Review of Auckland Council's proposed Ecological Significance Criteria

Landcare Research
Manaaki Whenua

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Summary

Project and Client

- I was engaged by Auckland Council in July 2012 to review a proposed set of ecological significance criteria developed by Auckland Council for incorporation into the unitary plan for Auckland Region.

Objective

- My brief was to provide a constructive critical review of the Council's proposed set of ecological significance criteria (the 'Proposed Auckland Council' or PAC criteria). contained in a draft document 'Ecological Significance Criteria revisited' dated July 2012 ('the ESCR draft'; Auckland Council 2012a).
- In this review, I consider first the five-part PAC criteria framework, and then each of the five individual PAC criteria for the assessment of ecological significance in the Auckland Region.
- My reference points for assessment are the Council's objectives for biodiversity protection as stated in the ESCR draft, the characteristics they desire in criteria, current practice and developing case law in New Zealand, and literature on significance assessment and biodiversity maintenance both in New Zealand and overseas.

Background

- The draft for review by the client ('the ESCR draft'):
    - outlines the purpose and legacy of significance assessment in Auckland Region
    - sets out the Council's response to a previous advisory report prepared by Wildland Consultants
    - presents and describes the Council's preferred approach and proposed set of criteria for the assessment of ecological significance in the Auckland Region
    - provides the Council's justification for their preferred approach and the specific criteria they propose.
- As the reference point for my assessment I have used the '*main factors*' stated to define the Council's approach, i.e.
    - *Does the vegetation or fauna habitat contribute to the on-going maintenance of biological diversity, including the full range of New Zealand's indigenous biological diversity, and enable its persistence (and continued evolution) into the future?* Although it is not stated in the draft, I assume that this question assumes a national frame (i.e. the Council is concerned with its contribution to New Zealand's biodiversity, not just that exclusive to Auckland).

- *Is the vegetation or fauna habitat important for achieving the objectives of the Auckland Council's biodiversity strategy (ACIBS)?*[1] I consider mainly the first two of those objectives: '*the conservation of the greatest number and most diverse range of Auckland's indigenous ecosystems and sequences'* (Objective 1); and *'the long-term recovery of the greatest number of threatened species whose range includes the Auckland Region'* (Objective 2).

Review and Recommendations

- The simple five-part structure of the assessment framework proposed by Auckland Council is sensible, clear and robust, in my opinion. I consider all of the five criteria are complementary and should be retained.
- *Representativeness*:
  - The proposed overall approach to identifying 'Representativeness' is novel but credible and workable. However, it requires more careful wording to be readily understood, in my opinion.
  - The choice of original ecosystems ('types') as a frame for Representativeness has strengths and weaknesses. I recommend:
    - that a higher percentage (at least 20%) of each type would require protection where this is still feasible
    - that either
      a. original ecosystems are reviewed using abiotic data, and those that span environmental gradients are subdivided across those gradients where appropriate, or
      b. careful attention is paid to ensure environmental representation is achieved within each ecosystem type, so that the environmental gradients are fully represented in significant sites, and
    - that a more dynamic, forward-looking view of representation is adopted. Novel assembages of indigenous species, and novel successional trajectories in response to past and future environmental changes, are important for biodiversity persistence and evolution, and should therefore be both expected and accepted.
- *Conservation status*: I recommend that:
  - 'threat status' or 'threat of extinction, loss or decline' be considered as an alternative title for this criterion, because there are various interpretations of the word 'conservation' in New Zealand, some of which may be unhelpful
  - four of the five proposed subcriteria be retained, and a fifth (habitats of naturally uncommon and range-resticted species) moved to the 'Uniqueness or distinctiveness' criterion

[1] Hereafter 'ACIBS'refers to Auckland Council 2012b. Auckland Council's Indigenous Biodiversity Strategy. July 2012.

- the inclusion subcriterion addressing indigenous vegetation and habitats of indigenous fauna that occur in Level IV Land Environments of New Zealand where less than 20% indigenous cover remains be expanded to also include vegetation and habitats in enviroments with high recent loss rates
- IUCN-type threat classifications of ecosystems should be treated with caution. It should be assumed these represent a minimum threat status, and that a higher threat status may apply to at least parts of ecosystems.

- *Diversity*: I recommend that:
  - the justification for this criterion should also mention that the protection of diverse sites confers resilience and protects interconnected functions and processes.

  Uniqueness or distinctiveness: I recommend adding two subcriteria identifying:
  - the habitats of naturally uncommon and range restricted species, and
  - naturally uncommon ecosystems (sensu Williams et al. 2007)
    that have more than some minimum proportion of their range or population within Auckland Region.
- In the section on '*Other factors to consider*':
  - Clarification is needed of the intent and implication of a '*Conservation dependent*' qualifier.
  - The reference to ranking of sites should be deleted or clarified.

1 Introduction

In July 2012 I was engaged by Auckland Council (hereafter 'the Council') to review their proposed criteria for ecological significance – for incorporation into the unitary plan for Auckland Region – as set out in an unpublished report 'Ecological Significance Criteria revisited' dated July 2012 (hereafter 'ESCR' or 'ESCR draft'; Auckland Council 2012a).

Before preparing the ESCR draft, the Council commissioned Wildland Consultants Ltd to review existing ecological significance criteria in district and regional plans in Auckland Region, with reference to national guidance, legislation, and relevant literature, and to develop a set of criteria for the new Auckland Council. The commissioned report (hereafter Myers 2011) provides a detailed review of national guidance, legislation and case law, and the relevant literature.

Myers (2011) proposed a framework of eight criteria for biodiversity significance assessment for Auckland. Following internal discussions[2] the Council decided to consider an alternative, five-criterion framework (hereafter the PAC – or Proposed Auckland Council – framework) to identify important areas for biodiversity protection. The ESCR draft contrasts the two frameworks (Myers (2011) and the PAC) but also notes that there are considerable similarities between them. My review primarily considers the recent PAC five-criterion framework.

In this review I first clarify the baseline against which I assess the adequacy of the proposed criteria, by restating the Council's requirements for an ecological assessment framework as set out in the ESCR document. I then comment on the PAC five-criterion framework as a whole, and in particular whether it exhibits the characteristics recognised as desirable in the criteria. Next I provide comments on each of the five PAC criteria in turn, and in particular whether each PAC criterion is adequate to meet the Council's goals for biodiversity, and on how it complements the other criteria. I comment also on the section on 'Other factors to consider' in significance assessment. Finally I provide some recommendations for consideration.

2 Goals and desirable features of Auckland Council's assessment framework

The Council's purpose and requirements of an ecological assessment framework are discussed in the introduction to the ESCR draft. These appear to divide into 'goals' (for biodiversity) and desirable characteristics (of the criteria, and criteria set).

2.1 Auckland Council goals for biodiversity

In 'defining the the Auckland Council approach' the ESCR draft states (Section 1.4, p. 6) the 'main factors' in mind when developing the criteria were two questions:

[2] Mr John Sawyer, pers. comm.

- *Does the vegetation or fauna habitat contribute to the on-going maintenance of biological diversity, including the full range of New Zealand's indigenous biological diversity, and enable its persistence (and continued evolution) into the future?*
- *Is the vegetation or fauna habitat important for achieving the objectives of the Auckland Council's biodiversity strategy?*

That section goes on to repeat that '*uncertainty needs to be managed by adopting precautionary, inclusive, and attainable criteria (low bars) if the goal is to guard against irreversible harm*'.

Sections 1.4 and 1.6 of the ESCR draft mention a requirement for 'inclusivity'. First (p. 8), the idea is restated that '*maintenance of biological diversity requires protection of the long-term capacity of a landscape to support species' populations. Survival of inherently dynamic ecosystems and their component species will not be achieved by preservation of a few isolated high quality sites, and elimination of less pristine (and more vulnerable) remaining ecosystems and truncation of remaining species' meta-populations*' (Walker et al. 2008, p. 233) . The proposed solution is to '*provide a more inclusive representative* [sic] *criterion that sets a lower bar due to the increasing evidence of the importance of even small, degraded fragments to the overall maintenance of biological diversity across a landscape*'. Section 1.6 (entitled 'inclusivity') draws attention to the extent of past loss of biodiversity in the Auckland Region, and again suggests low thresholds are appropriate, and that there is a need to consider cumulative significance of multiple patches. However, it is also noted that the assessment criteria are '*not devised to protect every natural feature unless that is what is required to meet Council's function of maintaining biodiversity*'.

I therefore consider four overlapping goals when assessing the adequacy of the criteria to meet biodiversity goals. I paraphrase these as follows:

(i) Enable the persistence (and continued evolution) of a full range of Auckland's indigenous biodiversity into the future, recognising that biodiversity loss across much of the region has already been extreme.

(ii) Achieve the ACIBS (Auckland Council's Indigenous Biodiversity Strategy; Auckland Council 2012b) objectives, and

(iii) Guard against irreversible harm to biodiversity, yet

(iv) Not include natural features not required to meet the Council's function of maintaining biodiversity.

My expertise is not in ecological services, social engagement, or integrated management, so I have confined my assessment to the first two ACIBS objectives ('*the conservation of the greatest number and most diverse range of Auckland's indigenous ecosystems and sequences'* (Objective 1); and *'the long-term recovery of the greatest number of threatened species whose range includes the Auckland Region'* (Objective 2)'.

Although the Council's goal is to '*consider the use of criteria for assessing significance in marine and coastal ecosystems to propose significant ecological areas across land and sea in one schedule*', I have restricted my comments to assessment of significance in terrestrial ecosystems, which is my area of expertise.

2.2 Desirable characteristics of significance criteria

Sections 1.1, 1.4 and 1.5 of the ESCR document discuss what the Council regards as desirable characteristics of criteria. Key requirements appear to be that the criteria are understandable to facilitate communication and provide certainty for stakeholders. This is to be achieved through criteria that:

- are measureable (amenable to 'quantification') as far as possible, and/or have exclusions that can be expressly defined
- contain little inconsistency, duplication (i.e. different criteria that identify the same site attribute), or ambiguity (i.e. terms that different parties may interpret in different ways)
- are precisely and clearly expressed in plain language (i.e. '*free as far as possible from jargon, acronyms…*')

3 The proposed five-part framework

3.1 Structure of the framework and independence of the criteria

The five PAC criteria (a. Representativeness, b. Conservation status, c. Diversity, d. Stepping stones, migration pathways and buffers, and e. Uniqueness or distinctiveness) together form a coherent and concise set.

To be judged to be significant, a site must meet at least one of the five PAC criteria. Each proposed criterion is a positive, recognisable attribute. Furthermore, each is largely independent, and does not require reference to any other criterion in application.

3.2 Qualifiers and application guidance

Many sets of significance criteria present site-selection qualifiers such as 'long-term ecological viability' and/or 'sustainability','size and shape', 'buffering and surrounding landscape' and 'naturalness' as criteria in themselves. These qualifiers, or 'secondary ranking' criteria (Kelly & Park 1986, p. 26) are often used in conjunction with primary criteria to rank or exclude sites that meet primary criteria. In contrast, the PAC criteria adopt an 'inclusion/exclusion' approach, which incorporates qualifiers as application guidelines that are internal to each criterion. For example:

- Aspects of 'naturalness' are subsumed into 'inclusion/exclusion' subcriteria of the proposed 'Representativeness' and 'Diversity' criteria. For example, a site must support assemblages '*…characteristic or typical of the natural ecosystem diversity of the ecological district and/or Auckland*' (i.e. natural) to meet the proposed Representativeness criterion. A site must also either '*support the expected ecosystem diversity for the habitat(s)*' or be '*a habitat type that supports a typical species richness or species assemblage for its type*' and not have '*[v]ery low expected species and habitat diversity for its type*' to meet the proposed 'Diversity' criterion.

- Inclusion/exclusion subcriteria also serve as implicit 'viability' and 'size and shape' qualifiers. For example, in identifying sites that are significant under the proposed Representativeness criterion, the draft states it is intended to favour larger areas, and to exclude ecosystems '*largely dominated by naturalised species*' and those that are depauperate '*because of pests, weeds, stock or other anthropogenic disturbance*'. Habitats with '*[v]ery low expected species and habitat diversity for its type*' are excluded under the proposed 'Diversity' criterion, and smaller sites are less likely to contain a diversity of ecosystem types or biological communites than larger sites.

3.3 Balance and complementarity of criteria

Because each criterion stands alone, and has limited overlap with others, it is important that the five criteria are complementary[3] in order to identify the full range of sites that are significant and need protection to meet the Council's objectives for indigenous biodiversity. For example, application of the proposed 'Representativeness' and 'Diversity' criteria (as they are currently written) will tend to favour sites that are more natural and larger, those with more certain future viability, and those with more tractable management options; these sites will also tend to support Auckland's less threatened biodiversity. Those sites that are important for indigenous biodiversity but of small size and/or with more limited prospects of future viability must therefore be identified by other, complementary criteria if the objective is to be met.

4 Criterion 1. Representativeness

As stated in the ESCR draft, 'Representativeness' is often a problematic criterion. It is also one of the most important for achieving biodiversity protection and maintenance goals. My comments on this criterion are therefore lengthy relative to those for other criteria.

The approach to 'Representativeness' proposed in the PAC is novel, and requires more careful wording for the intent to be readily understood. Specifically:

- It was only in discussion with one of the authors that I understood the intent to identify and schedule remaining areas of indigenous habitats amounting to at least 10% of the original area of all defined 'original ecosystems' (subject to various qualifications).
- It is also not clear to me from the current wording (pp. 8–9 and p. 12) how the 'spatial framework' of ecological districts (EDs; McEwen 1982) are to be used in conjunction with the 'original ecosystems'. For example, is it proposed to identify at least 10% of the original area of all designated 'original ecosystems' within each ED, or across EDs? This also requires clarification in the document.

[3] Complementarity is the degree of novelty or uniqueness added by a new element to an existing set. I use the word complementary in this report to refer to the distinctive contributions that different criteria and subcriteria make to identifying sites of significance for biodiversity.

- The layout of the 'critera for inclusion' in Representativeness introduced further ambiguity. It was not clear to me whether the first inclusion subcriterion and the third (following the word 'OR') were alternatives, or whether the first inclusion subcriterion is primary, and the second and third subcriteria that sit above and below the word 'OR' are subsidiary alternatives. If the latter is the intended interpretation, the second and third inclusion subcriteria should be indented, relative to the first. If the former is correct, some numbering would help to clarify this.

Below I comment on three important aspects of the proposed 'Representativeness' criterion: the choice of units for representation (including the notion of original ecosystems, the effects of inconsistent or inappropriate lumping on representation statistics, and the need for abiotic data); the focus of this criterion on the 'common', 'expected', and/or 'typical' (as opposed to the rare, distinctive and unusual); and the proposed representation target of 10% of original extent.

4.1 Choice of units for representation

Biological variation is naturally continuous rather than discrete. However, it is usual in biodiversity protection policy and programmes for a framework (or classification) of discrete classes or types to be used to represent units of the 'full range', and thereby determine how well each unit of the full range is represented. In the PAC, the proposed framework of units for Representativeness is a subjective classification of 'original ecosystems'.

I was sent a draft spreadsheet of 'original ecosystems' for Auckland that suggests the primary basis for the classification is biological – specifically vegetation – composition and structure (physiognomy). The list names recognisable vegetation types that are distinguished primarily on the composition of the dominant species and their physical structure (e.g. rushland, treeland, forest). The list is partly derived from that of Singers & Rogers (in prep.).

It is proposed to estimate the 'original' extent of each of the 'original ecosystem' types and calculate their area. The present representation of each type will be calculated as the percentage of the area of each type remaining in vegetation approximating the 'original ecosystem' or with 'potential to approximate an original type'.

4.1.1 The notion of 'original' ecosystems

The use of 'original ecosystems' as a representation framework has both advantages and disadvantages. An important benefit of an 'ecosystem' classification is that, being based on observable biological character, it may be more readily conceived and communicated to the public than a purely abiotic classification such as the Land Environments of New Zealand (LENZ; Leathwick et al. 2003). The idea of 'originalness', with its associations of 'relict of the past' 'untouched' 'primeval', is also often intuitively appealing to people. However, there are also important drawbacks that should be addressed where possible.

Some of the problems associated with the concept of 'original' in defining ecosystems for significance assessment have been canvassed elsewhere, including by Kelly (1980) and Kelly & Park (1986). They include:

- the difficulty of credibly determining and verifying what is original and where it occurred, because one must guess what was present in the past. The classification developed must rely on subjective and non-repeatable expert opinion
- arbitrariness of a baseline (e.g. at what stage of recovery from a major volcanic explosion, or warming after the last ice age, does one choose as the 'original' or 'historic' Auckland?; what stage of human settlement is 'original'?) (No preferred date is given for 'original' in the ESCR draft)
- an inherent assumption that there is some past steady state, with environmental conditions that continue to be experienced, so that 'original' ecosystems can realistically persist or be reassembled.

In fact, environmental conditions were dynamic historically, and have also changed in response to both natural and anthropogenic causes since the assembly of any 'original ecosystems'. Ecosystems can be reasonably expected to change too, so over time those approximating some notional 'original' state will become rarer, and fewer sites will show trajectories towards something approximating that state.

It is certainly important for future biodiversity persistence to protect (and represent in the landscape) healthy ecosystem function and processes, and the disturbance-sensitive species, that are usually associated with notional 'original' ecosystem character. However, ecosystems approximating the 'original' (and/or those with potential to approximate them in future) probably now exist only in some parts of the major environmental gradients across the range of Auckland's potential biological diversity pattern.

A focus on 'original' ecosystem character may also be problematic for meeting Auckland's biodiversity goals. This is because continued evolution of biological diversity into the future requires species and ecosystems to adapt into novel forms and assemblages that tolerate and thrive under the new conditions. Disturbance regimes, hybridisation, and novel species and population combinations are essential processes in evolution, and need to be allowed for to facilitate the continued evolution of biological diversity.

Achieving future biodiversity representation goals (enabling both persistence *and* continued evolution into the future) therefore requires a balance between preserving and protecting existing natural assemblages and ecological functions and processes from disturbance and adverse effects, *and* enabling the evolution of new genotypes and species and development of novel assemblages in new and changing niches. For this, a forward-looking concept of representativeness that fosters emergence of potential future ecosystem character is therefore needed, rather than a special focus on past ('original') states. Walker et al. (2008) suggested a need for '*a future-looking concept of representativeness that … advances beyond a notion that past New Zealand ecosystems can and should be fossilised*', and a concept that: '*[r]ecognises that ecosystems are dynamic, and accepts that change – evolutionary, climatic, successional, cyclical, seasonal, meteorological, and stochastic – is an inherent property of ecosystems...*'

As currently drafted, the proposed PAC 'Representativeness' criterion ascribes greater value to ecosystems that are purported to be '*original*' than on those that are novel assemblages responding to current ecosystem drivers. In fact, a novel assemblage '*which exhibits conditions and combinations of organisms never before in existence*' is a criterion for

exclusion, which may be problematic for maintaining the full regional spectrum of indigenous biodiversity. Alternative approaches attempt to integrate biodiversity persistence and changing environmental conditions. For example, in a New Zealand context, Lee et al. (2005) define ecological integrity as a biodiversity protection goal based not on similarity with any past configuration, but rather on whether or not the ecosystem is dominated by indigenous species and communities, across the full representation of New Zealand's environmental space.[4]

Environment, rather than ecosystem, is used purposefully by Lee et al. (2005) to ensure the continued representation of indigenous biodiversity in those 'corners' of New Zealand's environmental space (generally those that are low, warm, dry, flat, and well-drained) where humans have selected to most thoroughly eliminate and/or modify indigenous biodiversity, and where evolutionary processes are most threatened. Biodiversity in better represented and more intact corners of environmental space will also be captured by the Lee et al. definition. In contrast, an ecosystem-based representation concept focused on 'original' habitat or biotic types, as in the PAC, may selectively direct attention to a diminishing set of sites in those 'corners' of environmental space where humans have had least impact, and where indigenous biological diversity is still best represented.

4.1.2 Effects of lumping and splitting on representation statistics

As noted by Holdaway et al (2012) '*The definition of ecosystem used in an ecosystem threat assessment can significantly affect the outcome*' [of that threat assessment]; the same applies to assessment of representation.

When using 'ecosystems' as a representation framework, uneven lumping and splitting of the biological diversity in the classification of types can lead to unreliable representation estimates. In particular, species and communities that are poorly represented may be masked through inappropriate 'lumping' together with better represented species and communities. If the 'ecosystem type' as a whole is considered 'relatively well represented' (and thus not warranting additional protection), this could lead to further erosion of poorly represented biodiversity. The problem may be especially severe when the classification is subjective (based on expert opinion, which is rarely comprehensive), and when classes are derived from data but based on only a few prominent or dominant species or low-intensity sampling, and those that are ecological generalists.

The percent of original or indigenous vegetation remaining (representation) is an average across any ecosystem unit or type. If ecosystems are defined as 'broad' types (i.e. they span

[4] 'Environmental representation refers to the abiotic aspects of ecosystems, and measures the distribution of indigenous biota across environmental gradients derived from data layers based on climate, soils, and geology. It assesses the contribution of a site/area to ensuring a full range of environments is included within the protected natural area network, or at least with some form of biodiversity protection. Environmental representation, as indicated in the Biodiversity Strategy, is a major contributor towards ensuring potential biotic representation, and the presence of the full range of genotypes. In combination with the other two elements, it ensures that evolutionary potential can be maintained. Environmental representation can be assessed at multiple spatial scales, and will need to incorporate small-scale distinctive habitats such as wetlands, geothermal areas etc., which often have specialised biota' (Lee et al. 2005).

environmental gradients, and encompass internal variation in ecotypes, species and vulnerability to loss across their natural range), the average representation will be an overstatement of the representation status of the of more reduced species and ecotypes within the type.

Examples of this problem in New Zealand can be seen in some 'naturally uncommon' ecosystem types defined on the basis of geological history, and in forest types defined on the basis of common generalist dominant tree species. Holdaway et al. (2012) note that their single ('lumped') class for New Zealand's moraines leads to an understimate of the threat status of highly threatened, and biologically distinctive moraine communities in dry eastern South Island inland basins.[5] Similarly, the podocarp-dominated forests of eastern Southland on the plains and the fringing hills and ranges are biologically distinct and differentially represented. If those different forest types are lumped into a single type – as in the classification of 20 'potential' forest classes of Leathwick et al. (2003) – the current representation of the remaining distinctive plains forests (that have been virtually eliminated) is greatly overestimated. In both of the above examples, the consequence of inappropriate 'lumping' is that important variation in biological character and contribution to representation of the full range will be overlooked.

The same problem is likely to arise for some, and perhaps many, of the subjectively-defined 'original ecosystems' in Auckland, which appear to be defined mainly on the basis of relatively few, readily recognisable plant community dominant species.

4.1.3 The need for abiotic data to distinguish ecosystems

Abiotic pattern is a primary driver of biological pattern, and ecosystems are a combination of abiotic (physical) and biotic (biological) characteristics. In defining 'ecosystems', an attempt is usually made to combine abiotic and biotic characteristics. However, as the examples above illustrate, the practical reality is that most 'ecosystem' classifications are oversimplifications that rely on distributions of relatively few obvious species and/or structural attributes, and/or a few prominent abiotic characteristics. Abiotic characterisations are also important because biodiversity is comprised of many types of organisms across

[5] Holdaway et al. (2012) state: '[f]or example, New Zealand's glacial moraines, as defined by Williams et al. (2007), include… those located in wet alpine, montane, or lowland environments on the western side of the Southern Alps, as well as dryland moraines on the eastern side of the range… As a whole, moraines were classified as vulnerable, rather than as endangered or critically endangered, because they are largely located in protected areas. However, these protected areas are strongly biased toward wetter climates. Eastern dryland moraines (<30% of the total area) have different species and ecosystem-level properties, have declined more in area and function, and are under threat from agricultural transformation, fire, and colonization of non-native plants (E. Weeks et al., unpublished data). If split into two ecosystem types on the basis of precipitation, then dryland moraines would be classified as critically endangered, whereas high-rainfall moraines would be not threatened.'

The same problem of unreliable assessment will likely attend some – and perhaps many – of the other naturally uncommon ecosystem types categorised by Holdaway et al. (2012). Unfortunately, because these types are subjectively defined and the analysis is necessarily non-spatial (most types remain unmapped) it is not yet possible to objectively assess their internal variation in either biological or abiotic character, to determine which are inappropriately lumped, and in which the status of truly threatened biodiversity is likely to be masked.

different trophic levels and is unlikely to be fully included in classifications based soley around vegetation.

The purpose of protecting representative sites is to provide habitats for uncommon, sensitive and specialist species *within* the units of the classification as well as for the common and generalist species. Uncommon, sensitive and specialist species, and different forms and genotypes, are unlikely to be evenly or randomly distributed within ecosystem types defined on the basis of community-dominant species. Instead, their occurrences are likely to vary systematically along environmental gradients, and this variation will be overlooked in a representation assessment unless finer distinctions are made and/or different factors included.

Fortunately, if potential (or 'original') ecosystems are able to be mapped, an ecosystem classification can be reviewed and combined with abiotic data (i.e. depicting the physical environment, including climate, soil and landform) to provide an improved basis for an assessment of representation of potential (past and/or future) biodiversity pattern.

Because species and their assemblages ('potential ecosystem character') vary with abiotic characteristics of the environment, subdivision of broad 'ecosystem' units based on internal abiotic patterns and gradients will provide a better chance that important biological variation is distinguished, and that consequently more of the full range of biodiversity will be included within representative sites. This subdivision will be particularly important for meeting biodiversity representation goals where readily available species' distribution information mainly concerns relatively common and/or generalist species, where data describing distributions of uncommon and distinctive biota are patchy or absent, and/or where indigenous ecosystems have been largely eliminated or are highly modified.

Human activities and exploitation usually closely follow abiotic patterns: flat, warm, fertile, well-drained sites are generally preferred for agricultural development, and many of our settlements are in coastal habitats. Consequently, the biodiversity characteristic of these environments has been selectively removed. Abiotic pattern is therefore often a useful predictor of the places where biological pattern has been most reduced, and most requires inclusion within a network of protected representative sites if indigenous species are to persist (and evolve) across the full range of Auckland's environments in future.

The best abiotic variables to use for refining an 'ecosystem' classification for representation assessment depend on the local importance of climate and soil factors for controlling biodiversity patterns and patterns of loss. A combination of climate (seasonal temperatures, moisture balance) and soil (drainage and fertility) is most frequently needed. However, it is usually impractical to determine which abiotic variables are the main drivers of biological pattern in a district or region, because of limited distributional data for rare and/or specialist species. I would therefore recommend pragmatically subdividing 'ecosystem' units using those particular variables that correlate well with patterns of loss within a district. These factors are generally easier to identify and will be certain to distinguish the biodiversity that is less well represented from that which is better represented.

Once potential (or 'original') ecosystem units are mapped, an abiotic refinement exercise need not be complex or onerous. The exercise should begin by determining which 'ecosystems' span wide gradients of environment and past loss, and then subdivide

ecosystems across those gradients accordingly. The categories of the Threatened Environment Classification (often abbreviated to TEC; Walker et al. 2006, 2007)[6] offer one potential basis for subdivision; these categories group together areas with similar extents of past loss, and those that are adjacent often also have similar environmental (and therefore biological) character; this averts the need to use a more detailed environmental classification such the 500 Level IV environmentsin themselves. Alternatively, simple elevation zones may also be adequate in some places; for example, it may be possible to divide ecosystem types into coastal, lowland and upland portions. However, slope, drainage and fertility usually interact with elevation in determining ecosystem character; creating zones combining these factors with elevation would be a more complex exercise, and may offer little advantage over the relatively simple environment or TEC classes, which already incorporate these variables.

The ecological districts (EDs) that I am familiar with often encompass a diversity of abiotic environments and elevation sequences, so I would not generally recommend using these alone as an 'abiotic' layer. However, the different EDs in Auckland do represent geographic (e.g. latitudinal) variation in ecological character, so it may also be useful to also split ecosystems among EDs.

4.2 Focus on the 'common', 'expected', and/or 'typical'

The draft states that '[r]*epresentativeness ensures the full range of biodiversity… is represented in the schedule to ensure that the expected or typical range of ecosystems naturally found in Auckland is maintained*'. However, as the following sentence explains, in practice the proposed Representativeness criterion is both narrower than '*the full range*' and has a primary focus on common elements of biodiversity, to ensure that '*examples of common ecosystems are valued for their contribution to the maintenance of biodiversity*'. Elements of biological diversity that are distinctive or rare are not addressed in the proposed Representativeness criterion, nor is that intended. For this reason, I think it would be more strictly accurate to state that it is not the Representativeness criterion alone, but rather the proposed significance criteria together that are required to ensure that '*the full range of biodiversity… is represented in the schedule*'. It may also be useful to highlight in introductory comments how the five different and complementary criteria collectively identify the full range of biodiversity that requires protection in Auckland.

I noticed that in the proposed Representativeness criterion, the idea of 'typical' is further narrowed to 'historic' [sic][7]or 'original' (i.e. typical in the past, rather than at present) by a

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[6] Each of the 500 units identified at Level IV of LENZ is assigned one of six threat categories on the basis of (a) past loss of indigenous vegetation ('% indigenous vegetation left'), and (b) current legal protection ('% protected').The six threat categories are:

1	<10% indigenous vegetation left	('Acutely threatened')
2	10–20% indigenous vegetation left	('Chronically threatened')
3	20–30% indigenous vegetation left	('At risk')
4	>30% left and <10% protected	('Critically underprotected')
5	>30% left and 10–20% protected	('Underprotected')
6	>30% left and >20% protected	('Less reduced and better protected')

[7] I assume the intended term is 'historical' (meaning 'in the past') rather than 'historic' (referring to an important past event).

requirement for an ecosystem to be either a mature or successional stage of a defined 'original' type to be considered representative. This is in contrast to the more inclusive idea of 'typical' and 'commonplace' recommended by Kelly & Park (1986). Although they also recognised as representative those '*places where ecological succession will eventually lead to a vegetation approximating the original*', they interpreted the concept of 'original' within an enabling 'longer view' as '*things taken together* [that] *make New Zealand distinctive*'. I have commented above on limitations of the PAC focus on representation of 'original' ecosystems.

4.3 Target for representation

Protecting just 10% of remaining 'original ecosystems' (and associated successional states) is unlikely to provide sufficient representation of Auckland's biological diversity to ensure the landscape has the capacity to support species' populations, ecological functions, and evolutionary processes in the medium and long term.

As a general rule, the loss of species and ecological functioning accelerates as habitat and biodiversity loss advance.[8] Fortunately (for biodiversity) 50% loss of habitat is not predicted to lead to a loss of 50% of species or ecosystem functioning. However, as habitat loss advances below this level, further increments of loss have increasingly serious adverse effects on species diversity and ecological processes (e.g. Tilman et al. 1994; Rosenzweig 1995; Hanski 1998). If only 10% of a landscape's ecosystems remain, the species and habitats that continue will generally have undergone considerable simplification (e.g. through effects of fragmentation, pests, grazing, and weed invasion). The landscape will have already lost many sensitive species and be committed to considerable future species extinctions; that many essential ecosystem functions will have been irretrievably compromised. This situation is evident in many lowland and peri-urban regions in New Zealand that have lost most of their indigenous vegetation.

Habitat loss, leading to low levels of representation, not only has immediate and direct adverse effects on individuals by killing individuals and removing essential resources, but it also leads to protracted small-population and small-habitat-area (SPHA) effects (Tanentzap et al. 2012)[9] so that the biota in remaining habitat fragments typically 'relax' over time towards lower species richness (Tilman et al. 1994; Laurance 2008). There are a number of

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[8] For example, in a recent paper in *Nature*, Cardinale et al. (2012) state that there is consensus that '[t]he impact of biodiversity on any single ecosystem process is nonlinear and saturating, such that change accelerates as biodiversity loss increases… initial losses of biodiversity in diverse ecosystems have relatively small impacts on ecosystem functions, but increasing losses lead to accelerating rates of change'.

This 'non-linear and saturating' pattern is a 'diminishing-returns curve' (see Walker et al. 2012) seen in a number of other familiar relationships in ecology. Prominent examples include the species-area relationship (accelerating species' loss with reductions in habitat area; Rosenweig 1995), the rapid decline of species' persistence probabilities with decreasing numbers of individuals in the population, and the isolation-area relationship (rapidly accelerating isolation of habitat fragments with reducing area; Andrén 1994, 1997).

[9] Incidentally, Tanentzap et al. (2012) also showed that He & Hubbell's (2011) prominent claims that species–area curves overestimated extinction were incorrect (see also Brooks et al. 2011). In fact, He & Hubbell's equation estimated only 'overnight' extinction, not accounting for extinction debt 'beyond the morning after'. Tanentzap et al. demonstrate that after habitat loss occurs, small populations and/or habitat area (SPHA) commit species to future extinction.

interrelated causes of this extended biodiversity decline. For example, because it reduces the size of species' populations, habitat loss increases their susceptibility to extinction from demographic, genetic, and environmental stochasticity (Lande 1988, 1993; Hubbell 2001). Communities in small, isolated fragments also receive fewer immigrant species, as predicted by island biogeography theory (MacArthur & Wilson 1967). Additonally, the persistence of isolated species' populations is also compromised by habitat changes associated with fragmentation, e.g. increased edge effects; disrupted competitive, reproductive, and trophic interactions; and lower resistance and resilience to disturbance, and increased vulnerability to threats such as fire, spray drift and pollution (Fahrig 1997, 2002; Laurance 2008 and references therein).

There is no 'correct' or 'adequate' level of representation in the landscape that will avoid the cumulative and protracted adverse effects of habitat loss and fragmentation. This is because these effects occur progressively are probably initiated early, at low levels of loss. However, it can be demonstrated empirically that landscape connectivity declines rapidly once less than about 30% habitat remains (Andrén 1994; Fahrig 2002). Reduced connectivity disrupts multiple ecological properties and processes: for example, compromising source–sink dynamics, dispersal and colonisation processes, and thus disrupting genetic interchange. Isolated fragments also have high edge-to-area ratios and experience edge effects and changes in microclimate, and increased canopy tree mortality, exotic seed rain and invasion of non-indigenous species (Laurance 2008). Furthermore, well before extremely low levels of representation – such as 10% – are reached, the remaining habitat is likely to have systematically lost its more sensitive species. Many species that require large, intact, or undisturbed habitats and/or ecological linkages, and those that are large-bodied, host-dependent, narrow-range and/or are habitat-specialists will be lost earlier, while common and robust generalist species are more likely to remain once habitat for indigeous species has been reduced to low levels.

5 Criterion 2. Conservation status

As stated in the draft, '*this criterion is included to ensure that any threatened biodiversity, some of which only occurs in the region, is protected*'. This focus on threatened biodiversity complements the focus on typical, common or expected biodiversity in the proposed Representativeness criterion.

The term 'conservation status' is consistent with some international terminology (e.g. IUCN) and is used by the Department of Conservation to describe its categorisations of indigenous flora and fauna species under the New Zealand Threat Classification System (e.g. Hitchmough et al. 2010). However, the word 'conservation' may not be the best term for this criterion because in New Zealand it is often automatically associated with protection in public conservation land by the Department of Conservation, and/or with conservation activities such as pest and weed management. Moreover, conservation is not a term that is generally used in describing councils' RMA responsibilities for biodiversity.

I agree that the term 'rarity' is also broad, and that many species are naturally uncommon or rare, but not necessarily threatened. I suggest the terms 'threat status' or 'threat of extinction, loss or decline' may be more readily understood expressions of the intent and content of this criterion. They might also function to engender public acceptance of the criterion.

Criteria for identifying sites that are significant for 'Conservation status' are provided as five bullet points. The order of these in the draft is somewhat non-intuitive, and a more natural order of levels of biodiversity organisation could provide a stronger and more logical rationale to follow. For example, habitats of species assessed to be threatened (currently bullet two) could come first, and species assemblages (habitat and/or community types, and/or ecosystems) thereafter. Three bullet points relating to different species assemblages form a natural group, and could perhaps be presented as three alternatives under a single higher level bullet.[10]

It is particularly important to protect indigenous vegetation or habitat of indigenous fauna that occurs in Land Environments New Zealand Category IV where less than 20% remains (bullet three). This subcriterion promotes the persistence (and evolution) of indigenous genotypes and species in 'corners' of Auckland's environmental space that have been disproportionately cleared in the past and, because of their limited extent, have an elevated risk of further decline. It also fills important gaps left by the other criteria: many sites identified by this subcriterion will meet neither the representativeness criterion (which emphasises higher-quality vegetation in the biologically-derived 'original ecosystems') nor the threatened ecosystems subcriterion of the 'Conservation status'criterion (i.e. the first bullet point on p. 13).

Recent research in the South Island grasslands (Weeks et al. 2013 and in review) shows that indigenous vegetation on gently sloping land in many less reduced LENZ IV environments (i.e. those with >20% indigenous vegetation remaining) was imminently threatened with loss. In many cases, this vegetation was more threatened than remaining vegetation in land environments where less than 20% remained. This pattern arises because many small indigenous remnants are now restricted to steep, inaccessible sites in environments where the least indigenous biodiversity now remains, and are therefore not currently threatened because of topographic protection from threatening processes, now and in the past. The current trend in inland South Island is to convert indigenous vegetation on flatter land in environments that were previously considered unsuitable for development, rather than to remove the last indigenous remnants on steep slopes and in gullies within environments that have been most heavily developed in the past. Investigation of land conversion trends across Auckland's land environments may well reveal a similar pattern.

It would be prudent to ensure that the LENZ-based subcriterion directs attention to those environments where indigenous biodiversity is in fact most threatened with decline and loss. Assuming rates of recent conversion and loss of indigenous vegetation and habitats of indigenous species in Auckland's land environments could be established, this subcriterion might be modified to also include environments with vegetation cover loss exceeding some absolute threshold (i.e. *x*% of environment area) or proportional threshold (i.e. *y*% of the indigenous vegetation that remained) within some recent time period (e.g. the last decade).

[10] For example, this might read along the lines of: 'Indigenous vegetation and habitats of indigenous fauna that
- occur in Land Environments New Zealand Category IV where less than 20% remains,
- represent a habitat, community or ecosystem type that occurs naturally in Auckland and has been assessed by the Council to be threatened or in decline…, or
- occur within a wetland or coastal dune

I question whether a separate subcriterion is required for indigenous wetland and dune ecosystems (the fourth bullet point on p. 13). If wetland and dune ecosystems are also to be listed and mapped among the habitat, community or ecosystem types for assessment (as indicated in the first bullet point on p. 13), this subcriterion would introduce repetition into the criterion.

Although the draft recognises (p. 7) that '*not all rare species are threatened*', it is nevertheless proposed to include naturally uncommon and range-restricted species in the 'Conservation status' criterion (fifth bullet point, p. 13). The further loss of populations of naturally uncommon and range-restricted species may rapidly increase their threat status if these populations represent a high proportion of what remains. Nevertheless, naturally uncommon and range-restricted species are not regarded as being threatened with extinction at present, so this inclusion is somewhat inconsistent with the stated purpose of the 'Conservation status' criterion *'to ensure that any threatened biodiversity… is protected*'.

It may be appropriate to move the bullet point concerning naturally uncommon and range-restricted species to the fifth ('Uniqueness and distinctiveness') criterion, which has a focus on those elements of biodiversity for which the Council has particular responsibility. For example, an additional 'inclusion' subcriterion could stipulate the habitats of indigenous species that are naturally uncommon or range restricted nationally, and that have some significant portion (say 10%) of their known distributional range or population within Auckland Region.

6 Criterion 3. Diversity

This criterion identifies sites with high or 'typical' species diversity and high ecosystem or habitat diversity, and sites containing gradients and associated ecological sequences. The draft also states that such areas may be important biodiversity hotspots.

With respect to diversity of species, it is important to note that some habitat types have naturally low species richness, and this does not necessarily mean they are less important for maintaining biological diversity than those with high species richness. Furthermore, in New Zealand high species diversity is associated with frequent disturbance maintaining early-successional communities. This reality appears to be acknowledged in the draft by the recognition of sites with 'typical' species diversity in the criterion.

This criterion makes an important complementary addition to the five-part set by providing for the recognition and protection of sites containing contiguous ecological gradients and sequences and therefore relatively high biological 'beta-diversity' (i.e. diversity associated with turnover of habitat and community types). Protection of a variety of different adjacent habitats and community types is likely to be important for the maintenance of species diversity and evolution over time because it confers resilience and fosters natural ecological processes and functions (e.g. source-sink dynamics, dispersal and migration, and interconnected physical processes such as hydrological regimes) in ecosystems that are inherently dynamic. Diverse sites (those containing a variety of interconnected habitats) are also likely to be particularly important for the persistence of mobile fauna requiring a diversity of resources, especially in a changing climate.

7 Criterion 4. Stepping stones, migration pathways and buffers

This criterion recognises and enables the protection of relatively small and scattered habitat patches, and of buffer areas that protect adjoining significant sites. Cumulatively these sites help to maintain indigenous biodiversity in modified and fragmented landscapes, including in larger and more intact sites. The criterion recognises and provides for the fact that '*[s]urvival of inherently dynamic ecosystems and their component species will not be achieved by preservation of a few isolated 'high quality' sites, and elimination of less pristine… remaining ecosystems and truncation of remaining species metapopulations*' (Walker et al. 2008). Specifically, sites meeting this criterion provide additional habitat for indigenous species and/or mitigate many of the isolation and edge effects of habitat loss and fragmentation described in Section 4.3, by allowing for the migration and movement of species or by reducing exposure to threats and degrading processes. This fourth criterion is therefore not an 'optional' add-on to the preceding three criteria, but is necessary to ensure long-term persistence of the indigenous biodiversity identified as significant because it is representative, threatened, or diverse.

By providing for the protection of sites that are biologically connected (e.g. through migration and dispersal) but spatially discontinuous, this criterion also complements the proposed 'Diversity' criterion (which will identify sites that are *both* biologically connected *and* usually spatially contiguous, and that will also usually be larger and often less modified). This fourth criterion should also identify areas of modified or non-indigenous vegetation and species habitat that are spatially continuous with, and provide buffering to, significant sites, but that would not necessarily be recognised as contributing to 'Representativeness' nor to meet the 'Diversity' criterion in themselves.

Many statements in the draft that justify the importance of stepping stones, migration pathways, and buffers for the maintenance of ecosystem function apply equally to connected sequences of different habitat types that would be identified as significant under the 'Diversity' criterion.

8 Criterion 5. Uniqueness or distinctiveness

This fifth criterion caters for indigenous biodiversity for which Auckland has particular stewardship responsibility in a national context, including elements that are unique or endemic to Auckland and/or that have their distributional limits and type localities in the region.

The criterion is an essential complementary addition to the proposed five-part set. Sites supporting unique and distinctive biodiversity that require protection to meet Auckland's goals for biodiversity would not necessarily be identified as significant for 'Representativeness', 'Conservation status', or 'Diversity', or for maintaining 'Stepping stones, migration pathways and buffers'.

As noted above, I suggest adding a 'criterion for inclusion' that stipulates naturally uncommon and range-restricted species with some defined minimum portion (e.g. 10%) of their known range or population within the Auckland Region. This would replace the criterion for inclusion that refers to naturally uncommon and range-restricted species in the proposed 'Conservation status' criterion. Similarly, it may also be appropriate to add a

‘criterion for inclusion’ that identifies naturally uncommon ecosystems (sensu Williams et al. 2007) that are not considered threatened (e.g. by Holdaway et al. 2012) but have a significant minimum portion (say 10%) of their known range within Auckland Region.

I suspect the exclusion subcriterion that refers to ecosystems or habitats found elsewhere in New Zealand may be superfluous. That exclusion is implicit in the first two subcriteria that refer to endemic species and assemblages, but would conflict with the biodiversity features identified in the remaining inclusion subcriteria (which occur outside Auckland), and in the two additional inclusion subcriteria I have suggested above.

9 Other factors to consider

Four additional factors are included for consideration in significance assesment. These are: significance of the site to tangata whenua, long-term ecological viability of the site, indirect or direct contribution to the delivery of ecosystem services, and quality of information about the site. It is noted that significance to tangata whenua still requires comprehensive assessment, and it is proposed to attach qualifiers to sites that are likely to depend on conservation management, that provide ecosystem services, and those for which the data for assessment is thought to be deficient.

Some of the material under Section 4.2.Viability on p. 17 repeats information provided in Section 1.4.2 (A new assessment system for Auckland). It was not clear from the text *how* information on likely viability or dependence on conservation action was to be considered. For example, it may be intended that these sites are to become Council priorities for discretionary funding and assistence. This should be clarified.

On p. 18 Section 4.2 describes Norton and Roper Lindsay’s (2004) suggested ‘sustainability’ criterion, which the Environment Court has twice queried (in 2004 and 2008).[11] The description appears incomplete because it is not mentioned that this was not proposed simply as a criterion but as a primary qualifier: Norton and Roper Lindsay (2004) suggested any site that was not considered ‘sustainable’ should also not be considered to be significant *regardless* of whether it met their other proposed criteria.

I note that the discussion of the ‘data deficient’ consideration (Section 4.4) refers to a significance rank. The intent to rank sites (implying sites will be sorted from higher to lower significance) is not mentioned elsewhere in the draft, nor are there guidelines suggested as a means of ranking. It may not be appropriate to rank sites, as recent case law does not support the addition of gloss such as ‘very’ or ‘highly’ to the word significant.[12]

[11] Royal Forest and Bird Protection Society Inc and others v Central Otago District Council (A128/2004) at paragraphs 62 & 63 and Long Bay-Okura Great Park Society Incorporated and others v North Shore City Council (A078/2008) paragraph 70.

[12] High Court judgment CIV-2010-409-002466 on the ‘West Coast Wetlands Case’ (Friends of Shearer Swamp Incorporated and others v West Coast Regional Council)

10 Assessment and recommendations

10.1 The proposed five-part criterion set, and overview of recommendations

The five-part criterion set has a simple, coherent and compact structure that should aid straightforward application. As currently written, the criteria appear to complement each other well, in my opinion, with few obvious gaps that would compromise the ability to achieve the Council's biodiversity goals. There is little, if any, duplication.

Particularly important complementary aspects of the criteria include the reciprocity between the 'Representativeness' criterion (which may focus attention on typical and relatively intact biodiversity that the Council has a particular national responsibility for protecting), the 'Uniqueness or distinctiveness' criterion (focused on the atypical and unusual) and the 'Conservation status' criterion (focused on the vulnerable and threatened). The 'Diversity' and 'Stepping stones, migration pathways and buffers' criteria will identify additional sites, combinations of sites, and features such as buffers that are important for maintaining the ecological and evolutionary processes that support biodiversity persistence.

Because the proposed criteria are already concise, with little repetition and duplication across criteria, I note few opportunities for the deletion of aspects (i.e. inclusion subcriteria) of criteria in review. In my opinion, any such deletion is likely to leave a gap, and compromise the present balance and complementarity among the criteria.

I make several suggestions and recommendations for the modification of the five significance criteria below. These are designed to improve the criteria so that they better meet the four biodiversity goals set out in Section 2.1.1 above; i.e. by ensuring that more of the full range of Auckland's indigenous biodiversity is maintained (and allowed to continue to evolve) in the future, that a greater number and more diverse range of Auckland's indigenous ecosystems and sequences are protected, a greater range of threatened features is able to persist, and there is less chance of irreversible biodiversity loss and harm. In particular, my suggestions would mean there would be a greater chance that biodiversity that is more modified from some 'original state' and biodiversity that is more threatened are recognised as significant.

Importantly, even if my suggestions are accepted, the modified significance criteria would not identify all natural features. Those natural features falling outside the criteria will be ecosystem types that are relatively common and intact, but (1) remain above the chosen representation target, (2) contain neither threatened nor unique and distinctive biodiversity, (3) are somewhat depauperate in species and (4) are not a diverse part of a diverse sequence of habitats, and (5) are not recognised as stepping stones or migration pathways, nor are buffers to other sites.

10.2 Representativeness criterion

10.2.1 Overall approach

This overall approach of identifying and scheduling remaining areas of habitats for indigenous species amounting to at least some percentage of the original area of all designated representation units represents an advance over non-systematic approaches used previously and elsewhere. In my view it appears to be a well-reasoned and workable approach. My main reservations concern the chosen framework of units, the somewhat backward-looking emphasis on 'original' ecosystems, and an inadequate representation target.

10.2.2 Framework for representation

In my opinion, subjective ecosystem classifications – especially those based on a few prominent or dominant plant species – have important drawbacks as a framework for the representation of the full range of biodiversity. Based on personal experience I would have more confidence in a purely abiotic (environmental) classification to deliver a representative set of significant sites that meet the Council's representation goals.

However, I acknowledge that 'ecosystem' classifications based on observable biological character are likely to be more readily understood and accepted by the general public than an abiotic classification. Furthermore, the RMA routinely relies heavily on 'expert' assessments and so the unverifiable nature of the classification may not be a hurdle to the robustness of the proposed frame to legal challenge. However, to provide a higher likelihood that more of the '*full range of biodiversity… is represented in the schedule*', I strongly recommend that GIS overlays on abiotic data are used to review the 'original' ecosystem types. Those 'ecosystems' that span relatively wide environmental gradients, and/or gradients of past loss and modification, should be subdivided across those gradients.

An alternative approach to such a revision would be to retain the 'original ecosystem' list but pay careful attention to environmental representation within each 'original ecosystem' type in selecting representative sites. The aim should be to ensure that environmental gradients within 'original ecosystem' types are fully represented in the schedule. In doing so, it would be necessary to remove the stipulation that site selection should start with the largest areas, and to replace it with a stipulation that representative sites are to be selected to span the full range of abiotic, geographic, and biological variation within each 'original ecosystem' type.

10.2.3 Future-looking representation of biodiversity

I recommend that a more dynamic view of future change is embraced in the 'Representativeness' criterion. This view should recognise the importance of representing relatively intact sites that support disturbance- and fragmentation-sensitive species and heathy ecosystem processes. However, the view of representativeness should also recognise that it cannot necessarily be expected that ecosystems will now be in, or will succeed towards, some defined historical 'original' state. This means recognising that modified and novel assembages of indigenous species, and novel trajectories emerging in areas formerly within

some notional ‘original’ state, are definitely important for the future persistence and evolution of indigenous biodiversity in Auckland.

In practice, and in combination with the recommendation above to better incorporate environmental representation (Section 9.2.2), this would mean removing the ‘exclusion’ subcriterion that a site should not exhibit ‘*conditions and combinations of organisms never before in existence*’. It would also require relaxing the stipulation that representative sites should exhibit potential to approximate some past notional original type.

Although there is provision for ‘*small and modified areas including early successional stages*’ to qualify as representative, I think the ‘original ecosystem’ qualifier will nevertheless place emphasis on higher quality (therefore safest and least modified) sites while excluding those that are less pristine and more vulnerable to loss. This would potentially exacerbate the non-representative pattern of persistence of Auckland’s biological diversity: as environmental conditions change and pressures progressively modify communities, the set of places considered representative will inevitably narrow, until few sites are left that would be thus considered. I therefore suggest relaxing the focus on ‘original’ vegetation to encompass communities that are presently typical and commonplace, and those that are much-modified, especially in the most depleted environments and ecosystem types.

10.2.4 Representation target

If the Council wishes to retain the disturbance- and fragmentation-sensitive indigenous species and ecological functioning necessary to meet its goals for biodiversity maintenance and persistence, it should be seeking to protect higher levels of representation of ecosystems than 10%, where possible. I suggest that a target of at least 20%, and preferably 30–40% of each type would be needed to enable the persistence (and continued evolution) of the full range of biological diversity now present into the future, including healthy ecosystem processes and disturbance- and fragmentation-sensitive species. However, I acknowledge that even 10% representation may be an unrealistic target for many ‘original ecosystem’ types, because less than that percent now remains.

10.3 Conservation status criterion

In my opinion, ‘threat status’ or ‘threat of extinction or decline’ would be a more appropriate, accurate and less confusing term for this criterion. This is because the word ‘conservation’ has multiple meanings and interpretations, some of which may engender resistance to the criterion.

Four of the five proposed inclusions (subcriteria) within the proposed ‘Conservation status’ criterion appear appropriate and worthwhile. Importantly, each of these four subcriteria is necessary to complement the representativeness criterion, which will focus attention on common and unthreatened biodiversity. In my opinion, the fifth subcriterion, referring to naturally uncommon and range-restricted species, would fit more appropriately within the ‘Uniqueness or distinctiveness’ criterion.

I recommend that the four remaining subcriteria are reduced to two; with the first referring to habitats of threatened species (retaining the same status qualifiers as those proposed), and the

second referring to species assemblages (indigenous vegetation and habitats of indigenous fauna) in three categories: (1) Land Environments New Zealand Category IV where less than 20% remains, (2) naturally occurring habitat, community or ecosystem types assessed by the Council to be threatened or in decline (including those naturally uncommon ecosystems as defined by Williams et al. (2007) and assessed by Holdaway et al. (2012), and (3) wetlands and coastal dunes.

Irrespective of determinations regarding a national policy statement, it will be important to retain the inclusion subcriterion derived from the National Priorities and addressing indigenous vegetation and habitats of indigenous fauna that occur in Level IV Land Environments of New Zealand where less than 20% indigenous cover remains. It is more likely that remaining indigenous biodiversity in these high-loss environments will be recognised as distinct if 'original ecosystems' are revised using abiotic information (as recommended above; Section 10.2). Nevertheless, many of the more modified communities that are important for biodiversity persistence would not be regarded as significant for 'Representativeness' because of thresholds in that criterion.

This subcriterion could be modified to also include Level IV Land Environments of New Zealand with vegetation cover loss within some recent time period (e.g. the last decade) exceeding some absolute threshold (i.e. *x*% of environment area) or proportional threshold (i.e. *y*% of the indigenous vegetation that remained).

I recommend that the results of a 'IUCN'-type threat classification of ecosystems should be treated with considerable caution. This is partly because of the subjective nature of both the ecosystem definitions and assessment process, which are unlikely to be comprehensive, conclusive or repeatable. However, I am especially concerned about the risk that such rankings will understate threat status of distinctive biodiversity that has been inappropriately 'lumped' with safer biodiversity.[13] As a general rule, I recommend that any assigned IUCN-threat-status category should be assumed to be a minimum threat status, and it should be expected that a higher threat status may apply to parts of all but very narrowly defined ecosystems.

10.4 Criterion 3. Diversity

This criterion is also critically important for meeting Auckland's goals for biodiversity and I recommend that it should be retained in its entirety. It complements the first two criteria ('Representativeness' and 'Conservation status'), which focus on ecosystem types individually, without considering their ecological context – which may also be significant.

I recommend that the justification for this criterion should also mention that the protection of diverse sites confers resilience and protects interconnected functions and processes.

[13] This problem is explained in detail in Section 4.1.2 (Effects of lumping and splitting 'ecosystems' on representation statistics).

10.5 Criterion 4. Stepping stones, migration pathways and buffers

This criterion is also of fundamental importance for meeting Auckland's goals for biodiversity in its entirety. Like the 'Diversity' criterion, it complements the first two criteria ('Representativeness' and 'Conservation status'), which focus on ecosystem types individually, without considering their ecological context – which may also be significant. It also complements the 'Diversity' criterion by protecting more modified adjacent buffer sites and sites that are physically disconnected from significant representative, threatened and diverse sites and that contribute to the maintenance of species' populations and ecological functions and processes. I have no recommendations for how it could be improved.

10.6 Criterion 5. Uniqueness or distinctiveness

This criterion reasonably identifies indigenous biodiversity that is unusual and distinctive and for which the Council has particular national responsibility. I recommend adding new inclusion subcriteria for naturally uncommon and range-restricted species, and for naturally uncommon ecosystems (sensu Williams et al. 2007) that have more than some minimum proportion of their range or population within Auckland Region. The exclusion subcriterion referring to biodiversity that occurs outside Auckland Region may be superfluous.

10.7 Other factors to consider

I recommend that the intent and implication of the 'Conservation dependent' qualifier should be further clarified. Repetition of subject matter relating to viability in the Introduction (Section 1.4.2) should be deleted either there or from this section. The reference to ranking sites in the discussion of data deficiency is surprising because it is not explained. No discussion of the intention to rank sites or protocols for doing so appears elsewhere in the draft. If it is not intended to rank sites, this reference should be deleted. Otherwise, the intention and associated protocols should be clarified throughout the document (this could require considerable redrafting).

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