhutukawa, pūriri, broadleaved forest [Coastal broadleaved forest]
		Stable dunes with free-draining recent sandy soils	WF5	Tōtara, kānuka, broadleaved forest [Dune forest]
		Stable dunes of the Foxton (>100 years old), Motuiti (500 years old) and Waitarere (2000–3000 years old) phases, with free-draining recent sandy soils	WF6	Tōtara, matai, broadleaved forest [Dune forest]

Literature, expert knowledge

ECOSYSTEM UNIT CODE AND NAME	DESCRIPTION	DISTRIBUTION (BOTH CURRENT AND HISTORIC), WITH EXAMPLES AND COMMENTS	REFERENCES
SF1: Kermadec pōhutukawa forest	Broadleaved forest of abundant Kermadec pōhutukawa of two variants: 1. dry forest with an understorey of *Myrsine kermadecensis*, *Coprosma acutifolia* and *Piper excelsum* subsp. *psittacorum*; and 2. humid forest with māhoe and an understorey of *Ascarina lucida* var. *lanceolata* in association with *Rhopalostylis baueri* var. *cheesemanii*, *Homalanthus polyandrus* and *Pseudopanax kermadecensis*.	Restricted to the subtropical and frost-free Kermadec Island group (e.g. Raoul Island). Dry forest is the dominant type, while humid forest occurs within gullies and on the upper (often cloud-covered) hillcrests of Raoul Island. Secondary derivatives occur on some islands (e.g. Macauley Island).	Sykes (1977) and Wardle (1991: 432–436). Includes rare ecosystems: recent lava flows (<1000 years old); cloud forest; coastal cliffs on acidic rock; and seabird-burrowed soil (Williams et al. 2007).
WF1: Tītoki, ngaio forest	Broadleaved forest of tītoki, ngaio, māhoe, five-finger, red māpou, kaikōmako, kōwhai, akeake and akiraho, locally occasional matai, tōtara and kahikatea, and locally nīkau, tawa and rewarewa in northern and central part of range.	Eastern coastal areas of the North Island and South Island from Nuhaka (Wairoa District) to Kaikoura, and in semi-arid areas south to Banks Peninsula. Largely only secondary derivatives remain, often dominated by karaka (though this is likely of anthropogenic origin; Stowe 2003).	Not covered by Nicholls (1976), but equivalent to general hardwoods class. Wardle (1971), Wardle (1991: 384), Wilson (1992: 111 & 276–277), Maxwell et al. (1993), Moore (1999) and Whaley et al. (2001).

Expert-based system – ‘azonal’ ecosystems

Wetlands

Outcrops

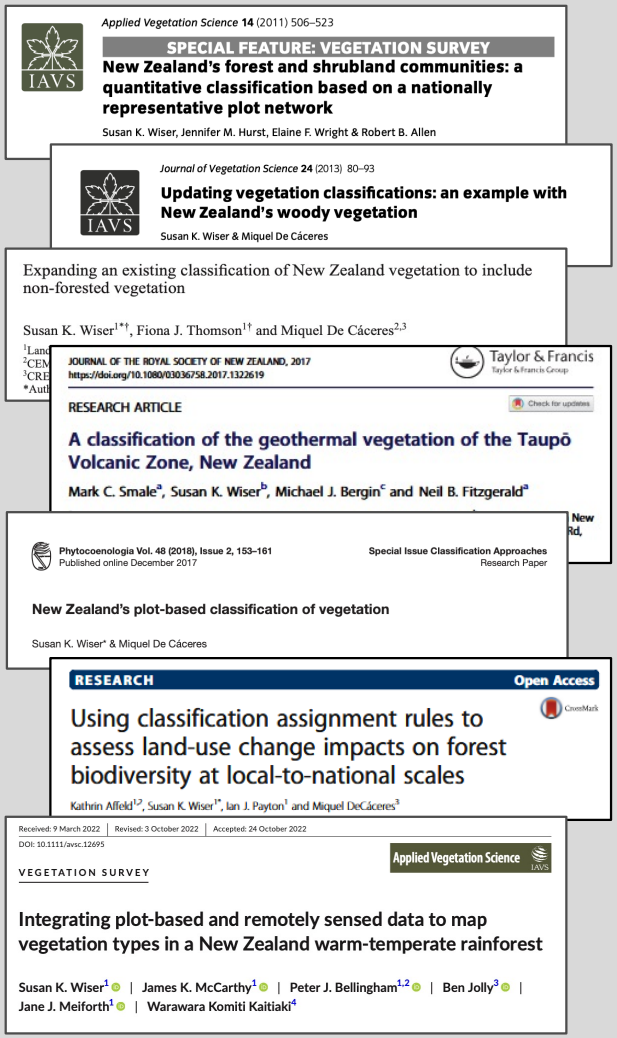
Geothermal

Table A2.2. Azonal ecosystems. The primary drivers for these ecosystems are A. high water tables, B. geomorphic disturbance, C. extreme soil and/or atmospheric chemistry, D. geothermally extreme heat and chemistry, E. light limitation, and F. anthropogenic fire.

A

PRIMARY ECOSYSTEM DRIVER: HYDROLOGY	SECONDARY ECOSYSTEM DRIVER: FERTILITY	TERTIARY ECOSYSTEM DRIVER: TEMPERATURE	QUATERNARY ECOSYSTEM DRIVERS: LANDFORMS AND SOILS	ECOSYSTEM UNIT CODE	ECOSYSTEM UNIT NAME
Permanent or seasonally high water table [Wetlands]	Oligotrophic—low nutrient status and high acidity [Bogs]	Warm temperate	Hillslopes and depressions with kauri podzols, e.g. Wharekohe or Te Kopuru soils	WL1	Mānuka, gumland grass tree, *Machaerina* scrub/sedgeland [Gumland]
			Depressions or the lagg of raised bogs with organic soils	WL2	Mānuka, greater wire rush restiad rushland
			Raised bogs on in-filled lagoons/ river oxbows with deep organic soils	WL3	Bamboo rush, greater wire rush restiad rushland
		Mild to cool temperate	Glacial moraines with strongly leached and acidic gley podzols (lacking peat), e.g. Okarito soils	WL4	Mānuka, lesser wire rush, tangle fern scrub/fernland/ restiad rushland [Pakihi]
			Depressions and raised bogs with organic soils	WL5	Chatham Island bamboo rush restiad rushland

ECOSYSTEM UNIT CODE AND NAME	DESCRIPTION	DISTRIBUTION (BOTH CURRENT AND HISTORIC), WITH EXAMPLES AND COMMENTS	REFERENCES
TI6: Red tussock tussockland	Tall tussock grassland of abundant red tussock with inter-tussock herbfield/short tussockland and prostrate shrub species. Early alluvial successions are dominated by short tussockland of *Poa*, *Festuca*, *Deyeuxia* and *Rytidosperma* species. Typically includes an embedded, complex mosaic of bog and fen wetlands on organic soils.	In the North Island, restricted to the volcanic plateau, from the Hauhungaroa Range south to Erua and the Kaimanawa Mountains on alluvial terraces and headwater basins, to southern Ruahine. In Northwest Nelson, occurs with wire rush (e.g. Gouland Downs and Thousand Acres Plateau) and with *C. rigida* in eastern Fiordland. Occurs on valley floors in Westland (e.g. Toaroha and Landsborough Rivers) and Fiordland (e.g. Takahe Valley).	Elder (1962: 22), Evans (1969a), Druce et al. (1987), Wardle (1991: 226), Grove (1994), Mark & Dickinson (1997) and Mark et al. (2003: 193 & 200–202). Includes rare ecosystem: frost hollows (Williams et al. 2007).
WL1: Mānuka, gumland grass tree, *Machaerina* scrub/ sedgeland [Gumland]	Low scrub, sedgeland of two broad types (poor-draining and seasonally dry), dominated by mānuka with gumland grass tree and tall mingimingi, and with species of *Machaerina*, *Schoenus*, *Gahnia*, *Tetraria*, *Lepidosperma* sedges and, locally, tangle fern.	Palustrine wetlands in the Northland and Auckland regions, developed in association with historic kauri forest podzolised Wharekohe and Te Kopuru soils (Molloy 1998: 92–94). Poor-draining type occurs on Wharekohe soils, while seasonally dry type occurs on Te Kopuru soils. Vegetation type also occurs on fire-induced and highly leached, non-podzolised soils, and it is now difficult to determine which areas are natural or induced.	Esler & Rumball (1975), Dodson et al. (1988), Conning (2001) and Clarkson et al. (2011). Includes rare ecosystem: gumland (Williams et al. 2007).
WL2: Mānuka, greater wire rush restiad rushland	Scrub, restiad rushland, fernland, sedgeland of abundant mānuka, with greater wire rush, tangle fern, *Machaerinateretifolia* (e.g. *M. rubignosa*) and *Schoenus brevifolius*.	Palustrine wetlands in Northland and Waikato lowland plains (e.g. Motutangi Swamp—Northland, and Whangamarino) within bogs of approximately 1500–7000 years of age.	Elliot et al. (1983), Clarkson (1997) and Clarkson et al. (2004).

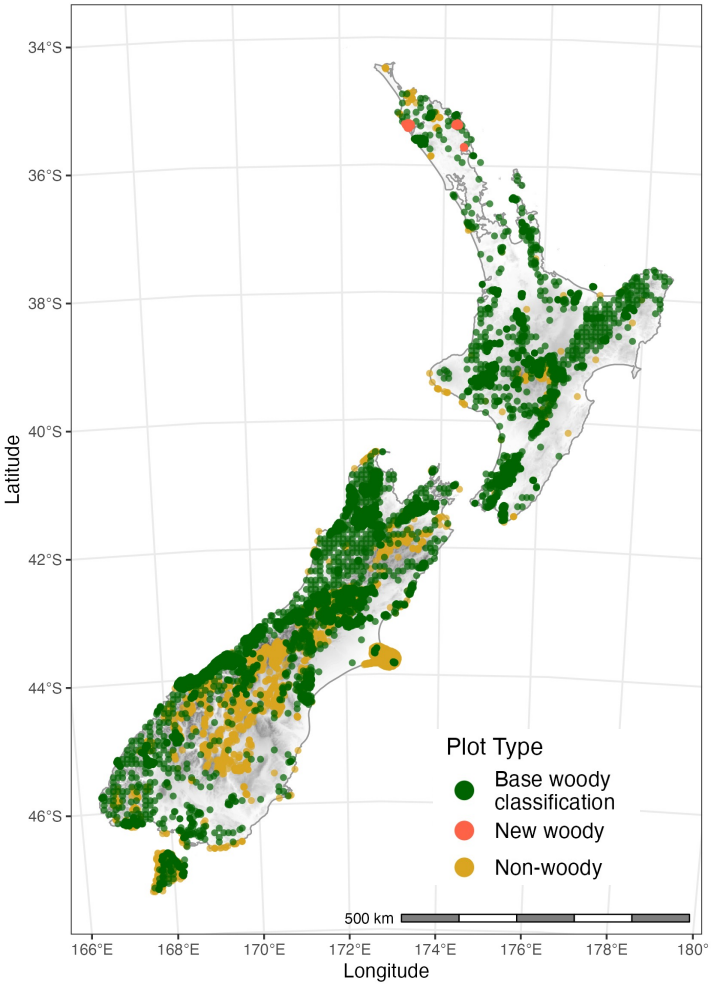


Quantitative plot-based system

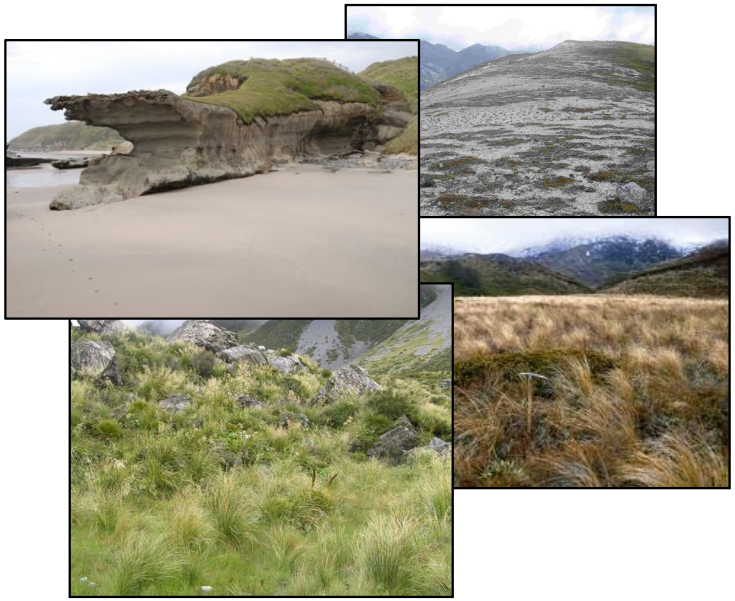
- Current ecosystem composition – includes human disturbance
- Goal to characterise current extent of ecosystems
- Guide management priorities
- Plot (point) based classification
    - Three Northland forests mapped

Quantitative plot-based system

Woody communities
- **14,607** plots
- **29** alliances
- **91** associations



Non-woody communities
- **5,907** plots
- **25** alliances
- **56** associations
- Includes some naturally uncommon ecosystems



Quantitative plot-based system

Appendix S5. Synoptic table of distribution and abundance of species any one alliance are listed. Constancy values ≥ 80% are l

	Raoulia grandiflora–Veronica pulvinaris–Anisotome imbricata–Dracophyllum pronum welfield	*Poa colensoi / Chionochloa oreophila–Celmisia ssiliflora–Celmisia haastii* grassland	*Poa colensoi / Luzula pumila–Raoulia hectorii* welfield	*Chionochloa crassiuscula–Schoenus pauciflorus–Poa colensoi / Astelia linearis* sockland	*[Chionochloa pallens] / Poa colensoi–Celmisia*
Alliance	GF2	G6	GF1	T1	
Dracophyllum pronum	76	+	.	+	
Veronica pulvinaris	96	+	+	.	
Anisotome imbricata	91	+	+	+	
Gentianella luteoalba	89	.	.	.	
Gentianella luteoalba	89	+	+	.	
Raoulia grandiflora	100	82	64	+	
Celmisia sessiliflora	.	87	+	+	
Celmisia haastii	.	86	.	+	
Chionochloa oreophila	.	86	.	+	
Phyllachne colensoi	+	81	68	+	
Marsippospermum gracile	.	64	.	+	

Black/mountain beech forest (subalpine)

Mountain beech with abundant [Coprosma pseudocuneata] in the understorey. Arthur's Pass National Park.

Where does it occur? This 219 000...

FACTSHEET

Black/mountain beech - silver beech forest/subalpine shrubland

[Nothofagus solandri] – [Nothofagus menziesii] / [Coprosma pseudocuneata] – [Hymenophyllum multifidum] forest. Cobb Ridge, Kahurangi Nati...

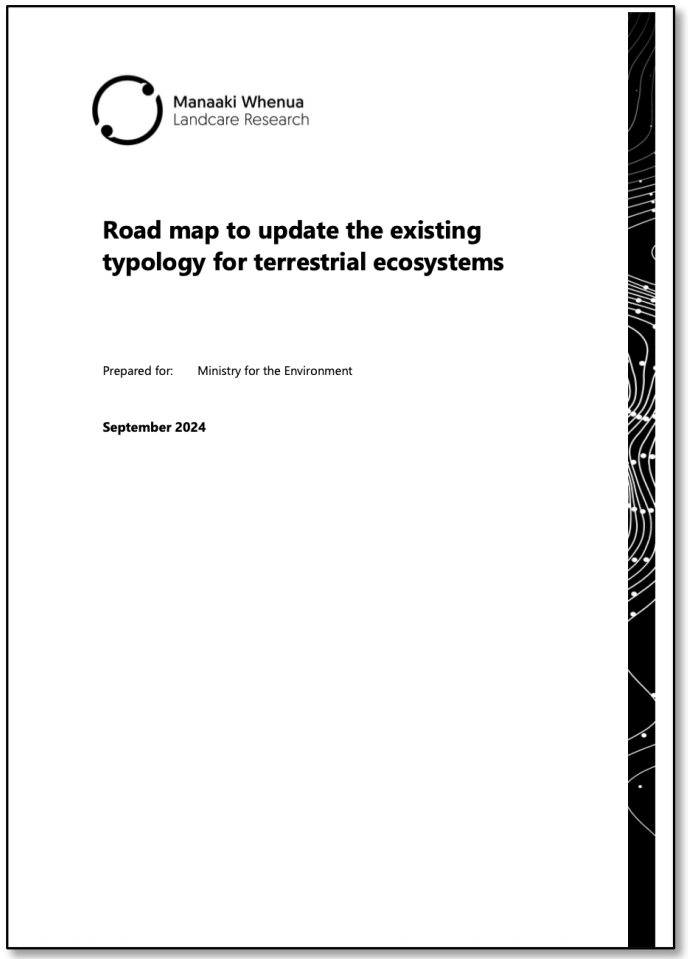
FACTSHEET

How to achieve a national ecosystem typology

Terrestrial

Expert-based system		Quantitative plot-based system
✓	• Hierarchical	~
~	• Mappable	✓
✓	• Updateable	✓
~	• Comprehensive	X
X	• Reproducible	✓
~	• Robust …	✓

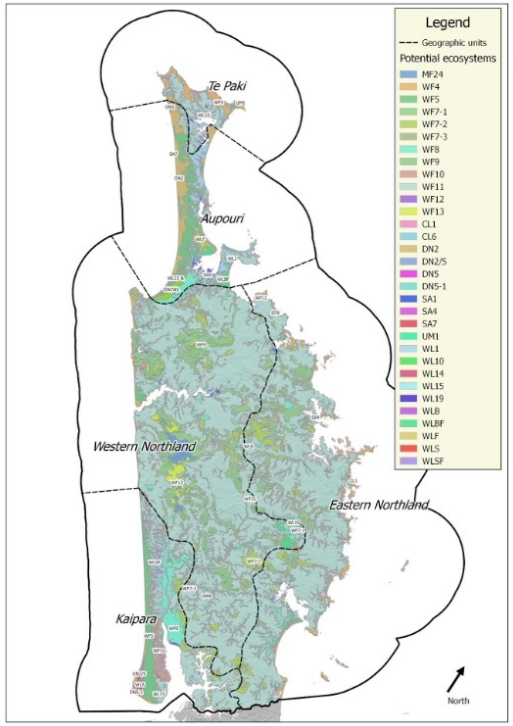
Terrestrial road map

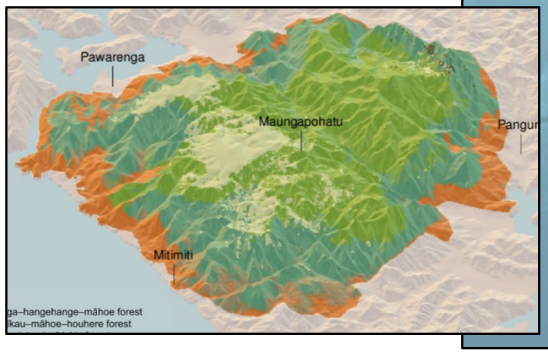


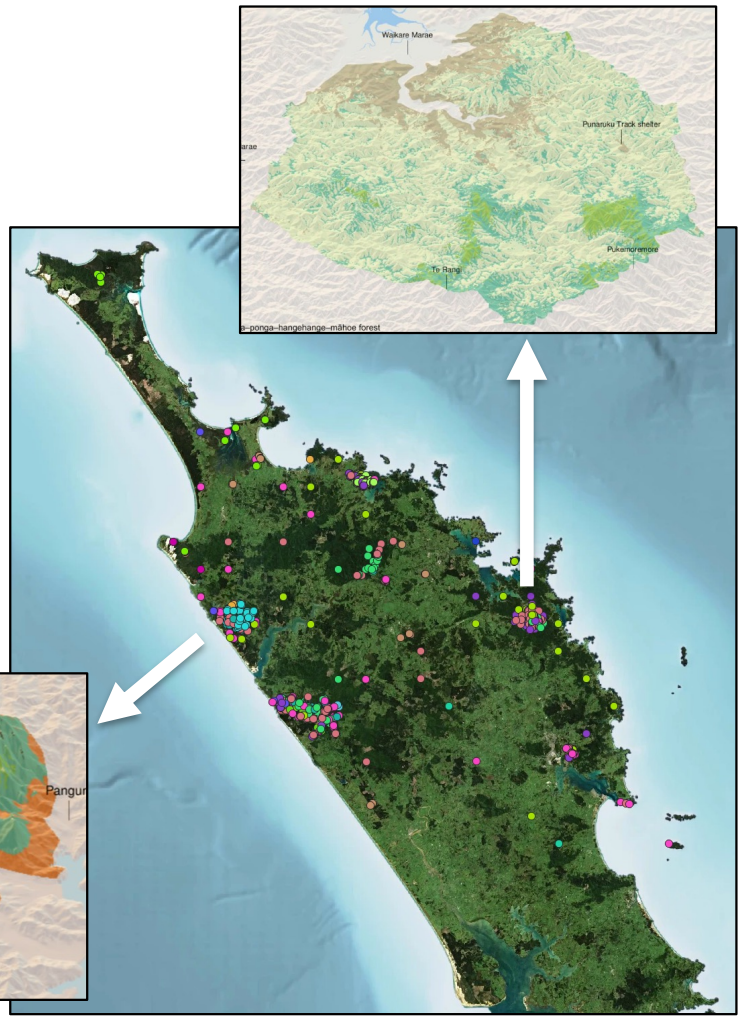
https://environment.govt.nz/assets/publications/Road-map-to-update-the-existing-typology-for-terrestrial-ecosystems.pdf

Pilot study in Northland

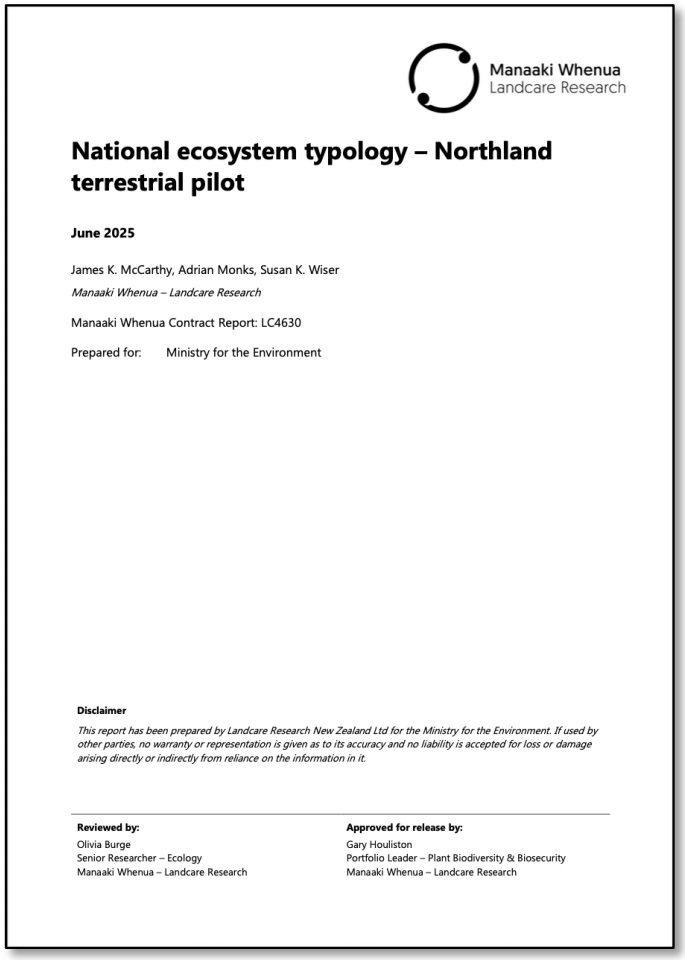
- High diversity of species and ecosystems
- 'Potential' extent mapped with expert system
  - 37 types
- ~550 plots classified with quantitative system
  - Five alliances
  - 20 associations
- Forests mapped with quantitative system ('actual' extent)







Pilot study in Northland



Manaaki Whenua
Landcare Research

National ecosystem typology – Northland terrestrial pilot

June 2025

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Manaaki Whenua Contract Report: LC4630

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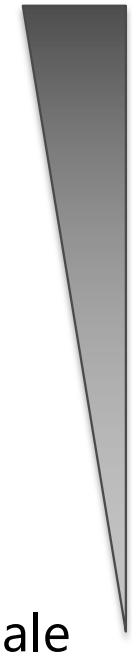
https://environment.govt.nz/assets/publications/science/LC4630_Northland-typologies-report.pdf

Assign types to levels of the EcoVeg hierarchy

Coarse scale



Fine scale

IVC hierarchy	Example (Faber-Langendoen et al., 2014)
Upper	
L1—Formation Class	Shrub & Herb Vegetation
L2—Formation Subclass	Temperate & Boreal Grassland & Shrubland
L3—Formation	Temperate Grassland & Shrubland
Mid	
L4—Division	Central North American Grassland & Shrubland
L5—Macrogroup	Central Lowlands Tallgrass Prairie
L6—Group	Central Tallgrass Prairie
Lower	
L7—Alliance	Central Mesic Tallgrass Prairie
L8—Association	Mesic Loam Tallgrass Prairie

Faber-Langendoen et al. 2025. Advancing the EcoVeg Approach as a Terrestrial Ecosystem Typology. Ecosphere 16(5): e70237. https://doi.org/10.1002/ecs2.70237

Assign types to levels of the EcoVeg hierarchy

Level 8 Association:
Black beech forest with broadleaf and Coprosma *species*

Level 7 Alliance:
Black/mountain beech forest

Level 6 Group:
Undefined

Level 5 Macrogroup: Undefined

Level 4 Division:
Undefined

Image: David Keith

Level 3 Formation:
Oceanic Cool Temperate Rainforest

Image: David Keith

Level 2 Formation Subclass:
Temperate Forest & Woodland

Image: Anne Raunio

Level 1 Formation Class:
Temperate-Boreal Forest & Woodland

Assign types to levels of the EcoVeg hierarchy

Examples, expert-based system:

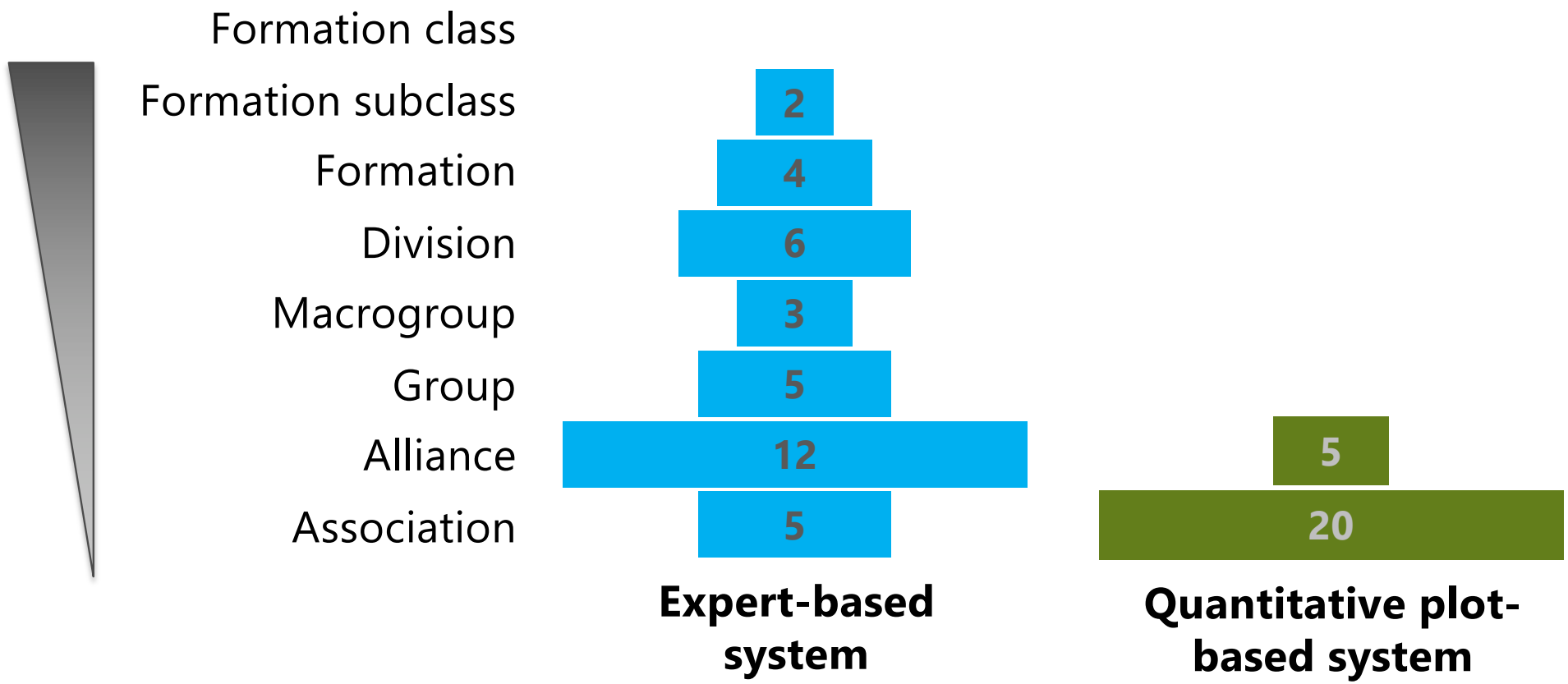
Code	Name	Description	Assignment
WF11	Kauri, podocarp, broadleaved forest	Kauri, podocarp, broadleaved forest with occasional rimu, miro, kahikatea, kauri, taraire, tawa, tōwai, kohekohe, pūriri and rewarewa. Altitude variants occur, with taraire and kohekohe more abundant at lower altitudes, and tawa and tōwai more common at higher altitudes.	Alliance (described as having altitudinal variation that influences composition)

Assign types to levels of the EcoVeg hierarchy

Examples, expert-based system:

Code	Name	Description	Assignment
WL10	Oioi restiad-rushland/ reedland	Restiad rushland with abundant oioi, locally with large *Machaerina*, *Bolboschoenus* spp., kuta and lake clubrush, and often with occasional raupō and scattered harakeke grading into wetland scrub on margins.	Level 4: Division (predominantly growth forms and genera used in the name and description)

Assign types to levels of the EcoVeg hierarchy



‘Crosswalk’ to define relationships between types of each classification

- Also called “cross-referencing”, “mapping”, “translation”…
- Defines relationships between typologies: crosswalking identifies how categories in one ecosystem typology correspond to those in another
- The outcome can be several one-to-one, one-to-many, or many-to-many matches

Crosswalks

Examples, expert-based system:

Code	Name (expert)	Match 1 (quantitative)	Match 2 (quantitative)
WF8	Kahikatea, pukatea forest	No match: **1.0**	
WF13	Tawa, kohekohe, rewarewa, hīnau, podocarp forest	a: BLP4 (Tawa – kāmahi forest – pigeonwood forest with silver fern), **0.65**	No match: **0.35**
WL1	Mānuka, gumland grass tree, *Machaerina* scrub/sedgeland [Gumland]	A.S8:a1 (*Leptospermum scoparium*/ *Gleichenia* spp.– *Baumea teretifolia* shrubland), **1.0**	

Crosswalks

Quantitative plot-based system → expert-based system

- 18 (out of 20) types had some level of matching with the expert-based system
- More often matched to expert types outside Northland

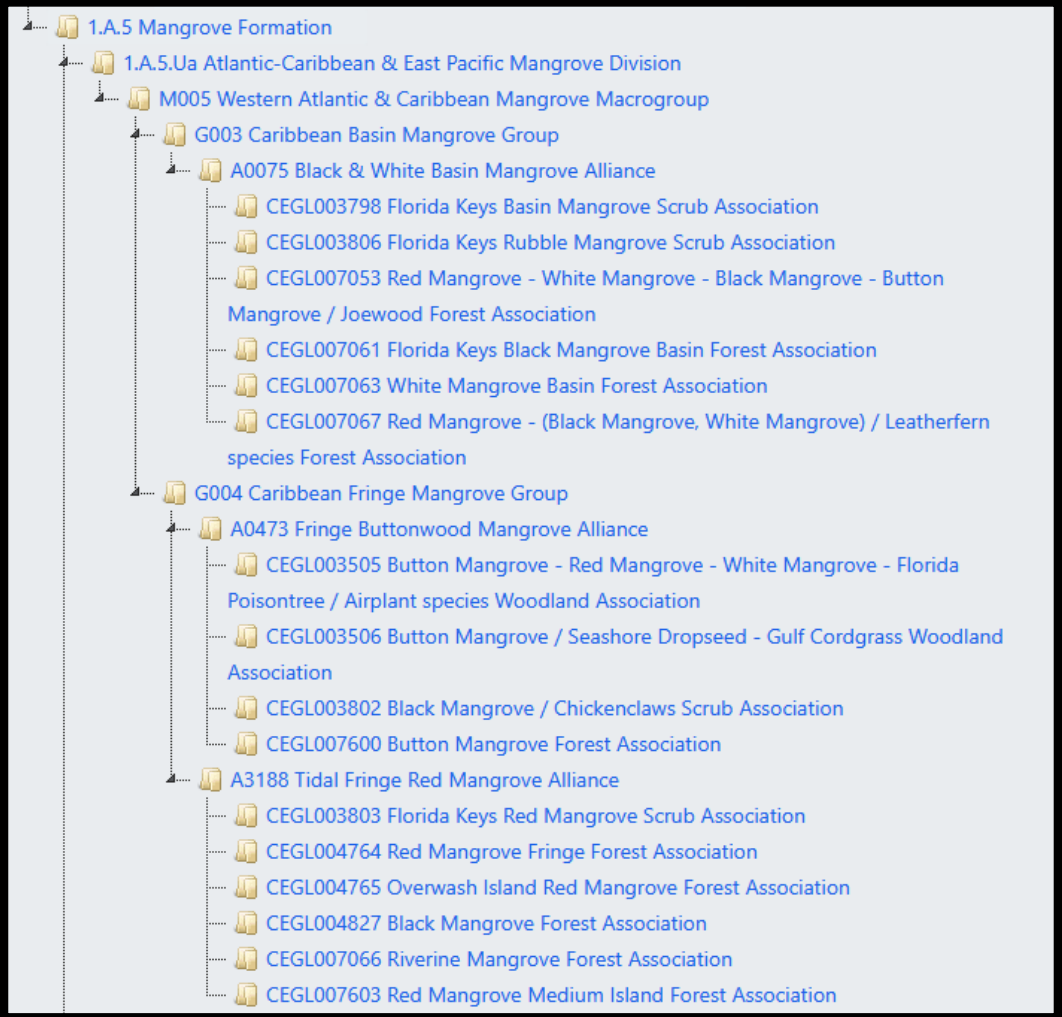
Expert-based system → quantitative plot-based system

- Six (out of 34) types had some level of matching with the quantitative system

Common to both: single expert-based types matching to several quantitative types

Northland catalogue

How can we use our results to produce a ‘catalogue’ of defined types in Northland?



US National Vegetation Classification (https://usnvc.org/explore-classification/)

Northland catalogue

- Formation
  - Division
    - Macrogroup
      - Group
        - Alliance
          - Association **a:S6**
- Formation
- Formation
- Formation **GT2**
- Formation
- Formation
  - Division
    - Macrogroup **WL18**
      - Group
        - Alliance
          - Association
- Formation
  - Division
    - Macrogroup
      - Group
      - Group **WF8**
      - Group **WF9**
        - Alliance
          - Association **a:BL7**

Types/associations with no analogues

a:S6 **a:BL7**

WF5 **WF7** **WF8** **WF9**
MF24 **MF4**
WL11 **WL12** **WL10** **WL3**
WL14 **WL15** **WL18** **WL19**
WL20 **WL2**
CL1 **CL6** **CL10**
SA1 **SA4** **SA7**
DN2 **DN5**
UM1 **GT2**

Northland catalogue

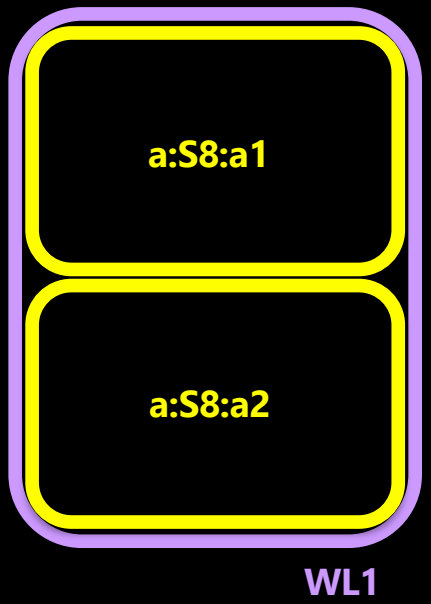
- Formation
  - Division
    - Macrogroup
      - Group
        - Alliance
          - Association
          - Association
- Formation
- Formation
- Formation
- Formation
- Formation
  - Division
    - Macrogroup
      - Group
        - Alliance
          - Association
- Formation
  - Division
    - Macrogroup
      - Group
      - Group
      - Group
        - Alliance
          - Association

WL1

a:S8:a2

a:S8:a1

Associations included within a single expert type



Where to from here?

- Complete catalogue for Northland ecosystems
- Repeat pilot in another region – somewhere in New Zealand with very different ecosystems to Northland
- Improve spatial and ecological coverage of the quantitative plot-based system – existing data (wetlands?) and new data
- Review and test mapping approaches

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