Manaaki Whenua
Landcare Research

Road map to an updated ecosystem typology for wetlands

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Summary

What does this report cover?

New Zealand is seeking to implement the International Union for Conservation of Nature (IUCN) Global Ecosystem Typology (GET) for a number of domains (Collins 2024; Sprague & Wiser 2024). This report covers the wetlands domain, and what modifications to the status quo might be needed for New Zealand wetlands to be incorporated under the IUCN GET. Wetlands are considered by the IUCN GET under several biomes. These include the palustrine wetlands biome (IUCN TF1) and the artificial wetlands biome (IUCN F3), but there are also overlaps with other wetland ecosystems, such as estuarine, riverine, and lacustrine systems.

For the purpose of this typology wetlands are defined broadly, using the Ramsar Convention definition (Ramsar Convention Secretariat 1971):

> areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.

However, the recommendations are restricted to a subset of wetlands to reduce redundancy between other domains, such as marine and freshwater.

Which typologies does this report assess?

The primary wetland typology used in New Zealand is that described in Johnson & Gerbeaux 2004 (hereafter referred to as 'the Johnson & Gerbeaux typology'). This typology builds on previous work and has been incorporated into regional monitoring programmes. The precursor work to this current road map (Collins 2024) also made it clear that Johnson & Gerbeaux is the 'preferred' typology. Johnson & Gerbeaux is widely used for inland palustrine wetlands, and the wetland classes within it are used in historical wetland mapping (Ausseil et al. 2011).

There is a wetland typology specifically for parties to the Ramsar Convention on Wetlands[1] (of which New Zealand is one). It comprises 20 inland wetland classes, 12 coastal and marine classes, and nine artificial classes (described in Denyer & Robertson 2016, Appendix 4). However, it has been determined that the Ramsar schema is not as applicable at a national scale as the Johnson & Gerbeaux typology (Denyer & Robertson 2016).

There is also a vegetation-only, expert-driven classification for New Zealand that includes wetlands (Singers & Rogers 2014). This is not widely used for classifying wetland types and has some disadvantages set out in the 'Road map to update the existing typology for terrestrial ecosystems' (McCarthy & Wiser 2024). In light of these two factors it is not

[1] The Convention on Wetlands is the intergovernmental treaty that provides the framework for the conservation and wise use of wetlands and their resources (https://www.ramsar.org).

considered further here, although is recommended to be used as part of the 'gap filling' process.

In response to stakeholder feedback and the recent development of an international framework for terrestrial and wetland systems, I also reviewed and considered the ecosystem-based International Vegetation Classification (e-IVC) as a framework for a national typology.

Other typologies, such as those that cover estuaries in relation to transitional ecosystems, will be relevant but are not explicitly considered here.

Assessing the typologies against the agreed principles

A set of end-user principles and requirements ('the principles') were developed during collaborative workshops (described in Collins 2024). Having assessed the Johnson & Gerbeaux typology against these principles, I consider it to be a comprehensive way of describing the abiotic drivers of wetland ecosystems. It is a semi-hierarchical typology that does not include a delimited biotic component but does provide for the addition of biotic descriptors following the open-ended Atkinson structure and composition protocol (see Atkinson 1985).

However, the Johnson & Gerbeaux typology's omission of wetland biota as a finite set means that in many cases the principles are not met, hindering its implementation at a national scale in a way that is consistent with the preferred IUCN GET (Keith et al. 2020; Sprague & Wiser 2024).

In contrast, the ecosystems-based e-IVC framework is designed for ecosystem classification and therefore meets criteria the Johnson & Gerbeaux typology does not. The e-IVC therefore has the potential to satisfy at least some of the principles, subject to national-level implementation, which means alignment with the principles will depend on its implementation.

Do the candidate typologies align with the IUCN GET?

Alignment of wetland vegetation communities from the New Zealand flora with the IUCN GET is not possible using the Johnson & Gerbeaux typology because it does not classify vegetation into compositional groups. This is a major impediment to applying the IUCN GET at a national level.

The e-IVC has been designed to align with the IUCN GET, albeit subject to implementation at lower levels. The e-IVC allows for more 'levels' of classification than the IUCN GET, which may be useful for providing national flexibility. At higher levels there is a reasonably good fit between pre-existing e-IVC levels and IUCN GET Level 3 classes.

What are the next steps for a national ecosystem typology in this domain?

I recommend that New Zealand adopt the approach of the e-IVC for wetlands, as well as for other terrestrial systems. The critical next steps include creating a data-driven compositional classification, with a subsequent expert elicitation process for gap-filling.

The Johnson & Gerbeaux typology can still be used as a method to describe wetland classes, and it is likely that classes named according to the Atkinson method will be able to be assigned to the e-IVC typology that will be created for wetlands. This preserves the value of historical and current investment and effort in the Johnson & Gerbeaux typology.

Governance and stakeholder liaison work is also recommended, which will be critical for the success of the e-IVC for wetlands in New Zealand.

1 Introduction

New Zealand is seeking to implement the International Union for Conservation of Nature (IUCN) Global Ecosystem Typology (GET) for a number of domains (Collins 2024; Sprague & Wiser 2024). The goal of this work was to create a road map that leads towards a domain-level ecosystem typology for wetlands that would fit within a 'global' typology of all the ecosystems in New Zealand,[2] while simultaneously being useful for national reporting and conservation planning. I was provided with principles ('the principles') against which each domain-level typology should be assessed.

There are several typologies that might be relevant. There is a specific Ramsar typology for wetlands (the Convention on Wetlands), but Denyer and Robertson (2016) determined that this is not easily applicable at the national scale. The Ramsar classification system comprises 20 inland wetland classes, 12 coastal and marine classes, and nine artificial classes (described in Denyer & Robertson 2016, Appendix 4). There is also a vegetation-only, expert-driven classification for New Zealand that includes wetlands (Singers & Rogers 2014). This is not widely used for classifying wetland types and has some disadvantages set out in the terrestrial domain report (McCarthy & Wiser 2024). In light of these two factors it is not considered further, although is recommended to be used as part of the 'gap filling' process.

I was asked to assess the Johnson & Gerbeaux wetland typology (Johnson & Gerbeaux 2004). This typology (see Figure 2) has hydrosystem class at the highest level (level I), then descends to subsystem (level IA), wetland class (level II), wetland form (level IIA), vegetation structural class (e.g. forest, shrubland; level III) and finally a method for naming the dominant species (level IV). The typology has extensive uptake in New Zealand.

The Johnson & Gerbeaux typology is a semi-hierarchical typology that does not include a *classification* for biotic composition. Which is to say, it does not classify vegetation composition (or fauna) into a constrained number of classes, which means the typology is unlikely to facilitate classification of wetland ecosystems within New Zealand as envisaged by the IUCN GET. This aspect notwithstanding, it does provide a way of *describing* the abiotic environments that drive much of the variation among wetlands in New Zealand, and provides a naming (but not classification) system for dominant species and structural class, using the Atkinson method (Atkinson 1985). The IUCN GET is clear in its guidance that national-level classifications should be defined from the bottom up, not the top down, and should use on-the-ground observations and compositional information to do so (Keith et al. 2020). The lack of a biotic classification component also means that the Johnson & Gerbeaux typology does not meet many of the principles set out for assessment.

Stakeholder feedback (see Acknowledgements) highlighted the need for a biotic classification component that allows different levels of detail of groupings, depending on the individual case. Very recent work has also been undertaken describing how the current International Vegetation Classification (IVC) might be adapted to provide an international framework for classifying ecosystems for the purposes of the IUCN GET. The IVC is based on an approach called EcoVeg

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[2] Including offshore islands like the Chatham Islands

and has been applied as a multi-scale approach across the Americas and Africa (Faber-Langendoen et al. 2018).

This recent work (Faber-Langendoen et al., submitted) has resulted in the e-IVC, or ecosystems-based International Vegetation Classification. Faber-Langendoen et al., who present the e-IVC, specifically restrict this approach to terrestrial and transitional freshwater (i.e. wetlands) domains, as follows:

> **Explicit Terrestrial and Wetland Transitional Realms**: The EcoVeg approach and the IVC largely encompassed terrestrial vegetation, including wetlands but was not explicit in doing so. Here we now follow the GET in explicitly recognizing the Terrestrial Realm and Wetland Transitional Realms as distinct from Freshwater, Marine, and Subterranean realms, and we exclude aquatic vegetation. By aquatic, we mean essentially permanent open water bodies with no emergent vegetation. Ecosystems that only ever have floating and submerged macrophytes are out of scope (e.g. seagrass beds, freshwater submerged vegetation). Ecologists interested in classifying freshwater or marine aquatic vegetation should treat those types in the freshwater or marine realms, for which the GET provides global Biome types.

It is my revised recommendation that New Zealand adopt the e-IVC approach for the wetland transitional realm (as above) as a *classification* of relevant wetland ecosystems, but retain the Johnson & Gerbeaux typology for domestic purposes when *describing* wetlands, including those that do not fall within the wetland transitional realm. This approach allows continued use of the Johnson & Gerbeaux typology, where appropriate, but also provides a pathway towards a multi-level classification schema that meets international standards and the criteria outlined in Collins 2024, and is highly interoperable with the terrestrial (non-wetland) domain).

This final benefit is highly desirable from a conservation perspective, as most wetland loss occurs where wetlands are replaced with dryland ecosystems (e.g. Denyer & Peters 2020). A classification schema that is highly interoperable with the terrestrial domain will facilitate improved understanding of the drivers and locations of wetland loss, and will thereby empower efforts to reduce such loss.

The draft report proposed having a hybrid classification in New Zealand of biota (two levels, e.g. Alliance and Association), and mapping these to the high levels of Johnson & Gerbeaux (e.g. wetland class), with some revision of Johnson & Gerbeaux to better meet the principles and for better consistency with IUCN classes. However, in addition to feedback about more levels, there was stakeholder feedback that Johnson & Gerbeaux (2004) is useful 'as is'.

Therefore, instead of proposing a hybrid approach, this report recommends that:

- Johnson & Gerbeaux be retained as is, as a parallel system for *describing* the range of wetlands and as an interim measure to classify wetland *classes* in New Zealand (e.g. bog, fen, etc) for broad reporting, and to describe structural classes.
- New Zealand adopt and implement the ecosystem-based International Vegetation Classification as a way to provide a multi-scale approach to classification at different levels.

This will provide a robust, internationally accepted way for New Zealand to classify palustrine wetland ecosystems that is interoperable with the terrestrial domain. Figure 1 provides a conceptual map of coverage by domain.

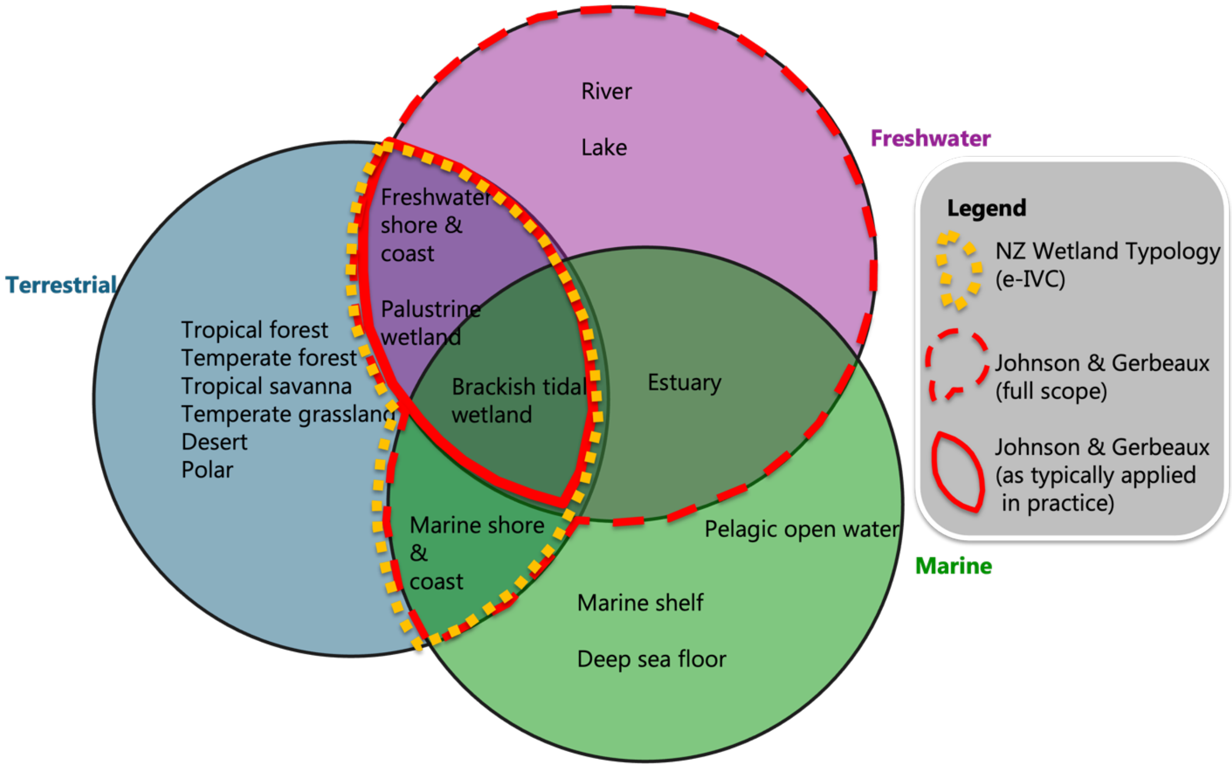

Figure 1. A conceptual map of the terrestrial, freshwater, and marine domains, and coverage of each typology.

Notes: The e-iVC proposes covering the entire terrestrial domain. The e-IVC for wetlands is delineated by the yellow polygon, while the conceptual coverage of Johnson & Gerbeaux is shown by the red dashed polygon. The coverage of Johnson & Gerbeaux as implemented is narrower, and is shown by the red polygon covering the topics freshwater shore & coast, palustrine wetland, and brackish tidal wetland. The rivers, lakes, estuaries, and marine domain reports cover the remainder of the marine and freshwater domains; the terrestrial report covers the non-wetland elements of the terrestrial domain.

Some stakeholders raised concerns about whether compositional data were essential for developing a classification schema in addition to information about vegetation structure. Other stakeholders identified clear use cases and the need for compositional information.

Among both groups there was interest in how using plot-based compositional data could work alongside expert-driven systems in practice. A combination of data and expert information sources would help to achieve the 'best of both worlds' and the unique benefits that come with both sources of information. Data-sourced typologies are robust evidence for classification units (Jennings et al. 2009) and provide a strong basis for reporting, while expert evidence incorporates New Zealand ecological expertise and experience, particularly for data-poor ecosystems, avoiding the need for delays due to incomplete data. This approach would be conceptually similar to the 'best of both worlds' approach undertaken for the terrestrial domain (albeit customised to the requirements of the wetland domain).

Previous work clearly demonstrates that compositional information will be required to fulfil proposed applications of any classification system. Sprague and Wiser (2024), in their overarching report, state that:

> Robust and data-driven typologies are needed for reporting on ecosystem integrity, connectivity, and resilience nationally and internationally in the post-2020 Kunming-Montreal Global Biodiversity Framework. (United Nations Statistics Division 2024)

Ecosystem integrity requires a consideration of five key components, which were addressed in a recent report for the Ministry for the Environment on potential attributes of ecological integrity in New Zealand (Berthelsen et al. 2022). The five components are ecological representation, composition, structure, function, and resilience. All of these – except structure – require knowledge of vegetation composition in order to make an assessment.

Another purpose of a classification schema might be red listing of ecosystems. The IUCN guide to ecosystem red listing (Bland et al. 2015) notes that collapse can be indicated by systems that have moved outside their natural range of variability in terms of composition, structure, and/or function. Units for red listing require the characteristic native biota to have been described, such that units can be compositionally distinguished from one another, and in order to describe the ecosystem dynamics and function, and the functional components. Composition is clearly a key component, although the required descriptions are not required to be exhaustive species inventories. Botts et al. (2020) provide the first published account of the process of red listing under the IUCN schema, using national-level vegetation types (i.e. incorporating composition) as their ecosystem unit.

It is acknowledged that different applications of a classification might need different levels of resolution. The e-IVC classification schema has the benefit of incorporating composition (and varying degrees of precision in composition) where an application requires it, while also providing the flexibility to move to coarser levels where precision is not required. Looking internationally, it is clear that different levels of compositional resolution are appropriate for different purposes, or different countries, but that the majority occur at the level of IVC 5 ('macro-group') or below and therefore incorporate composition.

2 Objectives

- Assess the Johnson & Gerbeaux wetland typology against the principles provided.
- Assess the Johnson & Gerbeaux typology against the IUCN Global Ecosystem Typology (IUCN GET).
- After stakeholder feedback, an additional objective was considered necessary: assess the ecosystem-based International Vegetation Classification against the principles.
- Provide a set of recommendations for establishing a wetland typology for New Zealand that is consistent with the principles and with the IUCN GET.

3 Methods

3.1 Assessing how well the existing typology meets the principles and requirements

The principles and requirements (hereafter shortened to 'the principles') were reviewed by the wider project team during a workshop on 29 May 2024. These were clarified with the project steering group after discussion among the domain leads and overall project leads. The principles (and project team members) are set out in Sprague & Wiser 2024.

First, I reviewed the principles (see Appendix). Next, I reviewed the Johnson & Gerbeaux typology (Johnson & Gerbeaux 2004).[3] I then undertook a systematic assessment of the Johnson & Gerbeaux typology against the principles.

The Johnson & Gerbeaux typology is semi-hierarchical and has four levels, although two of these levels are split into two parts (Figure 2). After feedback I also reviewed the ecosystem-based International Vegetation Classification (e-IVC) against the principles. While this is still in preparation, it is extremely similar to the original International Vegetation Classification (IVC), which is discussed in the Introduction.

[3] Available from: https://www.doc.govt.nz/globalassets/documents/science-and-technical/wetlandtypes.pdf).

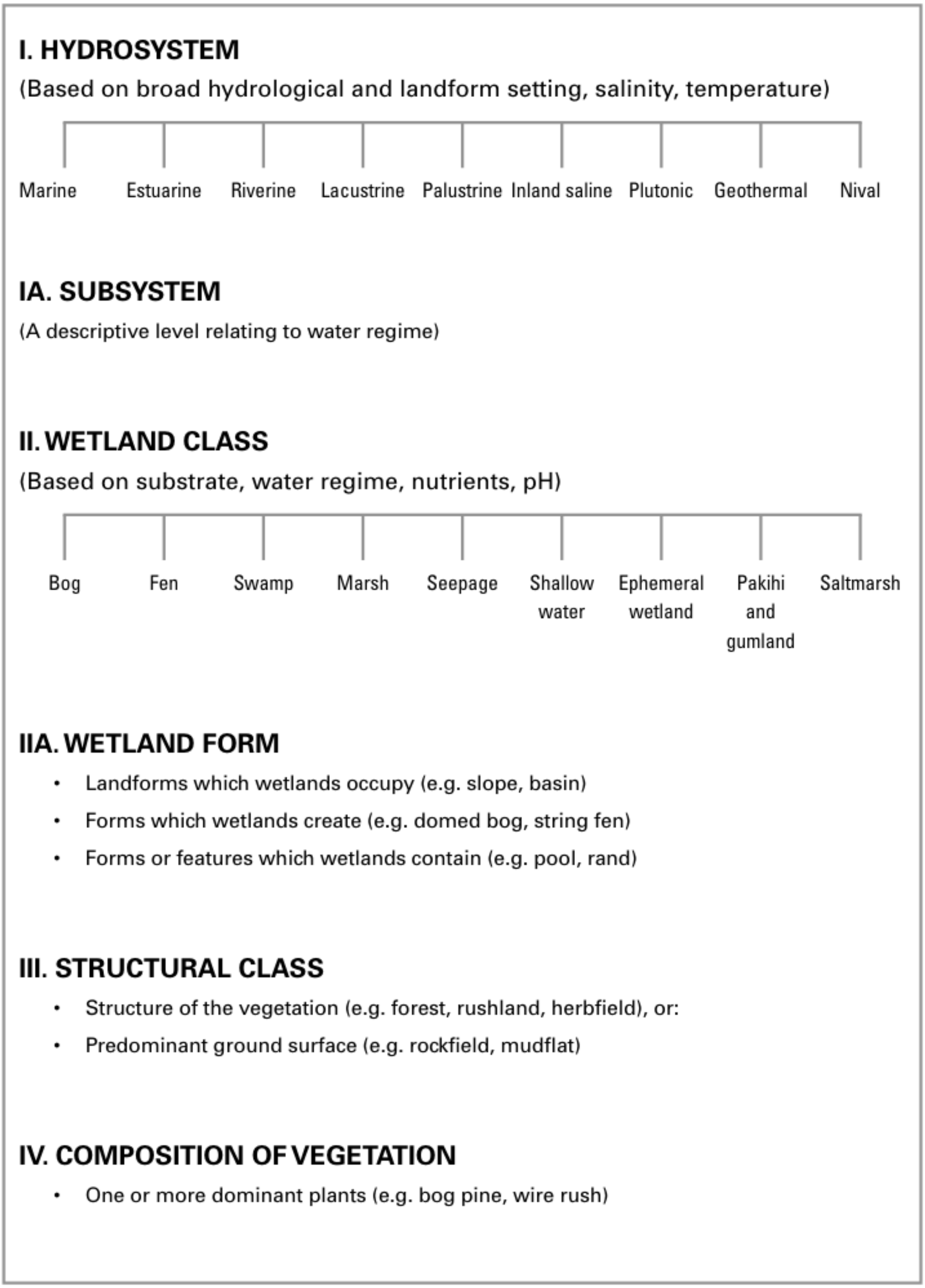

Figure 2. Structure of the Johnson & Gerbeaux wetland typology. (Source: Johnson & Gerbeaux 2004) Notes: Levels IA, IIA, and IV are neither circumscribed nor nested within higher classes, and as such a near-infinite number of combinations is possible. Experienced users are aware of which combinations are possible due to field experience, however, the number of possible combinations makes the typology suitable for describing wetlands, but not for classifying ecosystems with a view to prioritising for conservation purposes.

Here I give some background to the e-IVC system. The IVC is applied using Eco-Veg (Faber-Langendoen et al. 2014, 2018) and is a hierarchical approach to vegetation classification. The terrestrial domain report (McCarthy & Wiser 2024) recommends Level 8 for primary use in New Zealand:

> It is not mandatory to populate all levels of the hierarchy. The most critical unit for New Zealand will be 'Level 8 – Association', defined as 'A characteristic range of species composition, diagnostic species occurrence, habitat conditions and physiognomy. Associations reflect topo-edaphic climate, substrates, hydrology, and disturbance regimes.' This is equivalent to the granularity of many of the zonal ecosystem units of the expert based system[4] and the associations of the quantitative plot-based system, although this remains to be confirmed. … To develop higher levels that are functionally based, clustering would be based on growth forms and functional traits of species rather than on species identity. This is consistent with EcoVeg Levels 4 and 5 and would facilitate linkage to the IUCN GET Level 3 EFGs.

The current EcoVeg/IVC levels are set out in Table 1, and then again in Table 2 alongside a demonstration of the applications of each level, where these exist. The e-IVC proposes minimal changes to the IVC itself.

[4] McCarthy and Wiser (2024) are referring to the Singers and Rogers system here.

Table 1. Existing EcoVeg/IVC levels

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Table 2. Levels, definition, and example of the hierarchy for natural vegetation.

Natural hierarchy	Definition	Example names	
		Scientific	Colloquial
Upper levels			
L1: Formation class	A broad combination of dominant general growth forms adapted to basic moisture, temperature, and/or substrate or aquatic conditions.	Mesomorphic Shrub and Herb Vegetation	Shrub and Herb Vegetation
L2: Formation subclass	A combination of general dominant and diagnostic growth forms that reflect global mega- or macroclimatic factors driven primarily by latitude and continental position or that reflect overriding substrate or aquatic conditions.	Temperate and Boreal Shrub and Herb Vegetation	Temperate and Boreal Grassland and Shrubland
L3: Formation	A combination of dominant and diagnostic growth forms that reflect global macroclimatic conditions as modified by altitude, seasonality of precipitation, substrates, and hydrologic conditions.	Temperate Shrub and Herb Vegetation	Temperate Grassland and Shrubland
Mid levels			
L4: Division	A combination of dominant and diagnostic growth forms and a broad set of diagnostic plant species that reflect biogeographic differences in composition and continental differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.	*Andropogon–Stipa–Bouteloua* Grassland and Shrubland	Great Plains Grassland and Shrubland
L5: Macrogroup	A moderate set of diagnostic plant species and diagnostic growth forms that reflect biogeographic differences in composition and subcontinental to regional differences in mesoclimate, geology, substrates, hydrology, and disturbance regimes.	*Andropogon gerardii–Schizachyrium scoparium–Sorghastrum nutans* Grassland and Shrubland	Great Plains Tallgrass Prairie
L6: Group	A relatively narrow set of diagnostic plant species (including dominants and codominants), broadly similar composition, and diagnostic growth forms that reflect regional mesoclimate, geology, substrates, hydrology, and disturbance regimes.	*Andropogon gerardii–Heterostipa spartea–Muhlenbergia richardsonis* Grassland	Northern Great Plains Tallgrass Prairie
Lower levels			
L7: Alliance	A characteristic range of species composition, habitat conditions, physiognomy, and diagnostic species, typically at least one of which is found in the uppermost or dominant stratum of the vegetation. Alliances reflect regional to subregional climate, substrates, hydrology, moisture/nutrient factors, and disturbance regimes.	*Andropogon gerardii–Sporobolus heterolepis* Grassland	Northern Mesic Tallgrass Prairie
L8: Association	A characteristic range of species composition, diagnostic species occurrence, habitat conditions, and physiognomy. Associations reflect topo-edaphic climate, substrates, hydrology, and disturbance regimes.	*Andropogon gerardii–Heterostipa spartea-Sporobolus heterolepis* Grassland	Northern Mesic Big Bluestem Prairie

Note: The name of the level can be added to the type name for clarity, where needed.

Source: Faber-Langendoen et al. 2014

Notes: Faber-Langendoen et al. (submitted), in explaining the adaptation of the IVC for IUCN GET purposes, note small changes to the top three levels but that no changes are proposed below (and including) the level of 'Division'. They suggest that IUCN GET Level 3 is equivalent to IVC Level 3 'Formation', and that IUCN GET Level 6 is equivalent to IVC Levels 6, 7, and 8.

Table 2. The current EcoVeg (IVC) levels, and conservation applications in which they have been used

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Table 2. Examples of applications of the CNVC, USNVC and IVC. See also Franklin et al. (2015).

	EcoVeg Level	Applications
Upper	Level 1 – Formation Class	
	Level 2 – Formation Subclass	1. U.S. Army Corps of Engineers – Stewardship (FGDC 1997) (USNVC) 2. "Gap analysis" of protected area representation for Canada, USA, and Mexico (in part) using international land cover classes
	Level 3 – Formation	1. Ecological Integrity Assessment (Environmental Protection Agency – National Wetland Condition Assessment, NatureServe, State Natural Heritage Program) Fish and Wildlife Service (USNVC) 2. Status and Trends of Wetlands in the Coastal Watersheds of the Conterminous United States (National Marine Fisheries Service) (USNVC) 3. Natural Hazards and Cultural Transformations (NSF-Supported Research Grant). Human Relations Area Files, Yale University, New Haven CT (IVC)
Mid	Level 4 – Division	1. Ecoregional Distribution – grasslands (NatureServe, World Wildlife Fund) (IVC)
	Level 5 – Macrogroup	1. Forest Assessment (US Forest Service Forest Inventory and Analysis Program) (USNVC) 2. Regional Assessments (U.S. Bureau of Land Management, NatureServe) (USNVC) 3. Ecosystem Red List of Americas (NatureServe, IUCN) (IVC) 4. Continental Mapping (NatureServe – North America, Latin America, Africa (with USGS)) (IVC) 5. Biodiversity Indicators Dashboard, Aichi Biodiversity Targets, Convention on Biological Diversity (NatureServe) (IVC) 6. Vegetation Zones of Canada (in part) (CNVC)
	Level 6 – Group	1. Natural Resource/Wildlife Habitat Inventory (U.S. National Park Service Vegetation Inventory Program, Northeast Association of Fish & Wildlife Agencies, Western Governors Association Initiative, State Natural Heritage Programs) (USNVC) 2. Ecological Integrity Assessments (U.S. Fish and Wildlife Service, U.S. National Park Service, NatureServe, State Natural Heritage Programs) (USNVC) 3. Forest Assessment (U.S. Forest Service Forest Inventory and Analysis Program) (USNVC) 4. Vegetation composition, structure, and wildfire fuels modeling (LANDFIRE) (USNVC) 5. National Mapping (U.S. Geological Survey – GAP Analysis Program, LANDFIRE) (USNVC) 6. Ecosystem Red List of terrestrial ecosystems in temperate and tropical North America (NatureServe) (IVC)
Lower	Level 7 – Alliance	1. National Park mapping (U.S. National Park Service Vegetation Inventory Program) (USNVC) 2. Natural Resource/Wildlife Habitat Inventory (California Fish & Game / California Native Plant Society) (state level use of USNVC)
	Level 8 – Association	1. U.S. National Park Service Vegetation Inventory Program, State Natural Heritage Programs (Natural Resources Inventory) (USNVC) 2. Rare Plant Communities (The Nature Conservancy, NatureServe, State Natural Heritage Programs, Conservation Data Centres) (USNVC, CNVC) 3. National Forest Inventory (NFI) – incorporation of CNVC type information in NFI reporting.

Source: Faber-Langendoen et al. 2018

Notes: As noted above, Faber-Langendoen et al. (submitted) propose that the IUCN GET Level 3 is equivalent to IVC Level 3 'Formation', and that IUCN GET Level 6 is equivalent to IVC Levels 6, 7, and 8.

Potential application of the e-IVC levels in New Zealand might look like the following (with specific examples taken from the EU and USA, given the lack of New Zealand classification):

a Level 1 Realm: Terrestrial-Freshwater (other systems may fall in Marine-Freshwater-Terrestrial) and therein: Palustrine Wetland (also Supralittoral Freshwater Coast in Terrestrial Freshwater)

b Level 2 Sub-biome: Forested wetland; emergent open wetland; bog & fen; shallow water wetland; developed freshwater shoreline

c Level 3 Formation: Boreal & temperate fen; inland salt marsh; boreal, temperate & montane peat bog; marsh, wet meadow, & shrub wetland (etc.)

d Level 4 Division: (none exist yet for NZ; but as an example from EU]: Western Eurasian Marsh, Wet Meadow & Shrub Wetland

e Level 5 Macrogroup: Phragmito-Magnocaricetea ('Reed swamp, sedge bed and herbland vegetation of freshwater or brackish water bodies and streams of Eurasia')

f Level 6 Group: (not from EU, but instead the USA) West Gulf Coastal Plain Nonriverine Wet Hardwood-Pine Flatwoods

g Level 7 Alliance: *Typhion laxmannii* Nedelcu 1968 ('Subsaline reed swamp vegetation of the upper littoral of the continental lakes of Eastern and southeastern Europe')

h Level 8 Association: *Phragmitetum australis*, *Typhetum latifoliae* (from Landucci et al. 2020).

3.2 An assessment of how the Johnson & Gerbeaux typology maps to the IUCN GET

I undertook a cross-walk using the levels of wetland class and vegetation from Johnson & Gerbeaux (Figure 2) to assess fit with the IUCN GET, and the results are presented in Figure 3. I could not undertake a biota-based cross-walk because the Johnson & Gerbeaux typology does not provide a biota-based classification. The lack of a biotic classification component means the Johnson & Gerbeaux typology does not meet many of the principles set out for assessment.

3.3 Developing a road map of steps to amend, merge or replace the existing typology to meet the principles and align with the IUCN GET

I met with key stakeholders on 20 June 2024. The following invitations were based on suggestions made by the project steering group: Ministry for the Environment representative Andy Hicks, and Department of Conservation representative Hugh Robertson. Beverley Clarkson (Manaaki Whenua – Landcare Research) and Philippe Gerbeaux (consultant) were also invited.

At the meeting we discussed the results of the review of the Johnson & Gerbeaux typology against the principles, and the cross-walk of the typology to the IUCN GET, as outlined in this document. Key issues discussed were the lack of a biotic component to the existing classification and the need to consider landform and/or irreplaceability, and proposed pathways forward. We agreed on key steps, which formed the basis of the previous road map.

In addition, Hugh Robertson gave feedback on an earlier draft of this report. A revised group of stakeholders was then formed to give feedback on the draft report. The revised group comprised Karen Denyer (Papawera Geological), Andy Hicks (MfE), Hugh Robertson (DOC), and Helen White (Greater Wellington Regional Council). A meeting with stakeholders was held in December 2024, and feedback was provided in January 2025. Key conceptual or 'big picture' feedback, and responses to it, are described below. More specific feedback has been incorporated directly into this report.

Table 3. Summary of stakeholder feedback provided in January 2025, and responses made

Feedback	Response	Recommendation	References
Fine-level composition won't be required for all purposes.	Agree there should be a 'stepping stone' between wetland class (e.g. IUCN GET Level 3 and Johnson & Gerbeaux wetland class), and fine-grained compositional classes. Composition required for IUCN GET.	Adopt the e-IVC method, which provides a stepped hierarchy of compositional detail and has been applied to many conservation use cases.	Faber-Langendoen et al. (submitted.) Faber-Langendoen et al. 2014, 2018
Is a data-driven approach necessary?	Data-driven approaches are preferred, as discussed in the terrestrial ecosystem report (McCarthy & Wiser 2024). Discussing the US approach to vegetation classification at finer scales, Jennings et al. (2009) recommend that standardised field plot data be used, and that Associations and Alliances defined where plot data are incomplete or not readily available be classified as low classification confidence. They note that the National Vegetation Classification (USA) requires plot data.	Data-driven approach recommended.	
What have other countries used?	Recent work indicates multiple countries have used the IVC, and have applied it at different levels of resolution depending on the question at hand.	Refer Table 2.	Faber-Langendoen et al. 2014, 2018
Johnson & Gerbeaux 'works' at present	Agree there is high utility (and familiarity and capacity) in Johnson & Gerbeaux for describing wetlands and key abiotic drivers. However, at finer scales it is clear that the naming approach of Atkinson (1985) for structural classes and dominant species does not support a classification approach and leads to an unworkable number of named classes if applied across New Zealand for the purposes of IUCN GET.	Retain Johnson & Gerbeaux as is, as a schema to describe *all* wetland types in New Zealand. Do not use for classification purposes. Adopt the e-IVC to the extent recommended within the e-IVC (broadly speaking, terrestrial wetlands). This ensures interoperability with the terrestrial domain. Defer to other typologies for rivers, and estuarine systems with no emergent vegetation. Review regularly to ensure no wetlands are 'left out' of coverage of ecosystem typologies in New Zealand.	

Feedback	Response	Recommendation	References
Waiting for a complete data-driven classification will cause us to lose valuable time for conservation purposes	A robust framework that is interoperable for the terrestrial domain within New Zealand, and international schemas (including Australia), is worth trading off against speed.	A pragmatic approach is suggested that builds on the current expert-driven system while a data-driven approach is developed.	
Structural classes should be sufficient for IUCN GET purposes	When assessing which level of the IVC was used for which conservation purpose, it was found that no application used structural class alone. Note that several levels of the e-IVC 'look like' the Atkinson naming approach (e.g. one or several diagnostic species and a structural descriptor); however, the difference lies in the underlying approach.	Recommend that structural class alone not be used for conservation purposes. Recommend the e-IVC be used as a robust approach that is consistent with international schemas and the New Zealand terrestrial biome.	Faber-Langendoen et al (2018). See also Table 2 for a summary of which level of the IVC was used for which conservation purpose, and Table 1 for examples of the e-IVC.

4 Results

4.1 An assessment of how well the Johnson & Gerbeaux typology meets the principles

Overall, the Johnson & Gerbeaux typology is a comprehensive way of describing the abiotic drivers of wetland ecosystems, and resulting wetland classes. The critical omission, for the purposes of the IUCN GET, is a classification that includes wetland biota. This means that in many cases the principles are not met – in particular, the principles relating to comprehensiveness, interoperability across domains and typologies, and New Zealand specificity. The IUCN GET 2.0 documentation (Keith et al. 2020, p. 3) defines ecosystem classifications as follows (emphasis in bold added):

> Ecosystem classifications are specific kinds of ecological typologies based on units that conform to the definition of ecosystems (e.g. ecological units that comprise **a biotic complex**, an abiotic complex, **the interactions between and within them**, and occupy a finite physical space (Keith et al. 2013).

The IUCN GET also envisages that the lower levels of the typology (Levels 5, and 6) are 'aggregated from bottom up' and are to be 'derived directly from ground observations' (Keith et al. 2020). This indicates compositional data, as reflected by the e-IVC approach, which implements the IUCN GET.

Therefore, except at one of the broadest levels (IUCN GET Level 3), the biotic component of Johnson & Gerbeaux is insufficient to consider it an ecosystem classification. This means Johnson & Gerbeaux is insufficient as a typology, and revision of it would only allow compatibility at the coarsest level of international reporting (IUCN GET Level 3); applications at the national scale require a biotic classification.

Below I give a narrative summary of the overall fit between the Johnson & Gerbeaux typology, the e-IVC, and each principle. A concise, tabular summary of the principles compared to the Johnson & Gerbeaux typology and the e-IVC is provided in the Appendix.

Principle 1: A hierarchical structure

The Johnson & Gerbeaux typology is an environmental (abiotic) typology that is imperfectly nested and only semi-hierarchical. As part of this project, Sprague and Wiser (2024) noted that it was unusual for a hierarchical classification schema not to constrain the number of combinations each category might have. Essentially, under Johnson & Gerbeaux there is a large number of potential combinations of hydrosystem, wetland class, wetland form, and structural class, which suggests that Johnson & Gerbeaux is a descriptive method rather than a typology of possible wetlands at fine scales.

For example, under the hydrosystem 'Marine' it should be possible to constrain the wetland classes that may occur (e.g. peat bogs are not foreseen to be a possible marine wetland class), and it should also be possible to constrain the number of wetland forms that occur (e.g. string fen is not foreseen to be a possible marine wetland form). While experienced practitioners will be able to use their experience and knowledge to group combinations into 'possible' and 'not possible', for robustness, it would be preferable for IUCN GET purposes for a classification system to be more nested.

The e-IVC is designed to be hierarchical and therefore meets this principle. A hierarchical approach must be adopted during national implementation to ensure this principle is supported; for example, by explicitly aggregating upwards from the lowest national levels, as recommended in McCarthy & Wiser 2024.

Principle 2: Spatially explicit

The Johnson & Gerbeaux typology is mapped *coarsely* at a national scale, using superseded data (e.g. the genetic soils classification), as described in Ausseil et al. 2011. The minimum polygon size is 0.5 ha, whereas current mapping being undertaken by regional councils on non-public conservation land is an order of magnitude finer (minimum size 0.05 ha). This, while appropriate for the data sources in the layer, is biased towards under-representing wetlands that are naturally small, such as seeps.

The Ausseil et al. 2011 mapping is also mapped *coarsely* in terms of the Johnson & Gerbeaux typology itself. Of six levels it is typically only mapped using one, wetland class, and within that class only eight of the nine wetland types (typically saltmarsh is excluded). There is also a historical layer that maps to wetland class (Ausseil et al. 2011), but this approach has similar limitations to the current mapping method. The historical layer is being revised through case studies to derive an updated method that accounts for developments in mapping such as LiDAR (author's observation).

New Zealand's Land Cover Database (LCDB) (MWLR 2020) includes more recent wetland mapping of some land-cover classes (such as 'Herbaceous freshwater vegetation') that are clearly wetland, and a wetland context indicator for classes such as 'Indigenous forest' that could be terrestrial or wetland. However it does not include the Johnson & Gerbeaux wetland classification of wetland class.

Some LCDB classes could be cross-walked to structural classes[5] and subsequently combined with other spatial layers of wetland class in an attempt to cross-walk to IUCN GET Level 3. However, this approach would not meet the requirements of a classification that includes composition (cf. structure). It is therefore important to emphasise that all existing, national-scale mapping does not sufficiently include a biotic compositional component and therefore does not meet the principles relating to an *ecosystem* classification for national level implementation of the IUCN GET.

The e-IVC is purely a framework to be applied at the national level and has pre-existing classes at higher levels. The Ausseil et al. (2011) mapping could be cross-walked to an appropriate higher level of the e-IVC, with the same constraints as identified above that apply to Johnson & Gerbeaux.

Principle 3: Accommodates change

Many of the elements of this principle are not met by the Johnson & Gerbeaux typology. At the broader scale, a lack of repeated national-scale mapping of wetland class and structural class means this principle is also not met in terms of IUCN GET Level 3. Effectively, compositional shifts in vegetation cannot be accounted for, because composition is not mapped by the typology, and changes in terms of IUCN GET Level 3 cannot be accounted for because of the lack of updated wetland class information.

Further, while changes in wetland at the Johnson & Gerbeaux class level are possible (e.g. change from bog to fen with increased nutrient levels) it is generally unlikely over human life-spans. The most likely short-term changes that could be detected at the wetland class level are between shallow water and other types in response to changes in water level – including flood or drought events – and changes in highly dynamic systems such as dunelands.

The e-IVC accommodates changes within human time-scales at its finer levels.

Principle 4: Compatibility across domains and typologies

With respect to other domains, the Johnson & Gerbeaux typology notes that other work focuses on marine systems, particularly, and Johnson and Gerbeaux themselves note that they focus mainly on palustrine wetlands. Tools exist to distinguish wetlands from drylands (e.g. a rapid vegetation test based on aerial imagery, as per Clarkson 2014), but there is little formal guidance on differentiating wetland systems from estuarine or riverine because they intergrade.

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[5] For some classes it will be difficult to distinguish the proportion of forest and non-forest within the same class, such as classes including mānuka and kānuka.

There is no *classification* of wetlands according to biota (specifically flora) under the Johnson & Gerbeaux typology, and so the requirement for biotic names to follow a reference taxonomy is not relevant for our purposes. Nesting under IUCN GET can occur, but again, probably not at the resolution expected, because there is no classification of wetland vegetation composition under the Johnson & Gerbeaux typology.

The e-IVC framework has clear compatibility advantages: it is being applied to the terrestrial domain in New Zealand, and the underlying IVC framework has been applied internationally, including for wetlands. The e-IVC is designed for compatibility with the IUCN GET.

Principle 5: Robust

In general the Johnson & Gerbeaux typology is robust in terms of what it seeks to do, but because its classification of wetlands does not include an explicitly classified biotic compositional component, many of the subcomponents of this principle cannot be answered by assessing the typology.

For example, 'Is the number of units manageable?' is not a question unambiguously answered here: the answer will be 'yes' if structural class by wetland type is considered (although the answer is probably 'too few classes', because even at the broadest level of ecosystem integrity, native vs exotic dominance will be ignored), but the answer will be 'no, unmanageable because nearly infinite number of classes' if the Atkinson (1985) naming system is considered (see Principle 2.) The use of a naming system to classify biota by the dominant species and structural class is not robust with respect to international norms, and does not have the ability to assess metrics such as ecosystem integrity.

The e-IVC framework is considered to be robust, but final results will depend on implementation. It is clear that a plot-based, data-driven approach is the only way to achieve a 'high confidence' classification, and that 'moderate confidence' will be achieved with plot data of restricted geographical scope (Jennings et al. 2009).

Principle 6: Comprehensive

This principle is not met by the Johnson & Gerbeaux typology. Although biotic structure is considered implicitly in classifying wetlands, biotic composition is not. Also, there is a variable level of detail and a focus on palustrine wetlands. Some wetland types, such as nival and marine, are discussed only briefly. Fully aquatic systems, such as marine and some estuaries, could not be classified further than wetland class, as Atkinson naming criteria are not designed for naming fully aquatic communities.

Regional councils have previously identified challenges in ascribing wetland class using the Johnson & Gerbeaux typology in modified wtlands. MfE was able to fund a field guide to wetland type, including more images of non-pristine wetlands (Burge & Bartlam 2024) and a Lucid key (Burge 2024) to complement the book, but the Lucid key could be further updated to incorporate more quantitative data, as is typical for keys.

The e-IVC framework is considered to be comprehensive, but final results will depend on implementation and will require resourcing to ensure under-sampled communities are included:

firstly by expert elicitation, and then by targeted data collection, to improve confidence from 'low' to 'high'.

Principle 7: New Zealand-specific

A critical issue under this principle is the lack of biotic composition in classifying wetlands, although coarser biotic structure is considered. This point notwithstanding, the Johnson & Gerbeaux typology does include wetland types that are globally uncommon, such as geothermal wetlands. The e-IVC, once implemented, would be New Zealand-specific, because it would be driven by New Zealand data.

4.2 Assessment of how the existing typology maps to the IUCN GET

I could not test the fit of classified vegetation communities from the New Zealand flora to the IUCN GET because the Johnson & Gerbeaux typology does not classify vegetation. Instead, I tested combinations of level II wetland class and level III structural class, which would allow a cross-walk at the IUCN GET Level 3 (see Figure 3).

For non-forested wetlands there is a reasonable alignment between the IUCN GET and structural wetland classes for some Johnson & Gerbeaux classes. For other classes, such as marshes, subtypes of marshes (e.g. seepage and ephemeral wetland), and shallow water, the breadth of class means that multiple IUCN GET classes will apply, and it is not immediately apparent which will apply and in what proportion. Conversely, the salt marsh class is probably best dealt with under the marine–freshwater transitional classes (see Figure 3). However, in freshwater–saline water transitional settings it is likely that there will be an interface between these classes and the IUCN GET wetland classes.

One quirk of the IUCN GET treatment of wetland ecosystems is that the precision with which ecosystems are split depends on their structure. Forested wetlands in New Zealand occur across swamps, fen, and bog wetland types, and historically they were far more prevalent than they are today (McGlone 2009). All forested wetlands would fit into one IUCN GET category, 'Temperate & subtropical forested wetlands', yet across the same range of wetland types there are five IUCN GET categories into which non-forested wetlands might fit: permanent marshes,[6] seasonal marshes, episodic floodplains, peat bogs, and fens. It is not clear whether this aggregation is appropriate at this scale; further consideration is needed. However, the international levels are set by the IUCN. I suggest that after the national-scale typology is finalised, a reconsideration of how the national-scale units cross-walk to the IUCN GET Level 3 be undertaken, and thereafter, some feedback to the IUCN might be provided for their consideration.

[6] In New Zealand terms this equates to a 'swamp'. 'Swamp' has a different meaning in New Zealand compared to some other countries.

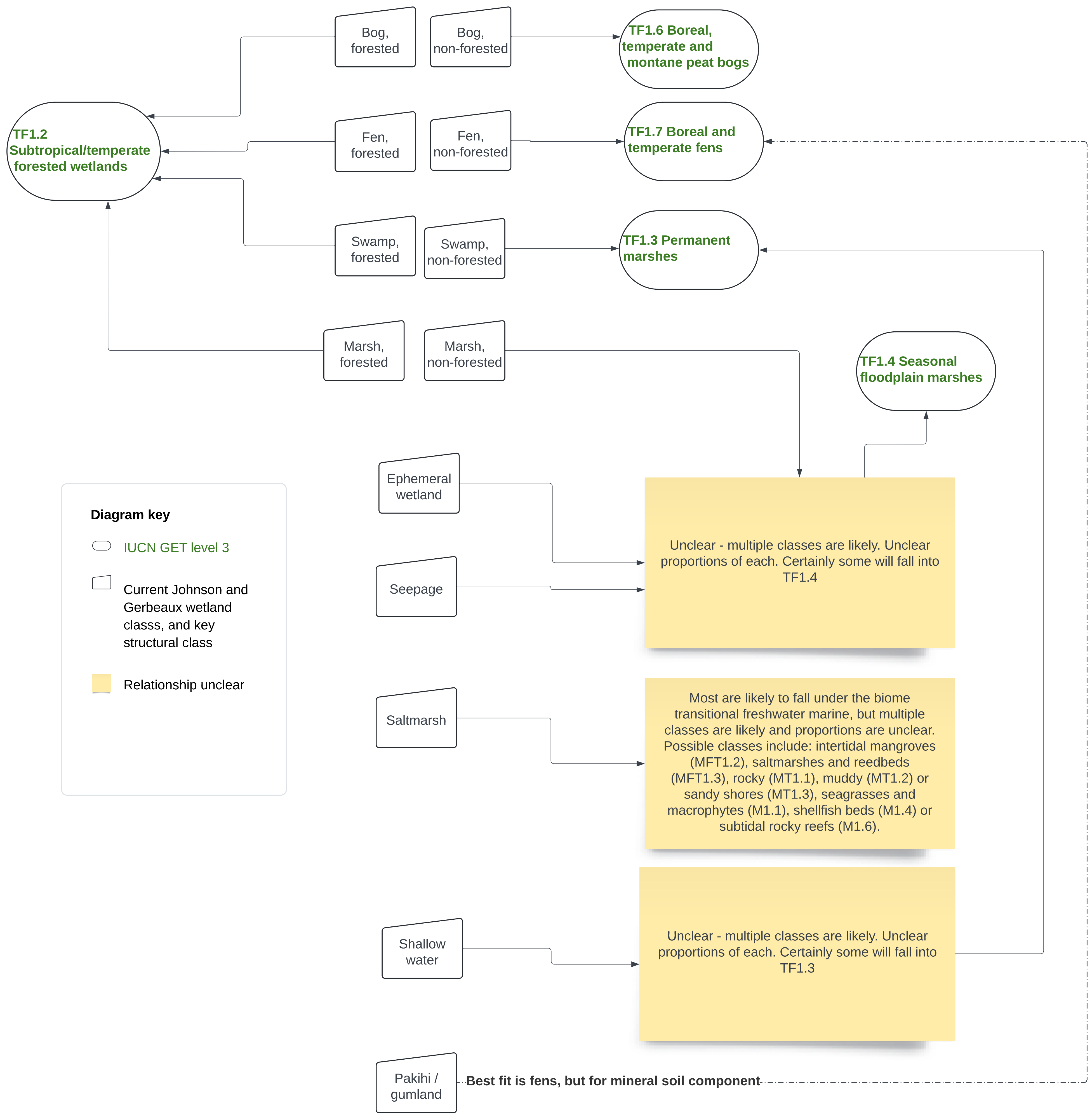

Figure 3. Preliminary cross-walk of existing Johnson & Gerbeaux wetland classes (level III), and structural classes (level IV), to IUCN GET Level 3. It is noted that after discussion with David Keith (lead author of the IUCN GET publications) prior to finalisation of this report, it is expected that a substantial proportion of New Zealand fens would also fall into IUCN GET bog category. These would be differentiated by vegetation composition and soil parameters, where available. Further work is required in this respect.

Notes: Two classes within the IUCN GET Level 3 for wetlands are considered not to apply in New Zealand: TF1.1 tropical flooded forests and peat forests, and TF1.5 episodic arid floodplains.

Multiple IUCN GET-level categories are likely to fit at least some vegetation types known to occur within New Zealand, depending on the resolution of the classification. For example, *Empodisma* spp. with a minor component of *Gleichenia* spp. can be found in both peat bogs and fens in New Zealand. This duality is not necessarily a problem if wetland ecosystem units (that include vegetation) are mapped. This is because wetland classes (per Johnson & Gerbeaux) are already mapped at a broad scale in New Zealand, and regional councils are required to map wetlands, and their types, down to 0.05 ha by 2030.

However, this requirement to map excludes public conservation land, and the national direction to councils regarding wetland mapping does not specify that type must include a biotic descriptor. It is unlikely that wetlands on non-protected land are representative of wetlands on protected land, in both type and condition. Combining mapped wetland classes with wetland vegetation ecosystem units would allow a spatially explicit estimation of how much each vegetation type falls within the IUCN GET categories, with the exception of public conservation land.

There are wetland classes in the Johnson & Gerbeaux typology that are probably best described as marshes at the broad level (e.g. ephemeral wetlands, seepages). This contributes to the 'many-to-many' outcome of the cross-walk. In any future revision of Johnson & Gerbeaux it would be worth considering whether it would be conceptually clearer for New Zealand to have a broad 'marsh' class, with relevant subtypes recognised within it. This would be consistent with the overall semi-hierarchical nature of the Johnson & Gerbeaux typology, and would make cross-walking a conceptually clearer process.

Finally, the Johnson & Gerbeaux typology does not include any anthropogenic elements, meaning that constructed or artificial wetlands are not accommodated in the typology. Although not all of the ecosystems listed under the artificial wetlands biome (IUCN F3) are necessarily a good fit for a wetland typology (some may be a better fit for a lakes typology, for example), it is clear that at least some artificial wetlands need to be included in a national wetlands typology for consistency with the IUCN GET.

The e-IVC is designed to accommodate the transitional freshwater ecosystems of the IUCN GET and can also accommodate cultural ecosystems. Cultural ecosystems are those that are planted and are dominated by human processes. This should allow for inclusion of anthropogenic wetlands such as constructed and restored wetlands. As such, all of the ecosystems in the palustrine wetlands biome (level 2 IUCN GET) are accommodated, as well as one from the marine biome (MFT1 Brackish Tidal Wetland).

4.3 Road map of steps to amend, merge, or replace the existing typology to meet the principles and align with the IUCN GET

While the Johnson & Gerbeaux typology has clear utility in terms of being a well-known, generally clear system to group wetlands by critical ecological drivers, it is also clear that the IUCN GET anticipates a bottom-up classification of vegetation (in the terrestrial and the transitional freshwater wetlands biomes) at a national scale. The development of an international framework (the e-IVC) that is designed for national uptake and is complementary to the IUCN GET is an ideal opportunity to align a finer-scale biotic classification to international practice and the New Zealand terrestrial biome. It is likely that substantial benefits will accrue from having the terrestrial and, broadly speaking, terrestrial wetlands under the classification system: for mapping, reducing duplication and overlap, and ease of comprehension for stakeholders interested in cross-system perspectives.

In Figure 3 a sequence of actions is suggested. The first substantive steps would be to classify wetland ecosystems at a fine scale; this has already occurred for the remainder of the terrestrial biome. A subsequent process would be to assess the vegetation associations found and undertake an expert elicitation process to create temporary associations until sufficient field data are available to transition to a fully quantitative system.

Next, it is necessary to aggregate to coarser levels of resolution, such that associations are nested within high-level groups. This will allow ecosystem mapping at a scale appropriate to data available. Finally, guidance will be critical for all stakeholders to provide confidence in the usage of the classification – whether that is by councils wanting to assign plot data to associations, by consultants seeking to map multiple wetlands at the 'group' scale, or by researchers seeking to map wetlands at a national scale to a finer level than currently, such as 'macro group'.

The road map also envisages governance and education steps to maximise stakeholder buy-in and uptake, and to maximise the consistency of national-scale typologies across domains.

I was asked to consider the relevance of Ministry for the Environment contract 2324-23-003 A to the next steps. This contract involved MWLR creating a short field guide to the wetland types of New Zealand (Burge & Bartlam 2024) as a portable complement to Johnson & Gerbeaux 2004. Also, a Lucid key was created under the contract in order to allow improved diagnosis of wetland types in New Zealand (Burge 2024). Like the field guide, this was intended to enhance application of the Johnson & Gerbeaux typology rather than forming a review and revision. As such, none of the work undertaken in contract 2324-23-003 A is a substitute for the tasks recommended here.

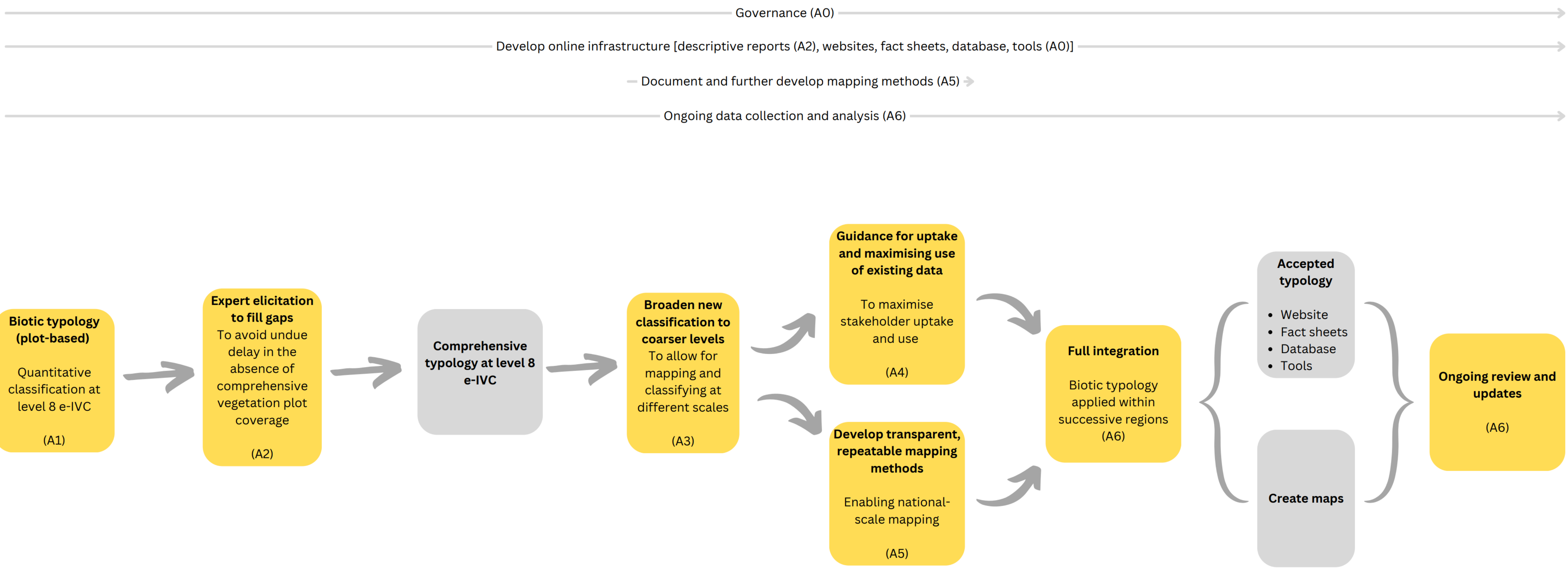

Figure 4. Suggested sequence of road map actions to achieve a wetland typology that applies at IUCN GET Levels 3, 5, and 6. Actions (described in detail in subsequent pages) are shown in brackets at the bottom of each box, where relevant: yellow boxes are actions, grey boxes are outputs.

Action 0 (overview action): Establish a structure for developing a classification that cross-walks efficiently to other domains

I wish to emphasise that representatives of several other domains consider there is no suitable pre-existing typology. This means there is an opportunity to design, from the outset, overarching guidance or a structure that will maximise interoperability between any developed typologies. It would be useful to establish a governance structure, process, and managed repository. In this regard I adopt Recommendation 2 from Sprague & Wiser 2024 and the suggested Action 0 from McCarthy & Wiser 2024:

> Establish a governance structure and process, and an accessible managed repository for ecosystem typologies, associated products and underpinning data.

A liaison group of domain leads should meet regularly for those who are actively undertaking work, and a funding mechanism should include provision for ensuring interoperability of classifications across domains. Finally, a stakeholder group specific to wetlands should be established to provide feedback on actions and at key decision points.

Key tasks

- Establish a national governance group across all domains.
- Establish a liaison group to ensure interoperability among domains.
- Establish a stakeholder group (i.e. a 'domain governance group', as per Sprague & Wiser 2024) for the wetland domain.
- Develop online infrastructure to support the revised typology (keys and fact sheets, a typology database system, maps).
- Develop tools to be hosted on online infrastructure to enable the assignment of plot data to created ecosystem types (data templates, R code, potentially a Shiny app for less technical users).

Action 1: Develop a biotic classification of wetlands: data driven, and based on an assessment of existing data coverage and transitional communities

A biotic classification of wetlands requires a review step to maximise consistency with other domains and to meet best practice internationally. A biotic, plot-based classification of wetlands would allow clear assignment of vegetation plots to communities and would be consistent with the relevant principles.

An extant classification trial at the level of Alliance is being undertaken by MWLR, with data from MWLR, multiple regional councils, and DOC's Arawai Kakariki programme. The resulting classification could be leveraged by adding on an assessment of data coverage and results coverage. I suggest that in this phase other parties be approached for recently collected data, or data not previously provided, before undertaking a revised classification at the finer scale of Association.

After this, descriptions and summary tables (often termed synoptic or constancy/abundance tables) for each unit should be created. These tables allow users to quickly grasp the commonalities and distinctions between the types, because they present the distribution and abundance of species with high dominance, frequency or diagnostic value in the types defined. These tables are common practice for data-driven classifications.

An ongoing task will be to collate information (metadata) about the availability of plot data to inform subsequent iterations of the classification, reducing reliance on lower-confidence expert elicitation (which is a temporary gap-filling step). Consideration should be given to whether data infrastructure should be developed to hold (a) plot data that inform the classification, and/or (b) metadata about data that may be used in a subsequent iteration of the classification.

Key tasks

- Assess coverage of in-progress MWLR classification at the Alliance scale for data coverage and results coverage. This is a task that requires input from experts and stakeholders, as well as integration of sources such as the Singers & Rogers and Johnson & Gerbeaux key vegetation types. This is a moderately sized task involving multiple parties.
- Agree with data holders (e.g. councils, researchers, central government agencies) on the principles for data sharing. This will apply to data used for the Association level (below), but also to ongoing data sharing for subsequent iterations of the classification for gap-filling. This is a moderately sized task incorporating extensive liaising with data holders, including discussions on data privacy and storage.
- Identify and collate new data (the party undertaking classification will need to collate, with assistance from parties holding the data). This is a small to moderate task, grading to moderate where data are in different formats (e.g. species names not resolved to the NZ Plant Names Database).
- Undertake a biotic classification of wetlands at the Association level. This is a moderate to large task, but would be entirely 'large' if the previous step (collation of new data) and subsequent step (gap analysis) were included.
- Assess coverage / conduct a gap analysis of the revised classification at the Association level. This is a moderate task, incorporating experts and other sources of data, and it feeds directly into Action 2.
- Create descriptive resources such as fact sheets for Associations. This is a moderate task, and could be combined with the gap analysis because the same stakeholders and experts are likely to be involved.

Action 2: Undertake a biotic classification of wetlands: expert elicitation for a complete typology

The data-driven classification will be incomplete in terms of geographical coverage and ecosystem coverage. In order to avoid unnecessary delays in creating a comprehensive typology, an expert elicitation process needs to occur in Action 2 to create a comprehensive typology (with varying degrees of 'classification confidence', as per Jennings et al. 2009).

Key steps

- Assess and compile available data sources for expert elicitation (e.g. vegetation descriptions, Singers & Rogers wetland types) in light of the gap analysis in Action 1. Building off work in the terrestrial domain, identified expert-described vegetation communities need to be assigned to a level of the e-IVC (i.e. EcoVeg) to assess whether modification of the communities is required. This is a small to moderate task depending on the number of communities that require assignment.

- Assemble experts and undertake expert elicitation for Association-level groups. This may be a large task, and is perhaps best combined with the next step of creating descriptive resources, given that the review of the resources should be undertaken by the same experts.
- Create descriptive resources for new Association-level groups, such as fact sheets and diagnostic keys.

Action 3: Broaden the new classification to coarser levels

Not all conservation or mapping purposes will require Association-level data. I therefore recommend aggregating the newly derived Association-level units into coarser levels of the e-IVC. The governance and liaison groups should discuss the appropriate levels to ensure consistency between the terrestrial and wetland domains.

The grouping process should use non-compositional data, such as growth form and functional traits, to aggregate communities that are driven by similar processes. Although this process is an analytical one, the results should be reviewed by an expert panel.

Aggregation should reach Level 3 of the e-IVC to enable international reporting. Guidance should also be prepared to advise on which levels of the national schema (exact levels to be determined by the governance and liaison groups) are most suitable for which purposes, to encourage consistency of use.

Lucid keys could be considered as a diagnostic tool to help identify units of the e-IVC within the field (e.g. diagnostic species).

Key steps

- Agree which levels of the e-IVC (between Level 3 and Level 8) should be included in the New Zealand typology for wetlands and terrestrial systems. This is a small task requiring coordination with wetland stakeholders and the terrestrial domain.
- Aggregate Level 8 observations to the agreed levels. This is a moderate task.
- Review and, if necessary, refine the resulting levels. This is a small to moderate task requiring stakeholder input.
- Provide descriptions of units within each level. This is a moderate task requiring stakeholder review.

Action 4: Develop guidance to encourage uptake and maximise the use of existing data

There are multiple ways stakeholders can ascribe or map ecosystems using the classification, and guidance will allow them to choose and implement an appropriate method with confidence. For example, some stakeholders may use remotely sensed data to ascribe a relatively coarse level. Others may take non-quantitative field observations of dominant species and growth forms and seek to ascribe to an appropriate level. Some stakeholders may collect plot data from unique vegetation communities and seek an easy-to-use interface to upload the plot data and extract the classification results at a level that suits them.

While I recommend creating resources to address the potential needs of stakeholders as part of this action, once stakeholders have been canvassed, the outputs from this action should enable all stakeholders – not just those familiar with analytical classification techniques – to use and apply (and critically assess) the typology.

Key tasks

- Assess stakeholder needs for *using* the typology (c.f. technical descriptions of units created in Actions 1 to 3). This, and the subsequent actions, combined form a moderate to large task, depending on whether, for example, a guided user interface (GUI) is desired by councils to enable them to upload plot data and then download an automated assignment of each plot to the classification.
- Create guidance to meet stakeholder needs to ensure widespread and cost-effective uptake. This is likely to be a small-moderate sized task.

Action 5: Develop transparent, repeatable mapping methods

There is no current ecosystem map of wetlands in New Zealand that is suitable for mapping wetland communities at the IUCN GET Level 3 (international) scale. The options are to use FENZ/WONI[7] for wetland type and LCDB for structural class, and therefore have a map that overpredicts wetlands due to recent wetland loss (FENZ/WONI data are from c. 2008, so 17 years old); or to use council data and supplement where lacking with LCDB, although LCDB has no wetland type information at present.

However, additional difficulties will arise when attempting to map at the scale of IUCN GET Levels 5 and 6, because many wetlands – particularly those recently mapped under the National Policy Statement for Freshwater Management using desktop methods only – will lack plot data from which communities can be inferred. Therefore, a hybrid approach of modelling and inference from plot data will be required.

As with the terrestrial domain, I suggest a methodology be agreed and documentation developed that describes the mapping process and how the maps are updated over time to enable reproducibility of the mapping process. I agree with the recommendation of McCarthy and Wiser (2024) that a pilot study should focus on a small number (one to three) of regions with a reasonable density of recently measured vegetation plots and assess the ability to map wetland ecosystems from these plots.

Key tasks

- Scope the project with the liaison group to ensure maximum complementarity between domains. This is a small task.

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[7] Freshwater Ecosystems of New Zealand / Wetlands of National Importance.

- Examine the available data for mapping using abiotic variables, existing plot data, and any existing mapped vegetation community data for one or more regions as a case study (or case studies). The case study is a moderate task.
- Trial a hybrid approach to mapping, using expert opinion where data are insufficient to map communities in data-poor areas, alongside data-driven mapping. This is a moderate to large task.
- Assess and review alternative mapping methodologies (e.g. machine learning) and test these, both regionally and nationally. This is a moderate task, although testing may push it to large depending on the number of methodologies tested and the spatial scale of testing.
- Disseminate outputs with the national governance group. This is a small task.

Action 6: Enacting a process for updating the typology

There should be ongoing review and feedback mechanisms as the typology is applied in New Zealand.

Key tasks

- Maintain the national governance group, the cross-domain liaison group, and the wetland stakeholder group, along with feedback pathways. The resourcing required for this (and therefore task size) will depend on the ultimate size of the groups.
- Consider creating new community types in the biotic classification if additional plot data suggest there is a need to do so. (Any additional community types would be in addition to existing community types, rather than replacing extant types, and as such the effect on existing classified areas would be minimal.) Small-moderate task.
- Update maps and descriptive data, as required. Moderate size task.

4.4 How the road map will achieve the principles

The suggested road map will achieve consistency and complementarity with the IUCN GET because it:

- is a data-driven biotic typology that integrates well with other domains and international systems
- is capable of being mapped
- is well documented
- is capable of being updated
- translates effectively to the IUCN GET
- was developed in unison with other domain typologies and with key stakeholders.

The suggested approach is both pragmatic and effective, by retaining key elements of the current classification while identifying a practical pathway for developing a data-driven approach that is consistent with international practice.

5 Acknowledgements

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6 References

Atkinson IAE 1985. Derivation of vegetation mapping units for an ecological survey of Tongariro National Park North Island, New Zealand. New Zealand Journal of Botany 23: 361–378.

Ausseil A-GE, Chadderton WL, Gerbeaux P, Stephens RTT, Leathwick JR 2011. Applying systematic conservation planning principles to palustrine and inland saline wetlands of New Zealand. Freshwater Biology 56: 142–161.

Berthelsen A, Cavanagh J, Clapcott J, Campos C, McDonald A, Eveleens R, et al 2022. Compilation of potential attributes of ecological integrity for Aotearoa New Zealand. Cawthron Institute Report prepared for Ministry for the Environment 3818. Nelson, New Zealand, Cawthron Institute.

Bland LM, Keith DA, Miller RM, Murray NJ, Rodríguez JP (eds) 2015. Guidelines for the application of IUCN Red List of ecosystems categories and criteria. IUCN International Union for Conservation of Nature.

Botts EA, Skowno A, Driver A, Holness S, Maze K, Smith T, et al 2020. More than just a (red) list: over a decade of using South Africa's threatened ecosystems in policy and practice. Biological Conservation 246: 108559.

Burge OR 2024. Key to New Zealand wetland types. Manaaki Whenua – Landcare Research. https://doi.org/10.7931/key-wet-001.

Burge OR, Bartlam S 2024. Field guide to wetland types. Guidance for regional councils to meet mapping requirements under the NPS-FM 2020. Manaaki Whenua – Landcare Research contract report LC4448.

Clarkson BR 2014. A vegetation tool for wetland delineation in New Zealand. Landcare Research contract report LC1793.

Collins K 2024. Standardised ecosystem typologies: recommendations for New Zealand. CR 554. Christchurch, New Zealand, Collins Consulting.

Denyer K, Peters M 2020. The root causes of wetland loss in New Zealand: an analysis of public policies & processes. Hamilton, New Zealand, National Wetland Trust.

Denyer K, Robertson H 2016. National guidelines for the assessment of potential Ramsar wetlands in New Zealand. Wellington, Department of Conservation.

Faber-Langendoen D, Keith DA, Loidi J, Helmer HH, Willner W, Navarro G, Hunter J, Liu C, Guuroh R, Pliscoff P. 2025. Advancing the EcoVeg Approach as a terrestrial ecosystem typology: From global biomes to local plant communities. Submitted. Ecosphere.

Faber-Langendoen D, Baldwin K, Peet RK, Meidinger D, Muldavin E, Keeler-Wolf T, et al. 2018. The EcoVeg approach in the Americas: U.S., Canadian and International Vegetation Classifications. Phytocoenologia 48: 215–237.

Faber-Langendoen D, Keeler-Wolf T, Meidinger D, Tart D, Hoagland B, Josse C, et al. 2014. EcoVeg: a new approach to vegetation description and classification. Ecological Monographs 84: 533–561.

Jennings MD, Faber-Langendoen D, Loucks OL, Peet RK, Roberts D 2009. Standards for associations and alliances of the U.S. National Vegetation Classification. Ecological Monographs 79: 173–199.

Johnson P, Gerbeaux P 2004. Wetland types in New Zealand. Wellington, Department of Conservation.

Keith DA, Ferrer-Paris JR, Nicholson E, Kingsford RT (eds) 2020. IUCN Global Ecosystem Typology 2.0: descriptive profiles for biomes and ecosystem functional groups. Gland, Switzerland, IUCN.

Keith DA, Rodríguez JP, Rodríguez-Clark KM, Nicholson E, Aapala K, Alonso A, et al. 2013. Scientific foundations for an IUCN Red List of Ecosystems. PLoS ONE 8: e62111.

Landucci F, Šumberová K, Tichý L, Hennekens S, Aunina L, Bițǎ-Nicolae C, et al. 2020. Classification of the European marsh vegetation (Phragmito-Magnocaricetea) to the association level. Applied Vegetation Science 23: 297–316.

McCarthy J, Wiser S 2024. Road map to update the existing typology for terrestrial ecosystems. Manaaki Whenua – Landcare Research contract report LC4528.

McGlone MS 2009. Postglacial history of New Zealand wetlands and implications for their conservation. New Zealand Journal of Ecology 33: 1–23.

MWLR 2020. LCDB v5.0: Land Cover Database version 5.0. Mainland, New Zealand.

Ramsar Convention Secretariat 1971. Convention on wetlands of international importance especially as waterfowl habitat (Ramsar convention).

Singers NJD, Rogers GM 2014. A classification of New Zealand's terrestrial ecosystems. Wellington, Department of Conservation.

Sprague R, Wiser SK 2024. Investigating a unifying ecosystem typology for all of New Zealand. Manaaki Whenua – Landcare Research contract report LC4513.

United Nations Statistics Division 2024. Factsheet - Indicators for the Post 2020 Global Biodiversity Framework, updated 2024.

Young AR, Davies HF, Ayre ML, Brekelmans A, Bryan BA, Elith J, et al. 2024. Bridging local and global knowledges to classify, describe and map ecosystems. Preprint. https://ecoevorxiv.org/repository/view/7654/

Appendix – Summary of assessment of the candidate typologies against the principles

Principle	Sub-component of principle	Wetlands: Johnson & Gerbeaux 2004 typology	Ecosystem-based International Vegetation Classification (e-IVC)
1. Hierarchical structure	1.1 Level type	Environmental	Clear hierarchical structure
	1.2 Nesting type	Imperfectly nested; no restriction as to which child levels fit within a parent level. This can lead to nonsensical combinations that are ecologically highly unlikely. This is not problematic for experienced users but may lead to confusion for new users.	Perfectly nested.
2. Spatially explicit	2.1.1 Is typology mapped?	At a coarse level (to wetland type, which is a coarse level in the typology) and at a coarse scale (c. 0.5 ha).	At the coarse level yes, it is mappable, by crossing-walking existing mapped wetland types to e-IVC upper levels.
	2.1.2 Indicate extent, resolution, and accuracy.	Extent: all of NZ. Resolution: 0.5 ha for older mapping, 1 ha minimum size for LCDB mapping. Accuracy: unsure.	Extent: all of NZ. Resolution: 0.5 ha for older mapping, 1 ha minimum size for LCDB mapping. Accuracy: unsure
	2.1.3 Also indicate how the ecosystem occurrence is represented (i.e. points, polygons, etc.)	Wetlands are represented coarsely at the wetland type level only for older FENZ[8] mapping (not LCDB mapping). This is at a coarse scale and less up to date than LCDB mapping, but at least it has wetland types. My understanding is that this mapping is primarily limited to palustrine systems for the FENZ mapping.	Wetlands are represented coarsely at the wetland type level only for older FENZ mapping (not LCDB mapping). This is at a coarse scale and less up to date than LCDB mapping, but at least it has wetland types. My understanding is that this mapping is primarily limited to palustrine systems for the FENZ mapping.
	2.1.4 If not mapped, are there data that could be used to produce maps?	This would need assessment in partnership with regional councils, which hold the bulk of this information.	This would need assessment in partnership with regional councils, which hold the bulk of this information.
	2.2 Extent (current, historical, potential)?	Historical and 'current', although current is as at c. 2008 so more recent wetland mapping has no type attribute. Historical is currently being revised, and is based on soil data, drainage data, and location of current wetlands.	Historical and 'current', although current is as at c. 2008 so more recent wetland mapping has no type attribute. Historical is currently being revised, and is based on soil data, drainage data, and location of current wetlands.
	2.3 Are the methods used to map the typology sufficiently well described that they could be reproduced by a third party?	No	No.
	2.4 Other comments?	It's self-described as 'semi-hierarchical'. It does have a biotic level at the bottom, but this is descriptive rather than a classification *per se*.	
3.1 Accommodates increased knowledge and change over time: updateable	3.1.1 Spatial boundaries on maps can change over time?	There are no mapped ecosystem 'types'; just abiotic environments.	Yes
	3.1.2 Temporal changes can be made to mapped unit attributes?	Yes, if you re-ran the analysis that led to the current data.	Yes, if you re-ran the analysis that led to the current data.
3.2 Accommodates increased knowledge and change over time: flexible/adaptable	3.2.1 New ecosystem types can be added?	No, because the current typology does not capture the biotic part sufficiently such that we have 'ecosystem types'.	Yes, there is a clear process for this
	3.2.2 Ecosystems can be split or combined?	No, because the current typology does not capture the biotic part sufficiently such that we have 'ecosystem types'.	Yes
	3.2.3 Methods can be changed to better define ecosystem types?	No, because the current typology does not capture the biotic part sufficiently such that we have 'ecosystem types'.	Analytical methods to derive ecosystem groupings, yes. Changing the overarching global methodology would be ill-advised, however, given the desirability of consistency among countries and interoperability with the terrestrial biome.
3.3 Accommodates increased knowledge and change over time: temporally explicit	3.3.1 Time span of underlying data and when typology created is documented? Changes have been date-stamped?	Yes, but no 'hard' vegetation data underly it. Johnson and Gerbeaux acknowledge preceding work in their text.	N/A
	3.3.2 If maps have been created, is the time period of application documented? Have any changes been date-stamped?	Unknown for council-generated maps. For FENZ maps, some documentation of the source of polygons exists, some of which will contain date information.	N/A
4.1 Compatibility across domains and typologies: compatible	4.1.1 Rationale behind typology structure clear?	Yes	Yes
	4.1.2 Does it build on/acknowledge other typologies? Are relationships to units in other typologies explained?	It acknowledges previous work. Relationships to other units are not really explained.	Yes, it builds on the widely adopted international vegetation classification system, discussed in the main text.

[8] FENZ is a common abbreviation of Freshwater Ecosystems of New Zealand, a set of spatial layers on freshwater. See: https://www.doc.govt.nz/our-work/freshwater-ecosystems-of-new-zealand/

Principle	Sub-component of principle	Wetlands: Johnson & Gerbeaux 2004 typology	Ecosystem-based International Vegetation Classification (e-IVC)
	4.1.3 Could the typology be cross-walked to other typologies in the domain?	Yes, to the extent that it is a hydrologically centred typology it is most relevant to other 'wet' systems. I'm not sure it would cross-walk well to the terrestrial domain.	Yes, the terrestrial domain is adopting the same framework. While it cannot be cross-walked to areas of wetlands that are out of scope, it provides clear guidelines to differentiate wetlands within scope and those that are more appropriately dealt with by other domains, such as the rivers or the marine domain.
	4.1.4 Other comments?	N/A	
4.2 Compatibility across domains and typologies: consistent use of species concepts	4.2.1 Describe whether and how taxonomic changes can be accommodated	The typology really deal with species at present, except that the most dominant ones in each vegetation *plot* are listed in a structured way.	The USA implementation of the IVC adopts the taxon concept approach, which limits ambiguity.
	4.2.2 Biotic names follow a reference taxonomy? Please provide name of reference taxonomy.	No biota	The e-IVC allows for this, but NZ would need to choose its domestic application. The NZ Plant Names Database (http://nzflora.landcareresearch.co.nz/) would be a strong contender.
4.3 Compatibility across domains and typologies: nesting under IUCN GET	Yes, No, Partial?	Partial	Yes: the e-IVC has been formulated specifically for compatibility with the IUCN-GET.
5.1 Robust: parsimony & utility	5.1.1 Detailed descriptions of units exist?	Yes, although the units do not include biota (a critical component of ecosystems).	A framework for doing so exists. NZ would need to create such units.
	5.1.2 Clearly applicable diagnostic criteria to allow identification of units?	Yes, although the units do not include biota (a critical component of ecosystems).	A framework for doing so exists. NZ would need to create such units.
	5.1.3 Do ecosystem names facilitate identification in the field?	At the wetland class scale, names do facilitate identification in the field. There are no 'ecosystems' (i.e. biota and abiotic component classes) under Johnson & Gerbeaux, and therefore at this level no relevant ecosystem names to assess under this category.	A framework for doing so exists. NZ would need to create such units.
	5.1.4 Is the number of units manageable? Please specify the number of units at each level.	Yes, although the units do not include biota (a critical component of ecosystems). Where Atkinson naming conventions are used for structural class and dominant species, the number of units would be unmanageable.	A framework for doing so exists. NZ would need to create such units.
5.2 Robust: transparent and reproducible	5.2.1 Is the method to produce typology documented and independently reproducible?	No (no classification of biota).	A framework for doing so exists. NZ would need to apply it to the NZ context and then document the methods used to do so.
	5.2.2 If 5.2.1 is 'No', is the method defensible?	No biota.	
	5.2.3 Were typology data derived, data-underpinned, or expert-derived/qualitative?	A combination of sources for the higher levels. Not applicable for lower levels where no classification takes place – only naming.	The typology would be data-derived, with scope for expert-derived groups as a transitional measure (with lower 'classification confidence' per Jennings et al. 2009).
6. Comprehensive (new heading)	6.1 Does it accommodate transformed ecosystems, including engineered, passed tipping point, successional, novel?	No – this would need revision both at the level of Johnson & Gerbeaux for constructed and engineered systems, but also incorporation of biota to allow assessment of successional and novel systems.	Yes – there is an entire schema for 'cultural ecosystems'.
	6.2 Does it accommodate ecotones?	No, although given the lack of biota this is not surprising.	Yes, potential for this exists.
	6.3 Does it distinguish biotic (e.g. species) assemblages that are uncommon?	No – no biota.	Yes, where plot data have been collected, or other knowledge can be used to create a transitional grouping.
	6.4 Is there any other form of ecosystem variation that is missing from the typology?	Biota.	No.
7. NZ-specific	7.1 Reflects NZ ecological diversity and processes (if No, explain why)?	No. No biota.	Yes, it has the capacity to do this. While it is a global schema, the upper levels translate well to the upper levels of Johnson & Gerbeaux (e.g. wetland class) and the lower levels are for NZ to define.
	7.2 Does the typology use terminology and concepts familiar to NZ ecologists and conservation practitioners?	Yes	Yes
	7.3 Takes account of te ao Māori (any comments on how this could be achieved will be useful)?	No.	Yes, there is flexibility to do this: refer to an Australian example: Young et al. 2024.