6.1 Wetland extent

Author, affiliation: Olivia Rata Burge, Manaaki Whenua Landcare Research

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State of knowledge of the "Wetland extent" attribute: No short answer given, see longer explanation in the following paragraphs.

Wetland extent is an attribute that can be considered at multiple scales. Wetlands are defined under the Resource Management Act 1991 (section 2): "*includes permanently or intermittently wet areas, shallow water, and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions"*.

Extent can be taken to mean the area covered by something. Wetland extent might seem, therefore to be a simple attribute: the area that is covered by permanently or intermittently wet areas within some wider area of interest. However, ecologically, and culturally, how extent is defined (and therefore calculated) will be critical to whether it can provide *relevant* information. For example: for iwi, the historical extent of *an individual wetland*, compared to current extent, may be relevant to its ability to provide cultural provisioning (a form of ecosystem service); this metric may scale up to the historical extent of wetlands within a rohe, compared to current extent. Conversely, at the national scale, current wetland extent will be relevant for consideration of topics like current vegetation carbon stocks in wetlands. Conversely again, at the regional or sub-regional scale, it is likely that the current extent of wetlands as a function of historical wetland extent is likely to be most relevant for questions like flood risk.

Therefore, the answer to 'the State of Knowledge' of this attribute varies across which particular measure or spatial scale is considered. In general, and we note that often a historical attribute of a certain scale is sought to be compared to a current attribute at the same scale, but possibly not the same precision:

1. At the national scale, historical extent of wetlands is **unresolved**, and **inconclusive** at the regional scale and below. The work by Ausseil et al [1] is the most recent work on historical wetland extent, but this work was considered to be a first iteration and is based on superseded data. It has a minimum polygon size of 0.5 ha. It has wetland types attributed to it. The loss of 90% of NZ wetlands in Ausseil et al [1] is consistent with a previous grey literature estimate [2].

2. At the national scale, current wetland extent is mapped to the 1 ha scale (LCDB v5), but lacks a wetland type[1] attribute, making it 'meaningless' per [3] when considering wetland extent ecologically, given the huge variation in ecosystems that occur on wet substrates. As such, we consider this attribute to be **unresolved**. If the wetland type issue were addressed, we would consider this attribute to be **good**. There is a clear issue mapping forested wetlands, which would need to be addressed for this attribute to reach the level of **excellent or well-established**.

3. At the local and regional scale, current wetland extent is **unresolved**, given the difficulties in mapping small wetlands [5], although the current National Policy Statement on Freshwater Management requires that councils map wetlands that are not on public conservation land, down to 0.05 ha, and classify their type, will provide a major step forward in knowledge on extent. However, given that public conservation land is excluded, any catchment scale analyses (or similar) will be incomplete, where a non-trivial amount of public conservation land exists in the area of interest. As such, once regional mapping is complete, we would consider this attribute to be **established but incomplete**, unless and until public conservation land is mapped to the same standard**.**

Part A—Attribute and method

A1. How does the attribute relate to ecological integrity or human health?

There is strong evidence for a positive correlation between current total wetland extent and ecological integrity, and human health at the catchment or larger scale. However, at the scale of individual wetlands, this is not be confused with biodiversity, as wetland extent may be negatively correlated with biodiversity values (i.e., small wetlands hold high biodiversity [6], [7], but when historically large wetlands become small, this may lead to ecological integrity loss [see below]).

In terms of ecological integrity, loss of historical extent has been linked to decreased ecological condition [8] and is an important predictor of ecological integrity [9]. Loss of wetland extent via drainage has been widespread in New Zealand [10], and drainage near remaining wetlands is surprisingly high [11] and is considered to have a negative impact on ecological integrity [12].

In terms of human health, there is strong evidence of the correlation between current extent of wetlands and ecosystem services that contribute to human health, such as provisioning of critical resources, such as food, fibre, and water, erosion regulating, natural hazard regulation (e.g., floods) [12], [13], [14], [15]; this is also recognised by the Ramsar Convention 1971, to which New Zealand is a signatory. The importance of wetlands to cultural human health has been recognised both internationally [15], and within New Zealand e.g., [16].

A2. What is the evidence of impact on (a) ecological integrity or (b) human health? What is the spatial extent and magnitude of degradation?

[1] The authoritative typology in New Zealand, Johnson and Gerbeaux's wetland typology [4], includes nine wetland types: bog, fen, swamp, marsh, seepage, shallow water, ephemeral wetland, pakihi and gumland, and salt marsh.

In terms of ecological integrity, the spatial impact of reductions in wetland loss is well documented in New Zealand, although there is some variation in regional historical losses [1]. Recent wetland loss in New Zealand, in the period 2012-2016, when assessed against multiple human pressure variables [17] was positively correlated with pasture areal extent around wetland edges at the national scale [34]. Evidence for impact on ecological impact has been documented for New Zealand in Ausseil et al. [1], who found that across New Zealand, where ecological integrity could be rated from 1, pristine, to 0, where 0 means complete loss of biodiversity and associated ecological function, that over 60% of wetlands in New Zealand were measured at less than 0.5 on the ecosystem integrity index. This indicated high levels of human-induced disturbance pressure and sustained biodiversity loss.

As wetland extent decreases, linkage to increasing flood impacts once historical loss was over 60% [18]. An international review has found strong evidence that floodplain wetlands reduce flooding [19], but that the evidence for reduction in flooding for other wetland types, evidence was mixed (p 366):

> *Most, but not all, studies (23 of 28) show that floodplain wetlands reduce or delay floods, with examples from all regions of the world. This same influence on floods is also seen, but less conclusively (30 of 66) for wetlands in the headwaters of river systems (e.g., bogs and river margins). A substantial number (27 of 66) of headwater wetlands increases flood peaks.*

Given the documented benefits of wetland extent, it follows that reduced wetland extent will result in reduced benefit; confirmed in a Florida analysis that found after controlling for other relevant variables, the number, type, and location of wetland permits to approve loss of wetlands was a significant predictor of flood damages (a measure of flood impacts) [20]. Additionally, most ecosystem service assessments are quantified on a per-hectare basis [14], [15], and as such, reductions in wetland extent will have a corresponding negative impact on ecosystem services and likely concomitant reductions in the provisioning of resources, but these declines have not been robustly quantified.

A3. What has been the pace and trajectory of change in this attribute, and what do we expect in the future 10 - 30 years under the status quo? Are impacts reversible or irreversible (within a generation)?

New Zealand is at the extreme of wetland loss globally; estimates of global loss have been estimated at 50%, with ‘extreme’ losses of >90% in parts of Europe [21]; New Zealand has been estimated to have lost 90% of its wetlands, although this varies across regions and by wetland type [1]. Recent work suggests that wetland loss has not slowed in Southland since the introduction of the RMA in 1991 (i.e., following the introduction of modern policy and law) [22]; and nationally, wetland loss in the period 1996 to 2018 has been estimated at 5,400 ha, most of which is now in high producing grassland indicative of dairying [10]. Losses differed across regions; by 2018, Gisborne had lost 15% of its 1996 extent [10]. As such, while the magnitude of estimates of recent loss differ among regions and time periods, it is clear that losses of wetland extent are continuing. While the NPS Freshwater Management requires mapping of wetlands down to 0.05 ha, which we expect will assist with identifying and reducing loss, recent uncertainty about a workable ‘wetland’ definition in New Zealand (*Page & Crosbie v Greater Wellington Regional Council* [2024] NZCA 51), and variable protection within current regional plans tempers any optimism [10].

Wetland restoration is possible, but varies in achievability by wetland type; humans typically value open water wetlands, which are just one kind of wetland [3]. McGlone [3] points out that talking about wetland loss, or wetland extent, of wetlands overall is meaningless, given the vast range of flora and fauna that inhabit different wetland types. Wetland types are described in Johnson & Gerbeaux [4]. One major issue is that the current land use of many lost areas of wetland is dairy farming, a high value economic activity. As the loss of wetlands is externalised from landowners to the surrounding catchment, but land use change costs with wetland restoration accrue to landowners, this represents a major socio-economic barrier to wetland restoration. That said, if emissions from drained wetlands were included in New Zealand's carbon accounting and accrued to responsible landowners, there are extensive areas particularly in the Waikato region that would be economically unfeasible to continue dryland farming. Technically, wetland restoration is possible in New Zealand, however restoration of certain functions, such as peat-forming and cessation of methane emission in restored peatlands, will take years [23], and therefore there will be a lag between restoration initiation and positive results.

A4-(i) What monitoring is currently done and how is it reported? (e.g., is there a standard, and how consistently is it used, who is monitoring for what purpose)? Is there a consensus on the most appropriate measurement method?

Currently wetland extent is monitored at different scales. Nationally, there is the LCDB wetland flag for all LCDB polygons, with a nominal minimum polygon size of 1-hectare. This nominal size means that wetlands smaller than 1-hectare are most likely excluded. There are a vast amount of small wetlands in New Zealand [5]. There is also the LUCAS NZ LUM (Land Use Management layer) which maps two kinds of wetlands: Open Water Wetlands, and Vegetated (non-forest) Wetlands. However, the LUM excludes 90% of the mangroves around New Zealand (that are in fact mapped by the LCDB) and fails to disaggregate forested wetlands from other forests. Forested wetlands are known to be particularly difficult to map, as land cover does not necessarily indicate the hydrological status of the soils below.

At the regional scale, regional and unitary councils are required to map wetlands down to 0.05 ha under the NPS Freshwater Management. Guidance for nationally consistent methods of regional-scale delineation using aerial imagery is now available [35]. As at May 2024, we understand while elements of the NPS Freshwater Management are intended to be repealed, it is not our understanding that the mapping component for wetlands is included in the intended repeal.

Most mapping has been undertaken using desktop imagery, as the cost of field surveying for wetlands across the country is likely unfeasible. The best method to map forested wetlands is unclear given that LCDB relies on vegetation type, and forested wetlands often contain species that may also occur in drylands, such as kahikatea (*Dacrycarpus dacrydioides*) [24]. Forested and woody wetlands have suffered disproportionate loss following human settlement, and even where native dominance has returned to wetlands, the woody components have failed to recover [3], and as such, forested and woody wetlands are considered ecologically significant. Our assessment is that forested wetlands remain a critical knowledge gap in monitoring wetland extent.

As noted, the critical gap to effective monitoring of wetlands is probably forested wetlands at the regional scale, and failure to include mangroves and wetland forests within the LUM at the national scale. While LCDB maps wetlands at the national scale, it fails to assign a wetland type (as does the LUM); as McGlone [3] pointed out: *the term wetland is too broad to be a practical conservation category [4]. Wetlands are only united by their position of a saturated substrate and […] vary enormously on every other physical, biological, and historical dimension***.** *[Statements relating to overall loss] are factually correct but largely meaningless from a conservation viewpoint.*

A4-(ii) Are there any implementation issues such as accessing privately owned land to collect repeat samples for regulatory informing purposes?

There are likely to be implementation issues. What these are/entail will be better known by regional councils.

A4-(iii) What are the costs associated with monitoring the attribute? This includes up-front costs to set up for monitoring (e.g., purchase of equipment) and on-going operational costs (e.g., analysis of samples).

Unknown: this depends on the minimum size wetland that is sought to be monitored, which will depend on the question that is sought to be answered. On the assumption that most monitoring is sought to be done at the regional and national scale, and therefore will primarily be undertaken with manual mapping using aerial imagery, supplemented by perhaps some modelling to identify candidate sites, we do note that change detection is more advanced of a field than object identification with respect to wetlands, and as such, once wetlands are mapped to 0.05 ha with some degree of manual intervention, a lesser degree of intervention may be required to monitor change. Recent guidance for nationally-consistent methods of regional-scale delineation using aerial imagery has been drafted and provided to MFE (February 2023; MFE report number not yet finalised; provided under contract 2324-23-003 A).

As noted above in section 'State of Knowledge', it is important to also identify wetland ecosystems uniformly to best facilitate conservation prioritisation. However, some wetland ecosystems are disproportionately difficult to measure using current techniques, and therefore, disproportionately under-mapped: this is the case for forested wetlands, where the tree canopy of species that may be present in both wetlands and drylands impedes the use of remote imagery to detect other wetland indictors. The current state of biased mapping is amenable to amelioration. For example, a combination of fieldwork in forested wetlands – and forested drylands, as well as modelling topographic and climatic wetland suitability e.g., [25], [26] could be used to validate that vegetation communities indicative of wetlands, as inferred on the basis of rainfall and topographic metrics, do in fact indicate wetlands.

A5. Are there examples of this being monitored by Iwi/Māori? If so, by who and how?

We understand there are health indicators of existing wetlands being monitored. However, this monitoring may not necessarily include assessments of wetland extent. We refer to Te Reo O Te Repo – The Voice of the Wetland [36].

A6. Are there known correlations or relationships between this attribute and other attribute(s), and what are the nature of these relationships?

There are, as noted above, links between wetland extent and wetland condition, and the wetland condition index for New Zealand takes into account the historical loss of extent of wetlands in the catchment [8]. Additionally, ecosystem attributes that affect the flow through of water in a catchment will affect wetland extent – it is been found that early Māori burning of forests in New Zealand led to an *increase* of fertile, surface water fed wetlands, given the reduction in canopy interception and water uptake that had once occurred within the forests [3].

Part B—Current state and allocation options

B1. What is the current state of the attribute?

As noted earlier, the current attribute state at national scale is unresolved, because although national scale mapping via LCDB is relatively up-to-date (imagery date stated to be summer 2018/2019), it does not include wetland type, and as noted above, wetland type will influence both human benefits such as flood attenuation and extent is meaningless ecologically unless broken down by wetland type. We do not currently have a good understanding of the state at regional scale, because regional-scale mapping is not required to be completed until 2030 and will lack coverage of public conservation land. Our comparison of historical to current extent will be limited as the current historical extent layer is based on legacy (superseded) information. MWLR is currently developing a methodology to revise the historical extent layer to incorporate next generation soils data and LiDAR data, however, there is no funding to scale this to the national-scale.

B2. Are there known natural reference states described for New Zealand that could inform management or allocation options?

The historical wetland layer exists [1], which estimates pre-human wetland extent and therefore could be considered to a reference state, although this layer suffers from the limitations identified in Question B1.

B3. Are there any existing numeric or narrative bands described for this attribute? Are there any levels used in other jurisdictions that could inform bands? (e.g., US EPA, Biodiversity Convention, ANZECC, Regional Council set limit)

To our knowledge, no numeric or narrative bands have been described for this attribute.

B4. Are there any known thresholds or tipping points that relate to specific effects on ecological integrity or human health?

Available information suggests that wetlands are vulnerable to tipping points, but it is difficult to generalise to the New Zealand context [27], [28].

B5. Are there lag times and legacy effects? What are the nature of these and how do they impact state and trend assessment? Furthermore, are there any naturally occurring processes, including long-term cycles, that may influence the state and trend assessments?

Yes. Drainage is the major form of reduction in wetland extent in New Zealand [3]. Drainage near wetlands takes multiple years to reach ‘equilibrium’ [29] and even then, peat shrinkage rates continue on drained peatland in the Waikato particularly [30]. Furthermore, carbon sequestration may *apparently* continue in drain-affected wetlands, however this is due to woody plant invasion, which has a time-limited effect on carbon, unlike peat-forming species that sequester carbon into the soil [31]. The effect of drain may also take time to become apparent on the plant community, and as such, there are many wetlands around New Zealand that may be ‘under the influence’ of cryptic drain effects [11].

B6. What tikanga Māori and mātauranga Māori could inform bands or allocation options? How? For example, by contributing to defining minimally disturbed conditions, or unacceptable degradation.

Mātauranga Māori is inherently place-based and so needs to be considered within a local context. Wetlands are valued by Māori as important systems. Discussions with iwi/hapū/rūnanga may reveal tikanga and mātauranga Māori relevant to informing bands, allocation options, minimally disturbed conditions and/or unacceptable degradation in treaty settlements, cultural impact assessments, environment court submissions, iwi environmental management and climate change plans, etc.

Part C—Management levers and context

C1. What is the relationship between the state of the environment and stresses on that state? Can this relationship be quantified?

As noted in B5, drainage is the major form of reduction in wetland extent in New Zealand [3]. Drainage has typically been undertaken to render the land suitable for primary production (although drainage and clearance for other land uses has also occurred to a lesser extent). Additionally, vegetation clearance, even where this is *near* but not *in* the wetland, impacts wetland extent while indirect linkages such as failure to enforce relevant council rules relating to drainage and vegetation clearance, insufficiently strong council rules relating to the same also impact wetland extent [10, 32].

C2. Are there interventions/mechanisms being used to affect this attribute? What evidence is there to show that they are/are not being implemented and being effective?

At the national and regional scale, interventions do not appear to be effective, because wetland loss continues. However, it is not clear the scale of the *averted loss* (loss that has been avoided) as a result of these efforts. Furthermore, it is not clear whether restoration projects restore extent of wetland types that have been lost, rather than just 'easy to restore' types. As noted above, wetland type is critical in considering rates and states of loss; different wetland types are not interchangeable.

The following interventions are known and relevant:

C2-(i). Local government driven

Council rules to prevent clearance of wetlands.

C2-(ii). Central government driven

National Policy Statement for Freshwater Management (NPS-FM) and relevant subsidiary policy to prevent drainage of wetlands, and better map what wetlands exist.

C2-(iii). Iwi/hapū driven

Wetland restoration is often a key component of iwi and hapū driven initiatives.

C2-(iv). NGO, community driven

Catchment care groups often play a role in wetland restoration on private land.

C2-(v). Internationally driven

New Zealand is a signatory to the Ramsar Convention, which promotes the wise use of wetlands.

Part D—Impact analysis

D1. What would be the environmental/human health impacts of not managing this attribute?

Changes in the attribute state affect ecological integrity and human health as described in A1 above. Not managing wetland extent will likely lead to continued loss of extent. This will continue to contribute to species loss and displacement and stress ecological function, and impact on flood risk, as well as reducing opportunities for iwi to practice kaitiakitanga of areas that were considered *taonga* food baskets.

D2. Where and on who would the economic impacts likely be felt? (e.g., Horticulture in Hawke's Bay, Electricity generation, Housing availability and supply in Auckland)

Economic impacts of wetland loss are likely to affect coastal communities, where they are protected from coastal storm events by wetlands [37], will suffer from increased impacts of coastal storms where wetlands are reduced – such as communities living around coastal mangrove wetlands. Where wetlands are reduced, communities and land owners such as farmers and crop growers in floodplains will be less protected by floodplain wetlands (or no longer protected, where loss is complete) – such as Hawke's Bay. Farmers where expensive flood mitigation schemes are required to replace the natural function of wetlands (such as Hikurangi catchment, Northland). Iwi who are already suffering from the estimated 90% loss of wetland extent in NZ and loss of cultural connection to wetlands.

D3. How will this attribute be affected by climate change? What will that require in terms of management response to mitigate this?

An assessment of the effects of climate change on wetland extent requires a by-wetland-type analysis, as the relevant risks and their magnitude differ. We consider impacts of wetland by type:

- Mangroves may *shift* in distribution, may migrate south in New Zealand with warming water; they may also shift in response to sea level rise (reductions in seaward extent, increases in landward extent).
- Remaining wetlands that receive overland flow (swamps, marshes, fens) may suffer increased sediment and nutrient deposition if the increase in extreme events comes to pass; this may lead to wetland loss, if not reductions in ecological integrity.
- Intermittently closed and open lagoons may be lost under increases in sea levels.
- Coastal wetlands may be lost under increased sea levels, with little room to 'migrate' inland if there are incompatible land uses.
- The bogs in the Waikato are already a climatic oddity [3], [33] and their resilience to a warming climate is unknown. It is possible the peat-forming species will be unable to persist in a warming climate, and therefore the vast bulk of carbon sequestration will cease (depending on the replacement vegetation community).

- Bogs in the Waikato are also under threat of climate change due to salinization, as peat subsidence (due to drainage).
- Across all wetland types, shifts in rainfall patterns may affect wetland extent.
- Across all wetland types, it is unclear to what extent extant wetlands in New Zealand suffer from drainage impacts [11] and the extent to which increased stress via climate change will lead to wetland loss of extent.

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