Before the Expert Panel appointed under the Fast-track Approvals Act 2024

Under	the Fast-track Approvals Act 2024
And	
In the Matter of	an application for approvals by NZSki Limited to upgrade existing infrastructure at the Remarkables Ski Area, including a new passenger transport lift, carparking areas, and expanding the ski field into the adjacent Doolans Basin

Statement of Evidence of **Glenn Alister Davis** on behalf of NZSki Limited in response to Section 53 Comments

Terrestrial Ecology

Dated: 3 November 2026

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INTRODUCTION

1. My name is Glenn Alister Davis.

2. I am the Managing Director e3scientific Limited and I have been in this role since 2007. I oversee the full work programme of e3scientific managing over 20 scientists providing environmental advice in the fields of ecology, contaminated land and water resources.

3. I hold a Bachelor of Science majoring in Ecology and a Master of Science in Geography, both from the University of Otago.

4. Much of my ecological experience has been in the Otago and Southland areas where I have completed many ecological impact assessments for projects in the tourism (including skifields), agriculture and land development industries. For the last 15 years I have been directly involved in a range of ecological assessments on the Remarkables skifield associated with upgrades to lifts and ski terrain in the Shadow, Sugar and Curvey Basins in addition to upgrades to the base building and carparks.

5. In addition to the work I have completed on the Remarkables, I have also been the lead ecologist or overseen the delivery of the following projects and workstreams:

    (a) ecological assessments on many high-country stations in the Queenstown Lakes District to support pastoral farming operations;

    (b) provided ecological advice in high country tenure review processes and supported LINZ in the review of pastoral lease applications for vegetation disturbance;

    (c) lead ecologist in the identification of Significant Indigenous Vegetation and Habitats across the Queenstown Lakes District;

    (d) lead ecologist to Queenstown Lakes District Council in the review of the district plan including development of Chapter 33 Indigenous Vegetation Biodiversity;

    (e) supported the Otago Regional Council in the identification of Outstanding Water Bodies (wetlands) across the region;

    (f) developed and implemented numerous restoration projects on both private and public land including landscape restoration work at Coronet Forest, Mt Dewar and Walter Peak; and

(g) provided ecological support to a range of regional and territorial authorities in Otago and Southland in both consenting and compliance matters.

6. This statement is given as part of NZSki Limited's (**NZSki**) response to comments on the Remarkables Ski Area Upgrade and Doolans Expansion (**Project**) made under Section 53 of the Fast-track Approvals Act 2024 (**FTA**). This statement responds to specific comments raised by: Dr Walker, Mr Dale, Mr Rossaak, Dr Kavazos, Dr Weston, Dr Watts, and Dr Liddell.

7. My original findings are provided in full in the Terrestrial Ecological Impact Assessment (**TEcIA**) B-12 Parts 1 to 4.

8. In responding to Section 51 and 53 comments, I have read and refer to Mr Barrell's Statement of Advice (12 Oct 2026).

9. I understand that the evidence of Dr Bramley, on behalf of NZSki, provides details of how the residual ecological effects of the project are proposed to be managed.

10. I have prepared this statement in the limited time available for NZSki to respond to comments under the FTA. If the Expert Panel requires elaboration on any of the matters raised in this statement, I am available to provide further information on request.

11. Although this is not an Environment Court proceeding my confirmation of compliance with the Code of Conduct for Expert Witnesses in the Environment Court Practice Note 2023 is included in the Executive Summary of the TEcIA (B-12 Parts 1 to 4) submitted as part of the substantive application.

12. In consideration of how the TEcIA was prepared, being jointly (as is stated in the TEcIA), e3s has responded to relevant Section 51 and 53 comments via an e3s Memo (appended to this statement of evidence as **Appendix A**), which has been prepared, and is supported, by myself, Mr Salemink-Waldren, and Ms Teele.



Glenn Alister Davis

3 November 2026

Appendix A: e3 Scientific - Response to Section 53 and 51 Comments – Remarkables Ski Area Upgrade and Doolans Expansion

MEMO

To:	NZ Ski Ltd	Ref:	24043_TE_s51-53
From:	e3Scientific Ltd		
Date:	3 November 2026		
Subject:	Response to Section 53 and 51 Comments – Remarkables Ski Area Upgrade and Doolans Expansion		

Introduction

The following statements have been made the e3s Terrestrial Ecology Team in response to the Section 53 and Section 51 responses by the Department of Conservation (DOC), the Otago Regional Council (ORC), and the Central Otago District Council (CODC). The matters raised by these parties are identified by each following heading and our response follows.

Consideration of Upper Doolans Creek Right Branch Basin as Unique - DOC

1. DOC's ecological expert, Dr Walker, considers that the upper Doolans Creek Right Branch basin is unique (**paragraphs 49 to 51**). We do not agree and consider the basin's ecology to be similar to that of other basins found in the Remarkables Ecological District (**ED**). The argument put forward (in **paragraph 49**) that the upper Doolans Creek Right Branch basin is exceptional due to a lack of regular or deliberate pastoral grazing compared to the entire remainder of the ED is not supported for the following reasons:

    (a) The vegetation in the upper Doolans Creek Right Branch basin is not expected to be unusually intact/different (**paragraph 49 a**) in comparison to other areas at similar elevations in the ED. The vegetation in the upper Doolans Creek Right Branch basin is like that seen in aerials across the ED (at the same elevations), with Figure 1, Figure 2, and Figure 3 (appended to this Memo) showing multiple other basins at similar altitudes with similar vegetation communities to the upper Doolans Creek Right Branch basin. This similarity across the ED (above 1,100m asl) is further reinforced at a finer scale, with compiled plant lists for other areas within the ED having similar plant species present, as noted in **paragraph 14** of this memo and the statement on page 103 of the TEcIA which sets out that "*it is not considered appropriate to compare the affected values to the entire Ecological*

District given the vast altitudinal range occupied by the ED and associated species that are not represented within the higher elevation vegetation assemblages identified within the study area (see Section 6.1.3). Rather, e3s have identified the appropriate scale as the Ecological District above 1100 m asl. This area contains similar topography, geology, climate, soils, and biological features resulting in comparable vegetation assemblages. This is supported by species lists sourced from NZPCN of the wider Ecological District suggesting a strong similarity for structural components of the vegetation communities within the upper catchments of various other basins and reflecting a high similarity in the Threatened and At Risk plant species recorded in the Doolans Right Branch. Notably, Wye Valley (Simpson & Druce, 1991), Upper Rastus Burn (Simpson, 2022) (Druce, Rastus Burn (Q407), 1990), Loch Linne Station (Barkla & Thorsen, 2007), Hector mountains (Druce & Simpson, 1991), and Staircase Creek (Druce, 1990)."

(b) The suggested absence of physical evidence within the upper Doolans Creek Right Branch basin of pastoral activity (**paragraph 49 b**), is not confirmation of the presence of such activity across the remainder of the ED at similar elevations. There are other basins in the ED, which would be expected to have a similar level (or lack thereof) of pastoral activity[i].

(c) Similarly, the lack of historic stock tracks in the upper Doolans Creek Right Branch basin (**paragraph 49 c**) is not confirmation of the presence of tracks throughout the rest of the ED at these elevations[ii]. No supporting evidence has been provided for the statement in paragraph 49 c of Dr Walker's evidence that in comparison to the Upper Doolans Creek Right Branch Basin "*other high-elevation basins in the Remarkables ED ... stock tracks are visible*".

(d) The high elevation and southern aspect of the upper Doolans Creek Right Branch basin (**paragraph 49 d**) is found in more than this location within the ED, including but not limited to nine other locations within the ED shown in Figure 4 (appended to this Memo). Therefore, the assumed limited potential benefit from seasonal pasturage could have occurred in multiple areas in the ED and does not create a 'unique' situation in the upper Doolans Creek Right Branch basin[iii].

[i] This statement is made in consultation with Dr D. Cropper, who agrees.

[ii] This statement is made in consultation with Dr D. Cropper, who agrees.

[iii] This statement is made in consultation with Dr D. Cropper, who agrees.

(e) The physical difficulty of access and incidence of early and late snows, and the implications for stock movement and loss and consequent grazing (**paragraph 49 e**), and the control of straying stock (**paragraph 49 f**), applies to multiple high elevation basins in the ED, not just the upper Doolans[iv]. Thus, in e3s's opinion, this does not create a 'unique' ecological situation in the upper Doolans Creek Right Branch basin.

2. Overall, the features stated in support of the upper Doolans Creek Right Branch basin being exceptional in the ED (**paragraph 49 a to f**), could apply to any other similar areas within the ED. No evidence provided indicates the pastoral activity was specifically different to multiple other basins above 1,100 – 1,500m asl across the ED[v].

3. An Ecological Significance assessment was completed by Dr Walker (Table 1, **paragraph 48**) and referred to in **paragraph 50** as showing '*an unparalleled ecological baseline for the ED*'. We agree for the most part with Dr Walker that the ecological significance of the communities present is High. The e3s TEcIA assessed all vegetation communities present within the study area to be of High to Very High ecological values. An exception is the 'Disturbed Vegetation' community, which was assessed as having Moderate ecological value. However, we disagree with the statement that the upper Doolans Creek Right Branch basin is an unparalleled ecological baseline for the ED, as described in **paragraph 3(a)(e)** below.

(a) *Representativeness* – the upper Doolans Creek Right Branch basin is highly unlikely to be the only basin in the ED that was '*never subject to regular or deliberate pastoral grazing, and therefore a unique baseline*'. The evidence for this is outlined in **paragraphs 1(b) - 1(e) and 2** above.

(b) *Naturalness* – There has been no supporting evidence provided to indicate that the upper Doolans Creek Right Branch basin is '*the most intact basin in the Remarkables ED*'. The following evidence would suggest it may be one of the more accessed and disturbed:

(i) No evidence is provided showing all other basins above 1,100m asl in the ED have had pastoral grazing and fire. The likelihood of the upper Doolans Creek Right Branch basin being the only basin in the ED to have

[iv] This statement is made in consultation with Dr D. Cropper, who agrees.

[v] This statement is made in consultation with Dr D. Cropper, who agrees.

experienced a particular and unique level of pastoral activity is highly unlikely, for reasons outlined in paragraphs 1 (b) to (e) and 2 above.

(ii) There are also reasonable levels of human activity and disturbance in the upper Doolans Creek Right Branch basin. Figure 5 (appended to this Memo) shows all the tracked activity routes from Strava across the Ecological District above 1,100m asl. This indicates that this basin is not an outlier in terms of human disturbance compared to other basins in the ED, in fact it is likely more accessible and consequently accessed more than most, if not all, other higher elevation basins in the ED.

(iii) The upper Doolans Creek Right Branch basin is a known backcountry ski location, easily accessible via the current operation ski field in the Rastus Burn. Outside of winter, it is accessed by hunters, walkers, mountain bikers (traversing ridges), and dirt bikes. It is accessed via multiple routes, including but not necessarily limited to: the NZ Ski current ski field in the Rastus Burn, Wye Creek, Coal Pit Saddle Road then along trails along the ridgelines. Figure 6, Figure 7, and Figure 8 (appended to this Memo) show the deliberately formed routes of lesser quality than a sealed road above 1100 m asl in the ED, and all the visible informal tracks surrounding and into the basin.

(c) *Rarity and Distinctiveness/Special Features –*

(i) Please refer to **paragraphs 20 – 35** of this memo in regard to how Naturally Uncommon Ecosystems have been addressed in the TEcIA.

(ii) The statement that the upper Doolans Creek Right Branch basin has "*the most extensive continuous tracts of unmodified alpine vegetation and habitats in the Remarkables ED, and the most ecologically intact basin in the Remarkables ED*" is not supported with evidence. **Paragraphs 1(b) – (e), 2, and 3(b)(i) to 3(b)(ii)** above show the basin is highly likely to not be the most intact basin in the ED.

(iii) No supporting evidence or reference has been provided to show that the basin in question is more geologically stable than elsewhere in the ED, where it is proposed that "[e]*lsewhere in the Remarkables and Hector Mountains, mobile slopes, creeping deformation and landslides have removed or obscured much of the former glacial record*". Further, these are glacial features, not ecological, and if any ecological rarity,

distinctiveness, and/or special features had been caused by aspects of glaciation, they are likely to be present across the ED at similar elevations. Shulmeister *et al*. (2019) model the last glacial maximum extent to be over a large portion of the ED at these higher elevations (see Figure 8 within Shulmeister *et al.* (2019)) and Dr Barrell's Statement of Advice (**paragraph 33**) states "*that the proposed gondola line, towers and base buildings are not in locations that compromise any landforms of notable significance*" and (**paragraph 19**) "*Apart from the late-glacial moraines, I consider that the Doolans Creek Right Branch Basin does not contain any rare or unusual geomorphological features, in the context of The Remarkables and adjoining mountainous areas*".

(iv) Tarn 3 is not considered a wetland, as described in **paragraphs 36 – 40** of this memo.

(d) *Diversity and Pattern* - no supporting evidence has been presented to indicate that the ecological Diversity and Pattern present in the upper Doolans Creek Right Branch basin is not found elsewhere in the ED. Based on further evidence presented above, the similarity of glacial originals (**paragraph 3(c)(iii)**), climate given spatial proximity, pastoral history (**paragraphs 1(b) – 1(e), and 2**), human activity likely being higher than south of the basin (**paragraph 3(b)(ii) – 3(b)(iii)**), and aerial imagery of similar vegetation communities elsewhere in the ED (**paragraph 1(a)**), the ecology of the site is highly likely to be similar in multiple other locations throughout the ED.

(e) *Ecological Context* - no evidence has been presented to indicate that the Ecological Context present in the upper Doolans Creek Right Branch basin is not found elsewhere in the ED. The basin is not fully '*buffered from many surrounding landscape pressures by natural barriers to access*'. This is evident from the proximity to the existing ski field with easy walking road access provided up to 1,900m asl, allowing ease of access into the Doolans year-round, along with access from Wye Creek and Coal Pit Saddle Road (see **paragraph 3(b)(ii) – 3(b)(iii)**). The location at the northern end allows ease of access for the growing populations of Queenstown, Frankton, Arrowtown, Gibbston Valley, and Cromwell. Most of the remainder of the ED above 1,100m asl appears to face less pressure (see Figure 5 to Figure 8).

4. In **paragraph 51**, Dr Walker states that the Doolans Basin has previously been proposed to be included as part of a wider National Park area. However, given the area is not

within a National Park boundary, nor has it ever been classified as a National Park, this emphasises that multiple decisions to date have not seen it be classified as a National Park, either in previously decades or as recently as 2019, indicating unknown potential deficiencies in meeting such criteria.

5. Overall, it is e3s's opinion that ecological locations that may be unique within an ED are identified during a TEcIA via review of aerial imagery, are already classified with official protection greater than the surrounding landscape, and/or are known to local ecologists for the ecological communities present. We do not consider that the upper Doolans Creek Right Branch basin meets these criteria. However, this does not diminish the ecological value that is present within the upper Doolans Creek Right Branch basin. This is characterised in the TEcIA in Sections 2 through 5, with the impact assessed in Section 6 and 7 moving forward with Very High and High ecological value assigned to all but one vegetation community and, a conservative approach to the threat status of fauna taken via the application of the higher of the threat status between the National and Regional Threat Classifications. This then culminates with the TEcIA clearly showing (in Table 18) that the level of residual effect from the proposed development after all avoidance and mitigation measures have been implemented remains Moderate to High for those listed effects.

Consideration of Upper Doolans Creek Right Branch Basin as Unique - Kā Rūnaka

6. The Kā Rūnaka ecological expert, Mr Dale, agrees with Dr Walker that the upper Doolans Creek Right Branch basin "*may be the only alpine basin within the Ecological District that has not historically been subject to pastoral grazing, providing an important and potentially unique ecological baseline (Walker, pers comm)*" (**paragraph 82**). We respectfully disagree, as it is reasonable to expect that multiple other high elevation basins in the Ecological District had similar pastoral activity and thus similar ecological outcomes would be expected; please refer to **paragraphs 1(b) – 1(e) and 2** above where we expand on this point.

7. Mr Dale also agrees with Dr Walker that the Doolans Basin is an "*interconnected mosaics of terrestrial vegetation, wetlands, unvegetated habitats and naturally uncommon ecosystems in a combination considered unreplicated elsewhere within the Ecological District (Walker, pers comm)*" (**paragraph 83**). We disagree that the terrestrial ecology is unreplicated (as is reasonably expected across neighbouring landscapes) as these vegetation communities and habitats are expected across the Ecological District at similar elevations; please refer to **paragraphs 1(a) and 3(d)** above specifically.

Scale of Assessment

8. Dr Walker, on behalf of the Department of Conservation (**DOC**), challenges e3s' application of the assessment scale used throughout the TEcIA and instead advocates for an aggregated assessment scale of interlinked (yet biologically distinct) species, habitats, and ecosystems. This is rationalised by Dr Walker citing the overarching aim of assessing Significant Natural Areas (**SNAs**) over large extents of area (SOA, **paragraphs 47 – 54**). We acknowledge that the ultimate statutory objective of an SNA or Section 6(c) Resource Management Act 1991 (**RMA**) assessment is to determine if a geographically bounded area or site qualifies as significant, however, should be measured against the Ecological District. We disagree with Dr Walker, as evaluating the underlying criteria (Representativeness, Naturalness, Rarity, Pattern and Diversity, Context) directly at a generalized "site scale" without additional structural stratification risks the dilution of distinct communities and individual ecological values.

9. The scale of assessment approach undertaken for the TEcIA is in accordance with the EIANZ guidelines noting "[t]he values assigned to different subsets can be combined to give a single site value. Combining values should be done in a way that avoids suppressing project impacts on individual features or components" (Roper-Lindsay, Fuller, Hooson, Sanders, & Ussher, 2018). Accordingly, the assessment must first identify

and evaluate biologically distinct ecological features at an appropriate scale before considering their collective significance within the wider landscape.

10. It appears that the scale of assessment used in Dr Walker's assessment (**paragraph 47**) is comparable to the Zone of Influence (**ZOI**). It is essential to differentiate the ZOI (being the spatial and temporal extent of the effect) from the scale of assessment, which provides perspective and ecological context against which to benchmark the magnitude of effect (Roper-Lindsay, Fuller, Hooson, Sanders, & Ussher, 2018). The ZOI is explicitly stated to be "the areas/resources that may be affected by the biophysical changes caused by the proposed project and associated activities" (Roper-Lindsay, Fuller, Hooson, Sanders, & Ussher, 2018). In this case, the ZOI is defined as the cumulative area of the Upper Doolans Right Branch basin and the Upper Rastus Burn. Importantly, it is noted that Roper-Lindsay et al. (2018) set out that "assessing magnitude of effect at the spatial scale of the effect (Zone of Influence) is not recommended".

11. Dr Liddell, on behalf of the Central Otago District Council (**CODC**), generally agrees with the application of the significance assessment and the approach to assess value against the specific vegetation communities, noting that the "assessed ecological values remain appropriate" (**Section 4.6, paragraph 1**). Dr Liddell further notes that "EIANZ guidelines are just guidelines and not statutory". While they are not statutory, the EIANZ guidelines are the only nationwide framework supporting ecological practitioners in undertaking ecological impact assessments and in our experience are used widely within New Zealand. Further, criterion for assessing ecological value noted within the EIANZ guidelines are directly comparable to the statutory framework for assessing ecological significance (**paragraph 12(b)** of this memo).

12. We disagree with Dr Walker's application of scale (**paragraphs 47 – 54**) and Dr Liddell's critique (**Section 4.5.2, paragraph 1**) and maintain that the scale used throughout the TEcIA is appropriate given the following context:

    (a) The scale of assessment is integral to providing the correct frame of reference. Where the scale is either too small or large, it has the potential to exaggerate or dilute the magnitude of effect and therefore, influence the level of effect. Making the scale of assessment smaller than the Ecological District above 1,100 m asl would exaggerate the magnitude of effect.

    (b) The Department of Conservation guidance (Davis *et al.*, 2016) emphasise assessments of significance should be undertaken "at the local scale, as it best recognises ecological variation across the country. Thus, the Ecological District framework is the critical scale for making s6(c) RMA significance assessments."

This is further supported in the National Policy Statement for Indigenous Biodiversity (**NPS-IB, Appendix 1**), Operative Otago Regional Policy Statement (**ORPS**), Proposed Queenstown Lakes District Plan (**QLDC District Plan**; (Queenstown Lakes District Council, 2024) and EIANZ guidelines, which directly references the Ecological District within all four/five assessment criteria. The EIANZ guidelines explicitly state, "Ecological Districts provide the most appropriate scale for terrestrial assessments" (Roper-Lindsay *et al.* (2018).

(c) To ensure compliance with the NPS-IB (Appendix 1; (Ministry for the Environment, 2025)), Otago RPS (Appendix 2; (ORC, 2026)), and DOC Guidelines (Davis , Head, Myers, & Moore, 2016), the assessment stratified and mapped the study area into distinct vegetation communities to ensure that localised, high-value attributes such as "originally rare" plant communities or under-represented vegetation communities were accurately captured against the Ecological District baseline. Further, ecosystem types have been assigned to the applicable communities based upon (Singers & Rogers, 2014) zonal environments and ecosystems. These are classified as one of five ecosystem types; AL1 (*Chionochloa* tussock grassland), AH2 (cushionfield and rock dominant substrates), WL9 (cushion bog and riparian wetland), VS7 (Dracophyllum scrub) and WL17 (seepage) based upon the physical and ecological characteristics present. Consideration has been given to identifying subsets of the dominant vegetation communities, only where biological composition and ecological function are influenced by specific topographic, geological, climatic, and soil features. Therefore, within the context of the TEcIA, ecological features (vegetation communities) have been categorised into a total of 12 biologically distinct features.

(d) e3s reviewed the wider Ecological District and noted that the vegetation communities identified within the study area were absent or different in their biological composition and expressed natural character below 1,100 m asl. Therefore, we considered it inappropriate to apply the entire Ecological District as the fundamental scale of assessment and instead adopted an elevational derived subset of the Ecological District where comparable ecological and biological components and processes are expected to occur. As stated by Dr Walker (**paragraph 65**) "industry (EIANZ) guidance which has clarified that '[t]he magnitude of effect should be assessed at the same scale as the ecological value assessment, with wider district, regional or national context informing, but not supplanting, that assessment'; that '[w]ider ecological context remains important but should not be used to dilute or amplify effects by substituting a

different spatial scale for that used in the value assessment'. Having used an appropriate subset of the Ecological District (being above 1,100 m asl), any potential dilution or amplification of effects has been limited and the most appropriate scale for the ecological environment has been used.

13. Further, although Dr Walker's designation of the ecological features (**paragraph 47**) was defined as three discrete 'practical areas' (the Rastus Burn, [Upper] Sugar Bowl, and Doolans Basin), the scale used by Dr Walker for assigning ecological value specifically references the Ecological District one or more times within each of the five assessment criterion (Representativeness, Naturalness, Rarity and Distinctiveness (NSP-IB)/Rarity and Special Features (DOC guidelines), Diversity and Pattern, and Ecological Context) (Dr Walker's **paragraph 48-50**).

14. As we have stated above, e3s have identified the appropriate scale of assessment as the Ecological District above 1,100 m asl. This area contains similar topography, geology, climate, soils, and biological features resulting in comparable vegetation assemblages. This memo provides the aerial identification of comparable ecological values within the wider Ecological District above 1,100m asl (see Figure 1 - Figure 3). This is supported by species lists sourced from NZPCN of the wider Ecological District suggesting a strong similarity for structural components of the vegetation communities within the upper catchments of various other basins and reflecting a high similarity in the Threatened and At Risk plant species recorded in the Doolans Right Branch. Specifically, Wye Valley (Simpson & Druce, 1991), Upper Rastus Burn (Simpson N. , 2022) (Druce, Rastus Burn (Q407), 1990), Loch Linne Station (Barkla & Thorsen, 2007), Remarkables (Druce & Simpson, 1991), and Staircase Creek (Druce, 1990). Given that e3s have assessed the value of the described vegetation communities at the scale of the Ecological District above 1,100 m asl, it would be inappropriate to alter the scale in assessing the magnitude of effect. Comparatively, where modification has resulted in a shift to the Ecological District baseline, specific consideration and accounting of the area where comparable values occur is required (e.g. above 1,100 m asl). This (in specific circumstances) may result in the contraction of an area within the Ecological District upon which the magnitude of effect is assessed against. Therefore, the Ecological District above 1,100 m asl remains an appropriate scale for assessing the extent and effect to comparable ecological values.

15. It is noted that the approach to characterising ecological values at the level of the biologically distinct vegetation community is scientifically supported and best practice within the ecological profession. Numerous approved FTAA Projects use this approach; examples include but are not limited to: Foxton Solar Farm, Southland Wind Farm, Kaimai

Hydro-Electric Power Scheme Re-Consenting, Waihi North Project, Ashbourne Development, and Maitahi Village, Kākā Valley, as well as various applications in progress including: Parkburn (Luggate-Cromwell Road), (https://www.fasttrack.govt.nz/).

16. Based upon the information provided above (**paragraphs 8 – 15** of this memo), it is our opinion, that the application of scale undertaken by Dr Walker is too narrow and overstates the ecological impact of the project, relative to the ecological context.

Random Forest

17. Dr Walker contests the application of the random forest (**RF**) GIS used to provide reference to the ecological values present across the Ecological District above 1,100 m asl (**paragraph 66**). The limitations of the modelling used are stated in the e3s document titled 'Remarkables Upgrade and Doolans Expansion TEcIA Stakeholder Response (DOC)' (dated 26 August 2026). For completeness, it is noted that it has not been assumed in its use within the TEcIA that the output of the RF model provides perfect Ecological District scale accuracy, nor has it been used in isolation of sound ecological judgement. Rather, it has been used as a tool and indication of comparable ecological values. In our opinion, when using this mapping as a tool, it adds greater understanding to current standard methods of assessing the magnitude of effect implemented by ecologists within Ecological Impact Assessments, which are highly qualitative. The intention of undertaking a level of geospatial analysis against comparable vegetation communities within an area recognised to contain comparable ecological values (the Ecological District above 1,100 m asl), is to provide an increased level of understanding when assessing the magnitude of effect compared to standard methods.

18. In acknowledgement of the limitations of the RF model, we acknowledge that the following actions were undertaken to manage bias associated with the training data and its position within the Ecological District.

    (a) Use of training data to extrapolate percent of occurrence within coarsened vegetation classes (e.g. wetlands) are acknowledged to introduce bias in the presence of a wetland subclass. Therefore, percentage of vegetation communities lost within the Ecological District is presented at two levels, the Singers and Rogers ecosystem types and the mapped vegetation communities resulting from e3s data.

(b) Assessment of individual units by expert interpretation via aerial imagery of areas beyond the surveyed training data area and manual correction and/or re-running of models based upon correction data.

(c) Splitting of RF analysis across two representative elevations (>1500 and 1500 – 1100 m asl) where specific ecological communities are restricted. Therefore, limiting the over-estimation of vegetation communities that only occur within one elevational range.

(d) Use of wetness index, DEM slope analysis, and flow accumulation modelling for identifying tarns and wetlands (which were overlaid and compared against model outputs rather than incorporated directly into the model).

19. While these measures improved the overall accuracy of the modelling, the resulting output does not present a perfect representation of all vegetation types; rather, it provides a tool for an estimated quantification of the relative extent of individual vegetation types across the Ecological District (above 1,100 m asl). The RF output was not intended to independently define final ecological unit boundaries; rather, it forms one component of a broader assessment process, and its outputs have been considered alongside other evidence. Accordingly, this output should be interpreted as one of several inputs used to inform the magnitude of effect. Additional considerations include expert interpretation, local ecological knowledge, comprehensive field studies within the study area, and comparison to data sets and aerial imagery displaying similar vegetation classes.

Naturally Uncommon Ecosystems

20. Mr Dale, on behalf of Kā Rūnaka, and Dr Walker make multiple reference to specific Naturally Uncommon Ecosystems (**NUEs**). Although Mr Dale's comments do not reflect the same intention towards use of NUEs as Dr Walker, it is noted that the following discussion regarding NUEs addresses Mr Dale's Statement of Evidence (**paragraphs 25, 84, & 87**) and Dr Walker's Statement of Advice (**paragraph 10, 30, 56 – 60, 67 – 73**).

Moraine

21. We acknowledge that the late glacial moraine feature identified by Mr Barrell, on behalf of the DOC, is a moraine (**paragraph 17 - 19**) that may be recognised under the Naturally Uncommon Ecosystem classifications (Holdaway *et al*., 2012) dependent on the age and structural composition thresholds applied to the definition provided by Williams *et al.*, (2007).

22. Dr Walker describes a second feature as 'moraine bench'. Mr Barrell does not specifically identify this location as a moraine bench. Although GNS maps identify this feature's parent material as glacial deposition consisting of till (GNS Science, n.d.), this does not automatically qualify this landform as 'moraine' under the NUE classifications (refer to **paragraph 23** below).

23. Dr Walkers characterisation of the bench feature within the 'moraine' NUE is not supported by Brownstein *et al.,* (2025) or the definition of 'moraine' provided by Williams *et al.,* (2007) in its initial classification. With specific reference to directly comparable landforms, Brownstein *et al.* (2025) review of NUE's explicitly states: "*although the geomorphic origin of these sites is moraine, the soils are far too developed to fit within the definition of moraines in Williams et al. (2007), which is 'raw–recent/cobbles–boulders/moraine' (Figures A5.2 to A5.6). If the concept were this broad these would not be naturally uncommon*." The full document (Brownstein *et al.*, 2025) is attached to this memo as Appendix A. Mr Barrell's Statement of Evidence (**paragraph 19**) supports this, stating "*[a]part from the late-glacial moraines, I consider that the Doolans Creek Right Branch Basin does not contain any rare or unusual geomorphological features, in the context of The Remarkables and adjoining mountainous areas*."

Alpine Deflation Surface

24. Dr Walker describes two further areas as 'alpine deflation surface' (**paragraph 57**); these are located in two different locations, one atop Helicopter Ridge and another in what is described as a 'wind touchdown' area near the proposed base building. Dr Walker defines the features as areas '*which are wind-scoured fell-fields that are regularly blown free of snow in the winter, often where wind is funnelled and strips snow from exposed saddles and localised sites in leeward valleys, subjecting the vegetation to unusually severe winter cold stress.*' The area described as a 'wind touchdown' alpine deflation surface (**paragraph 57**) is biologically distinct from Helicopter Ridge and directly comparable to all of the Cushionfield vegetation community within the surrounding landscape. Specifically, the 'wind touchdown area' and all other areas depicted as 'Cushionfield' reflect comparable assemblages of plants, soil depths/structure, and geological and climatic occurrence. Hence, it has been mapped as such within the TEcIA. Furthermore, the prevailing wind direction is from the northwest, funnelling through the Rastus Burn, hence why the north-west side of helicopter ridge experiences greater wind speeds and exposure. Comparatively, the Doolans Basin (within which the 'wind touchdown' area is located) is considerably more sheltered with mild easterly winds providing the required direction to funnel through the Doolans Right Branch to this

location. Furthermore, the benched landform creates noticeable uplift in the wind prior to making contact with the feature, in turn missing its location.

25. Mr Dale on behalf of Kā Rūnaka also provides reference to alpine deflation surfaces, however, the classification that Dr Walker and Mr Dale use is not a published nationally recognised NUE. Furthermore, the very recent review by Brownstein et al. (2025) of potential additions to the NUE framework includes no mention of 'alpine deflation surface(s)' or any comparable ecosystem. e3s therefore do not consider the inclusion of 'alpine deflation surfaces' appropriate.

26. Dr Walker further classifies Helicopter Ridge as an area containing 'screes of acidic rock'. The Bioeconomy Science Institute (formerly Landcare Research; BSI) (2026) defines this classification as "Screes comprise loose, mobile rock, mostly smaller than boulders, lying on steep slopes (30-40°)." We do not consider Helicopter Ridge to be consistent with this definition. The substrate surface does not show evidence of active migration. The vegetation has formed across a relatively stable, shingle surface with a gentle slope and flat saddle. Furthermore, notable floristic species typical of 'screes of acidic rock' are not present.

Ephemeral Wetland – Tarn 3

27. Dr Walker classifies Tarn 3 as an ephemeral wetland. However, the evidence provided to substantiate its characterisation as a wetland has not been provided by Dr Walker and is unclear. Further, the classification of the Tarn 3's wetland status has been by Dr Kavazos (**paragraph 52 - 54**) and Mr Rossaak (**Section 3.1, Paragraph 2**) and is addressed in **paragraphs 39 – 43** of this memo.

Screes of acidic rock

28. Dr Walker's addendum identifies the location of two isolated areas of scree that the proposed access trail traverse **(paragraph 15 - 21**). It is Dr Walker's opinion that the proposed tracks, trails and retaining walls will result in reforming and stabilisation of the screes, therefore removing the function of the naturally dynamic scree slope ecosystem. Although alteration of the vegetation community supporting the NUE will occur and has specifically been identified in the TEcIA, we disagree with the weighting given by Dr Walker to the change as this is not undertaken at the scale of the assessment specifically identified in Dr Walker's Statement of Advice (**paragraph 47 – 54)** or that of e3s (**paragraph 8 – 15**). Furthermore, contrary to the approximately 1,000 linear metres of screes of acidic rock identified by Dr Walker (inferred based upon the Dr Walker's markup provided in **paragraph 18, Figure 2**), only 550 linear metres actively intersects the

landform consistent with the scree field. We consider that the TEcIA appropriately identifies the occurrence of the NUE within the Rockfield community (Section Table 9 of the TEcIA; noting that not all areas of within the identified Rockfield vegetation community are consistent with the description of 'screes of acidic rock') and have provided weighting to the overall ecological value assessed to that specific vegetation community. This has been carried through the TEcIA assessment and is appropriately addressed given the magnitude of effect and widespread occurrence of the landform.

String Mire

29. We recognise the presence of the string mire identified within the bench feature, located at approximately 1,600 m asl. We agree with Dr Walker (**paragraph 48**) and Dr Kavazos' (**paragraph 128**) assessment of the landform and note it has been intentionally and specifically avoided. Given it is not being directly impacted, and no adverse effects are expected to occur within the system as a result of the proposed works, it is not included within the impact assessment. It is further noted that the string mire is incapsulated within an area of cushion bog that is otherwise already described as a NUE in the TEcIA. The associated cushion bog system is also being specifically avoided and other than a one isolated area, generally has more than 30 m of tussock grassland buffering it from the nearest point of proposed direct disturbance. Therefore, any further inclusion within the TEcIA would not materially affect the assessment of adverse effects.

Use of Naturally Uncommon Ecosystems

30. We disagree with the weighting and separation of NUEs from the ecological context of the vegetation communities as used by Dr Walker (**paragraph 10, 30, 56 – 60, 67 – 73**). Singers and Rogers (2014) provide a comprehensive classification of New Zealand's terrestrial ecosystems, using primary (temperature), secondary (moisture), and tertiary (landform and soil) environmental drivers to distinguish ecosystems where these factors, in combination with their associated biota, result in ecologically distinct communities. Landforms are an important contributor to the formation of distinct ecosystems; however, their ecological relevance is dependent on the relationship between the physical environment and its associated biological communities.

31. Holdaway *et al*. (2012) similarly assess New Zealand's NUEs building on a classification framework that uses physical environmental characteristics to distinguish ecosystem types. These characteristics include landform, substrate, soil properties, drainage and climate. While these physical characteristics can support specialised and distinctive biological communities, the presence of a particular landform does not, in itself, demonstrate that a site supports a distinct or otherwise significant biological community.

32. We recognise the importance of protecting NUEs and maintaining viable populations of indigenous species and ecological communities. However, the identification of a feature as a NUE should inform, rather than replace, an assessment of its actual ecological characteristics and values. In the TEcIA, weighting has been assigned to NUEs as part of the ecological values assessment. Dr Liddell acknowledges this (**Section 4.6**) stating "the status of different vegetation communities as NUEs does not change their assessed ecological value, as they are already assessed as having a "High" or "Very High" rarity score. We agree that the assessed ecological values for NUEs remain appropriate."

33. We consider that the application of this weighting should distinguish between features that support demonstrably distinctive or specialised ecological communities and those identified primarily by their physical or geomorphological characteristics, where corresponding ecological distinctiveness has not been established.

34. Accordingly, the value of a feature as a NUE should be considered alongside its vegetation composition, indigenous species assemblages, habitat values, ecological function, condition and representativeness within the relevant assessment context. This approach does not diminish the importance of naturally uncommon physical environments; rather, it ensures that the ecological values attributed to a feature, and the consequent weighting given to avoidance, are proportionate to the ecological characteristics present.

35. The national classification of NUEs provides an important mechanism for identifying and recognising NUEs. However, a national classification does not necessarily establish the ecological value, condition or significance of every individual occurrence at a smaller scale. Consistent with the EIANZ Guidelines, ecological values should be assessed having regard to the characteristics of the affected ecological feature and the spatial scale relevant to that feature. National classifications and wider ecological context provide important supporting information but should not supersede the assessment of ecological values at the relevant assessment scale. Consequently, the designation of a feature as a NUE should not, in isolation, determine its ecological value or the weighting applied to avoidance; rather, this designation should be considered alongside the site-specific ecological evidence and the nature and magnitude of the effects.

Effects on Wetlands

36. Dr Kavazos (**paragraph 52 - 54**) and Mr Rossaak (**Section 3.1, Paragraph 2**) consider Tarn 3 to be a natural wetland, primarily on the basis of the RMA definition (Resource Management Act, 1991), citing the presence of macrophytes and zooplankton,

together with fluctuating water levels attributed to surrounding groundwater levels. However, the rationale of the wetland delineation protocols (Ministry for the Environment, 2022) have not been applied, and the evidence presented does not describe the extent to which the vegetation exhibits hydrophytic characteristics or otherwise demonstrate that Tarn 3 supports a natural ecosystem of plants and animals adapted to wet conditions.

37. The RMA (1991) defines a wetland as "*includ[ing] permanently or intermittently wet areas, shallow water, and land water margins that support a natural ecosystem of plants and animals adapted to wet conditions*". The presence of a waterbody or persistent inundation alone does not necessarily establish that an area is a wetland; the ecological characteristics of the feature must also be considered.

38. It is our opinion that the Tarn 3 feature is an alpine tarn (not a wetland), noting that the presence of open water and associated hydrology is consistent with this landform. Johnson & Gerbeaux (2004) specifically describe tarns as "small mountain lakes". Brownstein (2025), provide additional clarification stating "[a] tarn is defined as a small mountain lake, especially one that collects in cirque basin behind risers of rock material or in an ice-gouged depression" and further stipulating "Although 'tarn' is not a wetland type (rather it could be one of several types), New Zealand wetland ecologists generally use the term to mean a small body of water in the uplands".

39. Our tarn (not wetland) characterisation is further supported by:

(a) The substrate within the area subject to water-level fluctuations comprises schist-derived shingle and other coarse mineral material, with localised deposits of finer sediment, particularly within the central depression where water pooling appears more persistent. This substrate is consistent with the site's location within a late-glacial moraine (as identified by Mr Barrell) and the input of highly mobile, non-organic scree material from upslope, which directly feeds the upstream ephemeral creek. These observations are relevant as it establishes the absence of hydric soil.

(b) During the 2025 survey, no vegetation was observed within the area inundated at the time of the survey. Elsewhere within the wider extent of the tarn which receives more periodic inundation, vegetation occurred only in scattered patches, with estimated total cover of less than 1%. The species recorded included *Viola cunninghamii* (FAC), *Acaena saccaticupula* (FACU) and *Wahlenbergia albomarginata* (FACU), with lesser amounts of *Cardamine corymbosa* (FAC (Clarkson, Fitzgerald , Champion, Forester , & Rance , 2021))

and other herbaceous species. The vegetation community is therefore sparse and predominantly comprises species with facultative or facultative-upland wetland indicator ratings, rather than clearly developed hydrophytic vegetation.

(c) The vegetation evidence does not support classification of the tarn as a wetland. In accordance with the New Zealand Wetland Delineation Protocols (Ministry for the Environment, 2022), the assessment must also consider the presence or absence of hydric soil indicators and wetland hydrology, particularly where hydrophytic vegetation is absent or inconclusive. On the basis of the observations described above, the main open-water body is assessed to be an alpine aquatic habitat presenting no conclusive evidence of 'wet adapt' species or the development of hydric soils.

40. This characterisation is further supported by Dr Liddell (**Section 4.1, Paragraph 2**) and Dr Bramley (**paragraph 24**), who both agree with e3s' classification and the rationale regarding why Tarn 3 does not qualify as a wetland, on the basis that survey of the area has confirmed that it does not include "a natural ecosystem of plants and animals that are adapted to wet conditions".

41. Mr Rossaak agrees (**Section 3.1, paragraph 1**) with the Very High ecological values assigned to all the wetland vegetation communities in the TEcIA.

42. Mr Rossaak notes (**Section 3.2, paragraph 1**) that no cumulative total of both tarn and wetland habitat loss has been provided within either the TEcIA or FEcIA. This is intentional given the distinction between terrestrial and freshwater disciplines and the respective values associated with each report. This is supported by Brownstein (2025), who advocates for the reclassification of 'tarns' to 'tarn margins', recognising that the framework specifically pertains to terrestrial ecosystems.

43. Mr Rossaak further notes (**Section 3.2, paragraph 6**) that e3s "declined to assess [direct] wetland loss as an effect separate from vegetation loss". We took this approach principally, because the extent of wetland loss is directly comparable to the loss of the wetland vegetation communities and providing an additional assessment of wetland loss would add additional residual adverse effects that have already been assessed within the TEcIA.

44. Mr Rossaak (**Section 3.3, paragraph 2**) challenges the level of avoidance and remediation undertaken during the site selection and masterplan development stages, stating "*[t]here is, however, no ecological comparison of track alignment options or*

consideration of the no-go option, with the applicant stating that avoidance options for the trail alignment were "already exhausted" before effects were assessed". We understand the evidence of Ms McQuillan and Attachment A to Part A.21 of the Substantive Application addresses the plans and decisions for avoidance, minimisation and where not possible the functional need for specific alignments to locate where they are proposed.

45. Mr Rossaak (**Section 3.3, paragraph 3**) states "[c]rossing designs are deferred to after consent". However, Mr Rossaak notes that the crossing designs "are to be approved by a hydrologist and ecologist engaged by the applicant. If checks fail, the only consequence identified is non-compliance and remediation". Various applicable designs have been produced by Stantec (Stantec New Zealand, 2025); site specific designs must be designed and implemented at each location, specifically accounting for the hydrological movement at each crossing. Therefore, providing specific specifications that must be achieved prior to implementation, which in our opinion is a feasible and achievable requirement. The retention of wetland hydrology across all crossing locations is integral to the assessment of effects and must be maintained. If an initial inspection identifies that wetland hydrology is impacted, the area must be remediated to ensure that this is achieved. Failure to do so would result in extensive adverse effects in interconnected downstream locations (and non-compliance with the resource consent conditions).

46. Mr Rossaak further notes (**Section 3.3, paragraph 2**) that "[n]o performance triggers are defined". We note that Table 18 of the TEcIA specifically sets out that "[a]ll wetland and stream crossing designs will be reviewed by a Hydrologist and Ecologist and approved prior to any works commencing and be inspected once complete to ensure the design is implemented correctly and is functioning as anticipated. Checks will ensure ecological and hydrological function is maintained; checks will be undertaken immediately after completion and again 12 months later by a Hydrologist and Ecologist. Ongoing monitoring methods as specified below will ensure wetland hydrology is maintained:

(a) At each wetland crossing location photo monitoring points and vegetation quadrats (recording species cover) will be established both up and downstream to monitor ecological change in wetland vegetative composition.

(b) Monitoring will be undertaken on an annual basis for 3 years and then biennially for a further 4 years. The monitoring shall be undertaken by a suitably qualified and experienced ecologist. Where monitoring identifies an adverse effect on the

ecological function or composition attributable to the proposed works, the mechanism of effect must be remediated and monitoring restarted."

47. Specific thresholds can be set to define the term 'adverse effects on the ecological function or composition attributable to the proposed works'.

48. Mr Rossaak proposes a number of changes to the proposed conditions relating to wetlands. We agree with the Mr Rossaak's proposed changes to Conditions relating to 'Interpretation: Terrestrial Ecology Management Plan', ECO.4, ECO.9, ECO.33, ECO.34, ECO.35(a), (c),(d; only as it relates to vegetative change, rest is outside our area of expertise), and (e; only where the wetlands within 100 m downslope are hydrologically influenced by proposed work), ECO.36, ECO.37, ECO.40 (noting that measures will likely differ during and following the completion of works), ECO.41, ECO.42, 'New: wetland plant translocation', and EW.5. Further, although we broadly agree with ECO.8(d) it should be reworded to "physically mark out the wetland edge and setbacks (10 m) utilising delineated boundaries and indicators of onsite vegetation, soils and hydrology (consistent with the Wetland Delineation Protocols). Additional conditions are relevant to wetlands however, where they are not within our expertise (i.e. specifically relate to engineering concepts, hydrology, freshwater or water quality) we have not commented.

Loss of Terrestrial Habitat

49. Mr Dale (**paragraph 81**) states that that 13.8 ha will not be revegetated following initial disturbance. However, we note, of the 15.94 ha of proposed direct disturbance, up to 11.88 ha could be revegetated this is the area that is not otherwise required to be maintained for operational use, i.e. all hard structures (roads, buildings, reservoir, snow guns etc). The exact number with depend on onsite conditions and total translocation area.

50. Dr Walker notes that the non-vascular flora has not been surveyed (**paragraph 48, Table 1**). Surveying and assessment of non-vascular species has generally not occurred in Impact Assessments under the RMA and has had sporadic inclusion in FTAA applications to date. More recently, non-vascular plant surveys have become a more common inclusion in Terrestrial Impact Assessments. Notwithstanding the omission of non-vascular flora survey, it is expected that a similar non-vascular flora would be expected through the sub alpine and alpine zone of the Ecological District, especially given the similarly low level of disturbance across the Ecological District. It is therefore unlikely non-vascular plant species in the Doolans basin is unique to the proposed disturbance area.

Indirect Effects

Weed Encroachment and Management

51. Dr Walker disagrees that residual effect level will be reduced to 'Low' following the implementation of the required weed management plan (**paragraphs 114 – 116**). Specifically noting that this has not been achieved in the Rastus Burn (**paragraph 116**). The specifications of the proposed Weed Management Plan (WMP) for the Doolans require enhancement of weed management practices and specific control measures to achieve no new exotic species introductions to the wider landscape, and to control all existing exotic species to ensure no increase in current populations/distributions, which is greater control than we understand is currently required within the Rastus Burn. Table 18 of the TEcIA provide a number of specific controls that should be implemented within the WMP. To successfully implement the objectives as stated above the WMP will require:

    (a) Baseline survey to establish the species present and their respective occurrences in the respective vegetation communities;

    (b) Specific control measures and frequency of use to be specified and tracked across control and survey locations;

    (c) Ongoing monitoring for the life of the concession; and

    (d) Strict adherence to washdown and decontamination for use of machinery and vehicles for the construction operation of the ski field expansion.

(e) The details of (a) to (d) above shall be set out within the TEMP.

Increased Usage

52. It is Dr Walker's opinion (**paragraphs 98- 106**) that the TEcIA has underestimated the impacts of increased visitor usage, including summer visitor use. The TEcIA was assessed based on a description of works that did not provide for the proposed infrastructure to be used to transport ski field visitors into the Doolans Basin during the summer months. Similarly, the assessed proposal did not include the use of ski field infrastructure for mountain biking. NZSki has confirmed the gondola will not be used to transport mountain bikes.

53. The TEcIA explicitly recognises the risk of increased human presence, noting it is likely to be observed as a result of increased capacity of facilities as well as increased access to

the study area during both winter and summer months. Notably, presence of operational staff and infrastructure will be an ongoing presence year-round. It is noted that usage of the Doolans Basin already occurs (**paragraphs 3(b)(i) – 3(b)(iii) in this memo**), and heavily trafficked areas remain between the Remarkables base building and Lake Alta.

54. Potential effect from increased human presence include, a startling response or area avoidance behaviours by fauna. Similarly, increased foot traffic and human generated waste/litter may impact sensitive vegetation by trampling or smothering. These have been considered in the TEcIA, with the associated magnitude of effect ranging from Negligible to Moderate. Specific mitigation has been implemented in response to adverse effects greater than Low or where physical harm could be incurred by a protected species (Table 18 of the TEcIA).

55. Dr Walker further notes the potential impact of fugitive dust plumes on plants biological processes and risk of heavy metal induction via vehicular usage of the accessways (**paragraph 106**). The TEcIA specifically recommends that "[a]ll unvegetated trail surfaces are to be finished with large coarse rock rather than fine gravels." This is specifically designed to mitigate the potential risk of sediment mobilisation with a secondary purpose of controlling dust plumes. Furthermore, we understand that vehicular usage of the Doolans for the purpose of summer maintenance and operation with be limited compared to that of the Rastus Burn and is highly unlikely to receive enough high traffic and vehicular wear to be of specific concern to the health and persistence of vegetation at the scale of the assessment. Therefore, further inclusion within the TEcIA would not materially affect the assessment of adverse effects.

Snowmaking and Snow Grooming

56. The scope of the lodged TEcIA was the disturbance footprint as shown in Figure 2 of the TEcIA. No footprint was provided for additional snow grooming and snow making outside of this footprint, and thus was not within the scope of the lodged TEcIA. Retrospective consideration of these effects is addressed below.

57. Dr Walker (**paragraphs 78 – 84**), Mr Dale (**paragraphs 90 – 95**) and Mr Rossaak (**Section 3.2, Paragraph 5**) suggests that unrecognised ecological degradation to alpine soils may occur through mechanisms such as "inducing physical compaction, increasing soil frost depth, altering moisture regimes, elevating nutrient loads, and causing erosion and sedimentation" (Dr Walker, **paragraph 76**). If the proposed network of snowmaking was proposed within the wider proposed ski trail network, these effects may need consideration. We have identified one snow gun (depicted as 'recommended revision

of snow gun location' in Figure 9 (appended to this Memo)) where the location should be reconsidered due to the likely effect it would have on ecological values outside the direct disturbance footprint. Excluding this snow gun (which we do not support the location of), snowmaking is only proposed to support usage of the main ski trail and will be almost entirely contained within areas proposed to be disturbed and altered as a result of the construction works, which are areas already assessed as total loss in the TEcIA.

58. In response to Mr Rossaak (**Section 3.2, Paragraph 5**), we understand that no snowmaking is proposed within the string mire or cushion field area. Additionally, all areas of cushion bog that may be inadvertently subject to wind drift, slope towards the trail and will be highly unlikely to transmit adverse effects to the wider bog system.

59. We agree that it would be inappropriate to presume artificially made snow can be contained to the proposed disturbance footprint and accept that there is likely to be leakage of artificial snow entering the adjacent vegetation communities, for example via wind drift. However, the effect on ecological values is likely to be highly restricted in occurrence and will likely only result in minor alteration of the associated values within the ZOI. It is therefore considered to be a Negligible magnitude of effect at the scale of the ecological values (see **paragraphs 8 – 15** regarding the use of scale) present and would result in a maximum level of effect of Low.

60. Additionally, we agree with Dr Kavazos (**paragraph 198**) that no additives should be used in conjunction with snow making, noting that NZSki have confirmed no additives will be used.

61. As noted by Dr Walker (**paragraph 78 and 85 – 87**) and Mr Dale (**paragraph 92**), snow compaction could lead to changes in thermal and hydrological properties of the snowpack. Further, the mechanisms are not limited to the area of disturbance assessed with the TEcIA as a result of the area of groomed trails depicted on Figure 9 (appended to this Memo) outside the direct disturbance footprint. Snow density, thermal conductivity and length of snow retention have been found to increase, while porosity, permeability and water-holding capacity are decreased (Neumann & Merrimam, 1972). However, Schlochtern *et al*. (2015) do not establish evidence that is directly applicable to the different ecological processes, parent material and climate observed within the study area compared to that of the European study locations. This said, effects of ski field induced change on biological composition or habitat condition remain a knowledge gap both nationally and globally.

62. Meijer zu Schlochtern *et al*. (2015) synthesise international research identifying how ski-slope construction and management can affect alpine vegetation through vegetation and topsoil removal, soil disturbance, snow grooming and artificial snow supplementation. These activities can alter soil structure, porosity, nutrient availability and water storage, while changes in snow depth and compaction can influence snowmelt timing, soil temperature, freezing and growing-season duration. Such changes can affect vegetation cover, plant development and species composition, and may increase erosion susceptibility where vegetation and soil structure are disturbed. However, the direction and magnitude of these effects depend on the initial vegetation, soil, topography, snow conditions and management practices. The review draws predominantly on overseas alpine research and does not establish a maximum loss applicable to alteration of New Zealand's indigenous prostrate alpine vegetation, nor does it demonstrate that local changes necessarily translate into material changes in ecological character.

63. New Zealand-specific research provides important context. Wardle & Fahey (2002) monitoring at Treble Cone found lower live vascular vegetation cover on groomed cushionfields, but no statistically significant differences in species richness or composition between treatments and controls over the monitoring period. This demonstrates the need to distinguish reductions in live vegetation cover from demonstrated changes in species composition. The proposed development also restricts snowmaking to the physical disturbance footprint, where vegetation removal will occur, and as we understand, do not propose additives in the artificial snow. Accordingly, additional snow-depth and snowmelt effects associated with snowmaking will be concentrated within the disturbance footprint, and effects specifically associated with additives are not anticipated. Changes to snow depth and meltwater timeframes only remain relevant within the area directly adjacent the snowmaking area where wind drift may occur or where snow is incidentally pushed to the edge of the direct disturbance footprint. These are considered to have a Negligible magnitude of effect against all effected vegetation communities when assessed at the scale of assessment. Grooming outside the disturbance footprint may still cause mechanical damage or alter snow compaction, particularly where vegetation is exposed by shallow snow.

64. Accordingly, the potential for ski-field management to affect alpine vegetation is acknowledged, but the significance of those effects should be assessed in relation to the actual disturbance and management footprints, the vegetation communities affected, their extent and condition, and their representation within the wider landscape. The international literature identifies potential mechanisms of effect but does not, in itself, establish that the proposed development will cause material changes in the

composition or ecological character of the wider basin or Ecological District. That conclusion should be informed by the site-specific ecological evidence and the extent to which effects on vegetation cover, composition and recovery are likely under the proposed management regime.

65. The findings of Wardle & Fahey (2002) within the nearby Treble Cone Ski Field concluded that "[t]he total species occurrence in any of the lifeform categories is not significantly affected by grooming, skiing, or control treatments in either 1997 or 2000, and no significant change in total species occurrence has taken place in that time." Wardle and Fahey (2002) also note that "[p]lants have different levels of vulnerability and ability to recover from the effects of snow compaction. The characterisation that determines their vulnerability are the timing of flowering, and growth form and size. Prolonged snow-lie adversely affects early spring flowering perennials and the ephemeral plants as they have a shorter growing season." It is further noted that no evidence was collected at Treble Cone that suggested artificial compaction resulted in the delay of snowmelt. Importantly, the timeframes for noticeable change in species composition is greater than most available research. Specifically change in species composition was not distinguishable on the nearby Old Man Range (Central Otago) for 32 years following natural change in snowpack characteristics (Wardle & Fahey, 2002). In our opinion, it is therefore logical to expect that the Remarkables could exhibit similar localised shifts in species composition and habitat value following long periods of prolonged snowpack alteration. It is noted that the specific outcomes of climate change are not well known and the species specific or composition reactions of the present ecological values under natural conditions including climate change cannot be known with certainty.

66. Dr Walker provides a draft monitoring approach for potential edge effects if the project is approved (**Addendum to SOA, paragraphs 25 to 30**). We agree that monitoring and (if necessary) management of edge effects would be beneficial. Although, we disagree on the scale of edge effects suggested by Dr Walker. The full detail of the monitoring design and management is outside what is possible in the current timeframes. However, this could be jointly worked through with relevant parties over time. At a minimum we would expect to see:

67. Given the lack of evidence and certainty as to how snow grooming and an altered snowpack may affect the ecological values within the proposed natural snow trail footprint (as depicted in Figure 9 appended to this Memo), we propose the following monitoring and adaptive management strategy. However, it is expected that adaptive management as described below (**paragraphs 66(a) – (h)**) is unlikely to provide sufficient mechanisms to rapidly halt any impacts, should they be incurred as a result of snow

making and grooming, particularly given the slow rate of growth and adaption of alpine specialist plants. Although change in management practices may result in the reduction to further loss or alteration of the respective vegetation communities and its associated habitat, these will not be realised for a number of years following the shift in management approach (likely experiencing a delay and period of continued decline, if successful). Therefore, where adverse effects are observed it can be assumed that the vegetation communities are highly unlikely to return to their pre-disturbed state and should therefore be anticipated within the compensation package:

Snow Grooming Controls

(a) A minimum snow depth of 40 cm is required within all areas of 'Groomed natural snow' (aside from where the underlying vegetation community is composed of Rockfield) on Figure 9 (appended to this Memo) before snow grooming can commence. Grooming must cease when snowpack reduces below a depth of 40 cm.

(b) No grooming of natural snow trails, aside from those where the underlying vegetation community is composed of Rockfield) can occur once certain snowpack conditions are reached in the surrounding Doolans Right Branch Creek upper basin; the thresholds relating to snowpack conditions are to be determined in consultation with an ecologist, hydrologist, and avalanche/snowpack specialist.

Snowmaking and Grooming Management Plan

(c) No later than six months prior to snow making or snow grooming occurring within the Doolans Basin ski area, the consent holder must prepare and submit an Operational Ecology Effects Monitoring and Management Plan to the Department of Conservation for certification.

(d) The objective of the Snowmaking and Grooming Management Plan is to identify how the potential adverse effects of snow making and snow grooming on the terrestrial ecology and biodiversity values are to be monitored and managed for the duration of these activities occurring.

(e) To achieve this objective, the Snowmaking and Grooming Management Plan must include:

(i) Detail of the monitoring to be implemented by the Consent Holder to monitor the effect of snow making and snow grooming;

(ii) Set out the trigger levels for remedial actions to be implemented if the monitoring shows adverse effects;

(iii) Document the remedial actions (such as rotating snow grooming or ceasing snow grooming) to be implemented by the Consent Holder if the monitoring identifies an adverse effect on vegetation communities where snowmaking and grooming is occurring; and

(iv) Set out the process for compensating for adverse effects if the monitoring required by (i) identifies an adverse effect, and the operational measures implemented (iii) do not reduce the adverse effects.

(f) The monitoring required by (e)(i) must include:

(i) Baseline vegetation plots must be surveyed before grooming starts on groomed trails and ungroomed control sites;

(ii) Baseline vegetation plots must be surveyed before snowmaking starts, and are to be located between the disturbance edge, extending out to 100 m.

(iii) Subsequent surveys must then be undertaken on an annual basis for the first five years following the commencement of snow grooming and snow making, and on a five yearly basis thereafter.

(iv) The surveys required by conditions (f)(i) to (f)(iii) must include the following requirements:

(A) For snow grooming: A minimum of ten control and ten affected (10 x 10 m) plots within each affected vegetation type. For snowmaking, a minimum of ten quadrats every 10 m out to 100 m on the transect; there must be a minimum of 10 transects across an altitudinal range.

(B) Each plot must permanently marked to be accurately repeated.

(C) Each plot must record presence and overall vegetative cover of every plant species across all present strata within the respective quadrats, suitable for comparison across years and suitable for detecting structural and compositional change in vegetative cover; and

(D) The surveys must be undertaken by a suitably qualified and experienced ecologist.

(g) The Snowmaking and Grooming Management Plan must document the remedial actions, and/or compensation to be implemented, if the monitoring shows vegetation change of affected plots shifts by more than 10% and is not similarly reflected in control plots.

Snowmaking and Grooming Management Plan Reporting

(h) The results of any long-term monitoring must be published in a peer reviewed scientific article every 10 years and then a final article at the end of the concession.

Invertebrates

Indirect Effects

68. Dr Watts, on behalf of the Department of Conservation, raises similar matters to that raised by Dr Walker regarding unassessed indirect effects on invertebrate populations (**paragraphs 28 – 61**). It is expected that given that the primary drivers of invertebrate health are soil, litter, and habitat quality and retention, the mitigation measures provided in **paragraph 65** above will also appropriately reduce the residual magnitude of effect to Negligible, resulting in Low level of effect attributable to Threatened invertebrate species and a Very Low level of effect against invertebrate species with an ecological value of High or lower.

Direct Effects

69. Excluding the matters raised in **paragraph 68** above, it is understood that Dr Watts and Dr Liddell broadly agree with the assessment of direct effects assigned to the 24 invertebrate taxa classified as Unclassified, Data Deficient, At Risk, or Threatened, noting that the effects vary by species and effect (**Dr Watts SOA paragraph 24 – 26; Dr Liddell Section 4.8**).

70. Dr Watts expresses that underlying abundance data should have been reported explicitly. Although Appendix D of the TEcIA provides some abundance data, specific abundance analysis was not undertaken. We have prioritised Unclassified, Data Deficient, At Risk, or Threatened species throughout the assessment of effects, assigning a conservative association based upon the location and habitats each species was identified within or suspected to inhabit. This is reflected throughout the mitigation and residual effects assigned to each species relative to the potential effect, and in turn,

likely provides an overestimation of the localities in which 'notable' species occur and the perceived effects. The prioritisation and conservative allocation to all potential communities negate the need for greater abundance data.

71. It is further noted that residual adverse effects are expected across a wide range of invertebrate taxa and various mechanisms of effects and the currently proposed remedial measures are not commensurate with the effect likely to be incurred, and compensation is required to address residual effects (which is discussed in the evidence of Dr Bramley). This is explicitly stated in the TEcIA (Table 18 and Section 7 of the TEcIA).

1.1.1 Lowest Resolution Taxonomic Units (LRTU's) vs Recognisable Taxonomic Units (RTU's)

72. Dr Watts (**paragraph 21**) noted the use of Lowest Resolution Taxonomic Units (**LRTU's**) vs Recognisable Taxonomic Units (**RTU's**). RTUs were used by the expert entomologists in the identification of collected specimens, and voucher specimens have been retained for every RTU perceived to differ from the University of Canterbury collections. While the use of RTU's was not explicitly stated within the TEcIA and each was not specimen placed within the datasheet into separate RTU groups, most of the RTUs were widely distributed, specifically where invertebrates were perceived to be potentially 'rare', effort was undertaken to highlight this (e.g *Huttonia* sp., *Pasiphila* sp.n).

Survey times

73. Dr Watts has expressed concerns regarding the timing of invertebrate survey efforts, although recognises the limitation in seasonal sampling practicality within alpine locations (**paragraph 22**). Also "accept[ing] that February–March sampling will detect a substantial component of the active alpine invertebrate fauna and that desktop review can provide useful information on taxa that may not be readily detected during field surveys" (**paragraph 22**). However, Dr Watts maintains that additional early or late seasonal sampling may detect additional species than those collected. Similarly, Dr Liddell (**Section 4.8**) acknowledges the limitations in invertebrate sampling period provided by e3s, although notes that additional sampling would provide more robust sample of collection data. We consider that the approach taken is acceptable and robust, in terms of the sampling window utilised, for the following reasons:

(a) For the target Lepidoptera species, the sampling period of February-March was preferable, falling well within the flight periods for the majority of taxa. This is similarly reflected for Orthoptera and Coleoptera taxa, with work undertaken during periods of weather when these taxa are active. Due to the nature of unfavourable and unpredictable weather conditions in alpine zones, weather windows were maximised within periods of favourable conditions.

(b) We note that sampling generally cannot be completed earlier or later due to extensive coverage of snow and variable wind and rain temperatures during spring and autumn months. Specifically, both sampling periods (2025 & 2026) observed isolated and persistent areas of snow with more extensive areas being prevalent prior to the dates the field work was undertaken on.

(c) It is acknowledged that there may be a small series of taxa which are under-represented by alpine sampling timeframes. However, as is common for Ecological Impact Assessments, this is dealt with via desktop review, with a larger range of additional taxa incorporated via desktop review, with a focus on identifying species with a threat classification greater than Not Threatened under the New Zealand Threat Classification System (**NZTCS**) and/or that are considered to be of ecological significance within the context of the Ecological District, and whose conservation may be at increased risk as a result of the project.

(d) Given the scope of TEcIAs and limitations in alpine sampling (discussed above), invertebrate surveys are never expected to detect all invertebrate taxa. Consequently, given these standard limitations, a desktop review was completed to support fieldwork surveys. The primary focus for both surveys and desktop review, was upon groups of invertebrates that can be quantitatively assessed under the NZTCS and those that may be susceptible to environmental change as a result of behavioural or life cycle dependencies.

74. Dr Liddell (**Table 1**) identifies two occurrences where both *Xanthorhoe frigida* and *Pyrausta comastis* have been identified as requiring further mitigation within Table 17 of the TEcIA and were not appropriately reflected in Table 18 of the TEcIA. This discrepancy was also identified by e3s following lodgement. We provide the following comment to address the matter:

(a) *Xanthorhoe frigida* has been reclassified in the lasted revision of the NZTCS (Hoare et al., 2026) from Threatened – Nationally Vulnerable to At Risk – Declining (reflecting a High ecological value score, rather than Very High). This has implications on the TEcIA assessment. Although this change was identified in Section 4.3.3 of the TEcIA this was not carried throughout when updated.

(i) With specific regard to the effect associated with operational noise, the now High ecological value and the Low magnitude of effect now results in a Low level of effect. It is therefore not required to be specified in Table 18 of the TEcIA.

(b) *Pyrausta comastis* should be reflected in Table 18 of the TEcIA with an assessed Moderate level of effect associated with operational noise. This magnitude of effect remains unchanged from that of Table 17 of the TEcIA, as no appropriate mitigatory actions were identified. Thus *P. comastis* does have a Moderate residual level of effect.

(c) The magnitude of effect specifically relating to the effect of light on *Xanthorhoe frigida* and *Pyrausta comastis* has not been consistently applied within Table 17 of the TEcIA. All other nocturnal species are expected to experience a Low magnitude of effect given the artificial lighting will predominantly occur during winter operations when these species are unlikely to experience detrimental effects. In autumn, only if due to unforeseen and uncontrollable circumstances that summer construction is delayed will there be lighting in the morning and evening. This reflects an error in the magnitude of effect applied to both *Xanthorhoe frigida* and *Pyrausta comastis* which should be stated as a Low magnitude of effect; therefore, reflecting a Moderate level of effect upon *Pyrausta comastis* (resulting from a Very High ecological value) and should be specified in Table 18. Similar to **paragraph 74(a)(i)**, the change to *Xanthorhoe frigida*'s threat classifications subsequently results in a Low level of residual effect associated with lighting effects. It is therefore not required to be specified in Table 18 of the TEcIA.

Avifauna

75. Dr Liddell (**Table 1**) challenges the residual effects relating to kea (*Nestor notabilis*) associated with noise and light effects. The rationale prior to mitigation is that "kea are highly intelligent and inquisitive birds that are likely to be drawn into unusual or new activities by noise and visual cues, including light and objects/structures. Without mitigation kea may cause direct or inadvertent harm to themselves and detrimentally alter their natural behaviour". Although light was unintentionally not included in Table 18, the effects of this are directly comparable to that of operational noise and increased human presence and skifield operation, noting that the unmitigated enticement to areas as a result of these mechanisms is the issue, not the mechanism itself. Mitigation has been provided for these potential effects within the TEcIA and is supported by both Mr Dale (**paragraph 66**) and Dr Weston (**paragraph 23**) with the addition of minor alterations suggested by Dr Weston (**paragraph 35**). Although the proposed mitigation for kea may help with kea interactions resulting from construction noise, the effects of the noise cannot be mitigated and therefore reflect a Moderate residual adverse effect as is stated in Table 18 of the TEcIA.

76. It is understood that Dr Weston generally agrees with the assessment of effects and is satisfied that the proposed mitigation is adequate and appropriately considered in regard to all three of the most affected avifauna species (**paragraphs 20, 21, & 23**). Further noting the limited scope for mitigating the loss of foraging habitat (**paragraph 18**).

77. Minor alterations and inconsistencies between the submitted documents were identified by Dr Weston (**paragraphs 24 – 35**). We agree with Dr Weston and specify the agreement and/or alterations required below:

(a) Table 6.4 of the Terrestrial Ecology Management Plan (**TEMP**) still says "'Relocate nests to adjacent undisturbed habitat where avoidance is not achievable" as a mitigation and management measure for falcon. We agree that this is not a feasible mitigation measure and was updated elsewhere in the Substantive Application to reflect a mitigation measure for direct effects on eastern falcon nesting that requires at least a 200 m setback around the nest to be established, with no attempted relocation of the nest proposed. We agree, the statement should be removed from the TEMP.

(b) Similarly, we agree that the TEMP should be updated regarding the mitigation measure relating to pipit nesting to reflect Resource Consent Condition ECO 22B part e) "Vegetation must be reduced within the disturbance footprint to a height of 20 cm in locations, identified by a suitably qualified and experienced ornithologist, where there is suitable pihoihoi nesting habitat."

(c) We agree with Dr Weston (**paragraph 28 and 29**), that pipit nest located in the late stages of the breeding cycle and where chicks are present but unfledged, works should avoid the area, applying a minimum disturbance buffer of 50 m until the chick(s) has fledged. This expected to be approximately 14 days on average.

(d) As noted by Dr Weston (**paragraph 31**), all documents should reflect "no longer than 5 days prior", in reference to the number of days prior to works beginning that nest surveys for pipit and falcon must be carried out.

(e) We agree with both of Dr Weston's comments regarding existing condition ECO.22A and ECO.22B (**paragraphs 33 & 34**). The existing terminology should be removed.

(f) Further, we agree alterations and additions suggested by Dr Weston (**paragraph 35**), specifically that "[all] measures should remain in place throughout the lifetime of the proposed permit, not just during construction".

78. Mr Dale references effects on cultural values (**paragraph 67**), noting that "[w]hile the proposed measures may adequately manage direct disturbance to nesting kārearea and pīhoihoi, this does not necessarily demonstrate that effects on the cultural values associated with these taonga species have been adequately addressed." We agree with Mr Dale's statement. Specifically, while some of these species have an ecological value assigned to them under the EIANZ assessment methodology, we have not attempted to assign a value for cultural purposes as this is a matter that is best addressed by mana whenua.

Alternative Reservoir Location

79. As part of the site selection and footprint design phase, e3s was asked to investigate an alternative reservoir location ('Option 2'), approximately 150 m northeast of Tarn 3. The proposed location ('Option 1') is situated within a natural cirque depression, otherwise referred to as Tarn 3. Figure 10 (appended to this Memo) shows both reservoir options and the earthworks associated with establishing access.

80. Detailed earthworks designs were not developed for Option 2 following a preliminary assessment of the terrestrial ecological values present. Accordingly, the access track shown represents the most likely alignment and the minimum anticipated disturbance footprint required to provide vehicle access. Given the steep terrain traversed by this alignment, additional cut-and-fill earthworks would likely have been required, further increasing the disturbance footprint.

81. An access alignment above Tarn 3 was not considered appropriate or practicable, as this would have traversed areas supporting *Pachycladon novae-zelandiae*, *Brachyscome longiscarpa* and *Raoulia hectori* var. *mollis*. These are all species that are sparsely distributed throughout the study area and represent some of the only individuals recorded by e3s. The unstable terrain in this area would also have presented a risk of indirect adverse effects on the tarn regardless.

82. Table 1 summarises the estimated direct disturbance to vegetation communities and other ecological features under each option. Option 2 was estimated to require approximately twice the total disturbance area of Option 1 (19,572 m² compared with 9,516 m²). Excluding the tarn and associated aquatic features, terrestrial habitat loss under Option 2 would be approximately 3.3 times greater than under Option 1.

83. The selection of Option 1 would avoid approximately 1.0 ha of additional direct disturbance relative to Option 2. This represents an important avoidance measure, reducing the extent of indigenous habitat loss and the associated reliance on mitigation, offsetting or compensation to address residual adverse effects. This is particularly relevant where effects on indigenous plant populations and specialised terrestrial invertebrate assemblages may already represent adverse residual effects (as shown in Table 18 of the TEcIA).

Table 1: Direct disturbance to various affected vegetation communities.

Vegetation Community	Ecological Value (as per the TEcIA)	Option 1 Area (m^2)	Option 2 Area (m^2)
Snow tussock grassland	Very High	2,279	15,967
Rockfield	High	927	331
Cushionfield	Very High	1,354	3,274
Tarn	Very High	4,880	0
Waterway	Very High	54	0
Rocky outcrops	Very High	5	0
Riparian wetland	Very High	14	0
Seepage	Very High	3	0
Total		**9,516**	**19,572**

84. The ecological survey recorded relatively high numers of *Carex kirkii* var. *kirkii* (At Risk – Naturally Uncommon) within the proposed direct disturbance footprint of Option 2. Without mitigation, this option would result in a reduction in the known population of this species within the study area, particularly given that it was generally recorded at low abundance in the surrounding snow tussock grassland. The larger disturbance footprint under Option 2 would also increase the potential loss of other high-value plant species associated with the Snow tussock grassland and cushionfield communities.

85. Although the magnitude of effects on the three most extensively affected terrestrial communities Snow Tussock Grassland, Rockfield and Cushionfield) may be comparable between options, the greater extent of disturbance under Option 2 would result in greater overall residual adverse effects.

86. Option 1 would result in the loss of limited habitat for avifauna and comparatively less terrestrial invertebrate habitat. Of the effected communities, the Snow Tussock Grassland and Cushionfield communities were recorded as supporting the greatest numbers of Threatened, At Risk, Data Deficient or Unclassified invertebrate species (12

and 7 species, respectively). The greater loss of these communities under Option 2 would therefore increase the potential for adverse effects on these invertebrate assemblages and increase residual ecological effects.

87. Option 2 would also intersect a known area actively patrolled by kārearea/eastern falcon (*Falco novaeseelandiae novaeseelandiae*), increasing the potential for disturbance or displacement associated with any nesting attempt. In addition, Option 2 would result in a greater loss of high-quality nesting and foraging habitat for New Zealand pipit.

88. Given the substantially greater direct vegetation and habitat loss associated with Option 2, indirect effects, including habitat fragmentation, construction noise, lighting and edge effects, would also be expected to be greater.

89. Overall, in e3s's opinion, Option 1 represents the ecologically preferable reservoir location in terms of terrestrial ecological values. This conclusion reflects the greater direct habitat loss, impacts on notable plant populations and potential disturbance to avifauna associated with Option 2. Further, Tarn 3 does not meet the criteria for classification as a wetland (**paragraph 36 – 40** of this memo) and it is not considered to make a material hydrological contribution to downstream wetlands, streams or wider ecosystem function. Accordingly, its presence does not alter the comparative assessment of terrestrial ecological effects.

90. It is understood that in response to comments from DOC, NZSki are exploring the potential of providing the water take from Lake Alta in addition to the existing take allocated from that location. We understand this addressed in the evidence of Ms McQuillan and Ms Badenhop. We do not comment on the hydrological, water quality, or freshwater ecological implications of this proposal as these matters lie outside our expertise. However, we provide the following high-level review, regarding the terrestrial ecological values likely to be impacted as a result. Based upon the assumption that all trenching will be located within areas previously disturbed or within the same alignment as the existing pipeline:

    (a) The proposal will result in a reduction to the direct disturbance footprint of terrestrial ecological values within the Doolans, specifically removing the disturbance associated with the water take access road and water storage infrastructure.

    (b) The proposed earthworks will be co-located within the proposed services trench into the Doolans to supply water as far as the base building. Therefore, the only

additional disturbance will be associated with upgrading of the existing pipeline from the top of the Alta Chairlift to Lake Alta).

(i) No formal survey of the additional work has been undertaken in association with the provided TEcIA. However, it will be located within an existing area that has already been disturbed (including a wetland) and had vegetation rehabilitation, which has regenerated well over a period of a number of years and provides a benchmark for what can be expected following remediation.

(ii) Provided the remediation efforts achieve similar results, as can be expected, we consider the associated magnitude of effect of vegetation/habitat loss could be Negligible. Specifically, as it can be expected to reflect similar baseline conditions both prior to and following disturbance (following an initial time lag in regeneration rates and isolated attrition).

(iii) This said, all mitigatory actions associated with vegetation and species-specific translocation, wetland hydrological function, monitoring, avifauna management, and erosion and sediment control will need to be implemented and adhered to.

(c) The brief summary of the terrestrial implications stated above (**paragraph 90**) does not account for unknown variables resulting from the lack of formal survey information in the area, and as such cannot be assessed fully without further lizard, invertebrate, avifauna and vegetation survey data and analysis.

91. The preceding discussion addresses the matters raised within the Statement of Evidence or Statement of Advice of DOC, CODC, ORC, and Kā Rūnaka Technical Experts in relation to the TEcIA prepared by e3s. The matters discussed above do not alter the overall conclusions and outcomes of the TEcIA, which remain valid unless otherwise stated. We acknowledge that the residual adverse effects requiring offsetting and compensation are addressed separately by Dr Bramley.

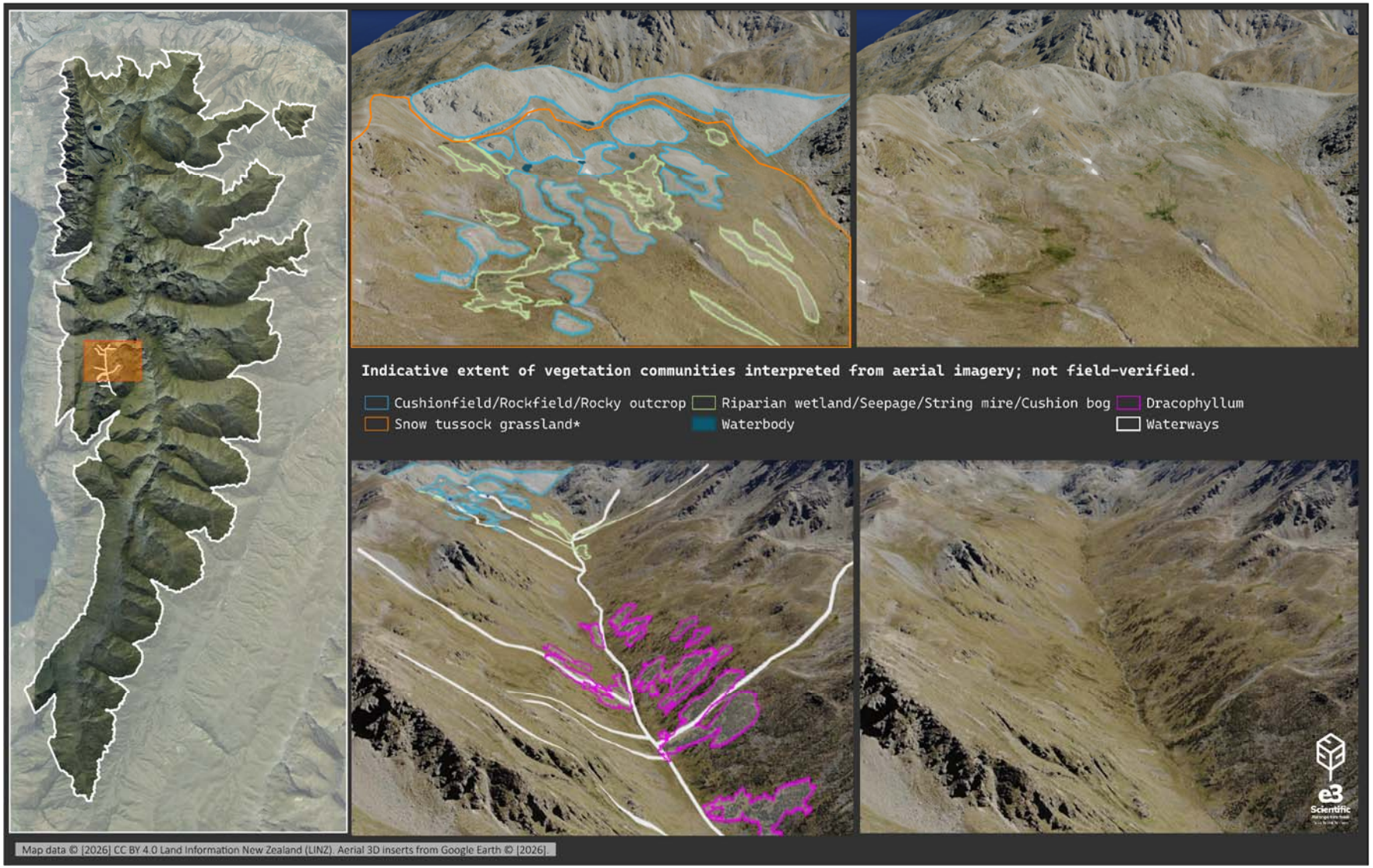


Figure 1: The location of an ecologically similar basin within the Ecological District above 1100 m asl, showing vegetation communities similar to the upper Doolans Right Branch basin, inferred from aerial review. The aerial images top left and right are the same (with and without polygons); the same applies for the bottom left and right aerial images. The 1100 m asl mark is shown by white outline. *Snow Tussock Grassland is in general the most common/dominant vegetation community between the other polygons.

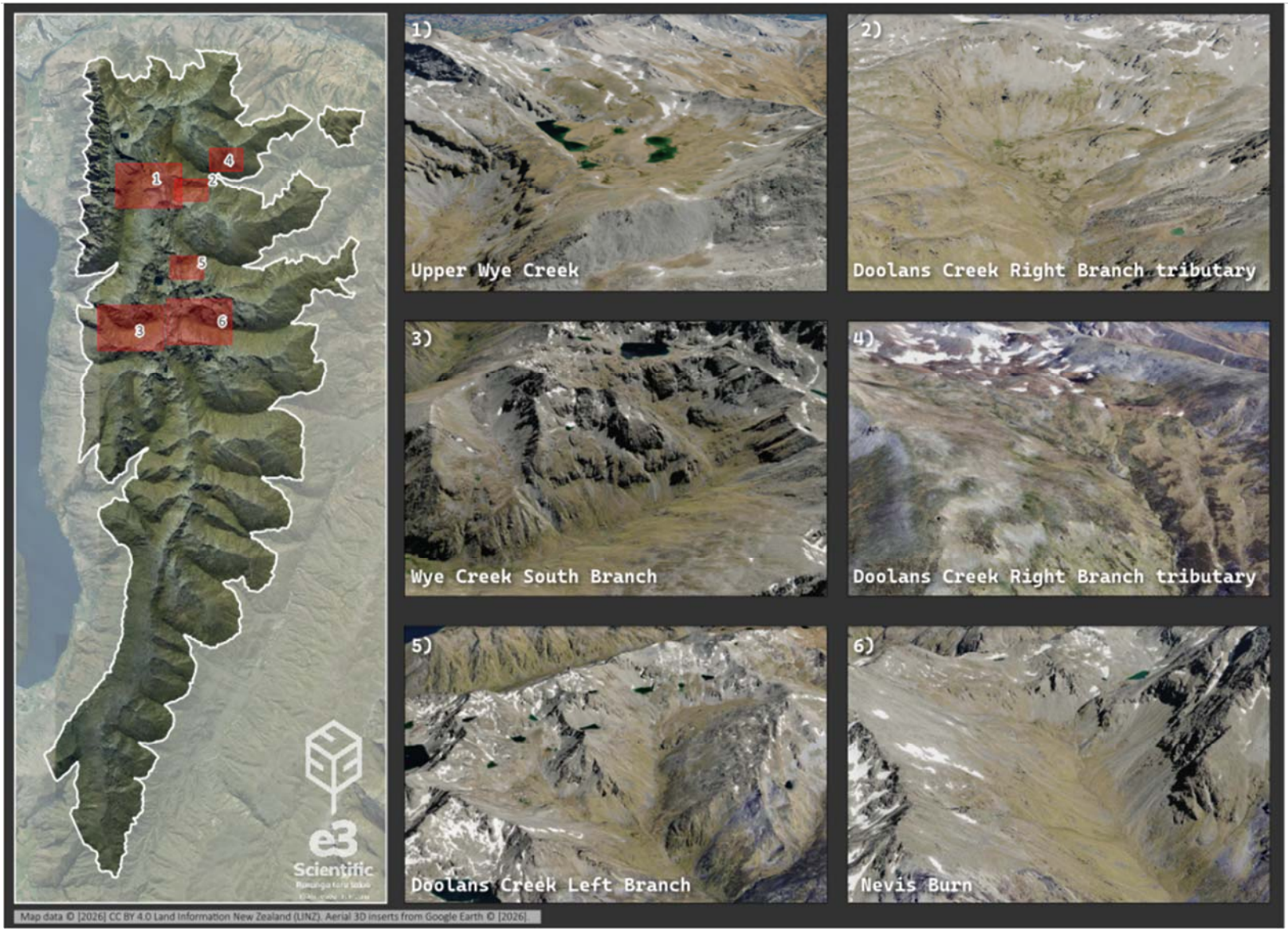


Figure 2: The location of multiple basins (1-6) ecologically similar to that shown in Figure 1a and the upper Doolans Right Branch basin, within the Ecological District above 1100 m asl (inferred from aerial review). The 1100 m asl mark is shown by while outline.



Figure 3: The location of multiple basins (7-10) ecologically similar to that shown in Figure 1a and the upper Doolans Right Branch basin, within the Ecological District above 1100 m asl (inferred from aerial review). The 1100 m asl mark is shown by while outline.

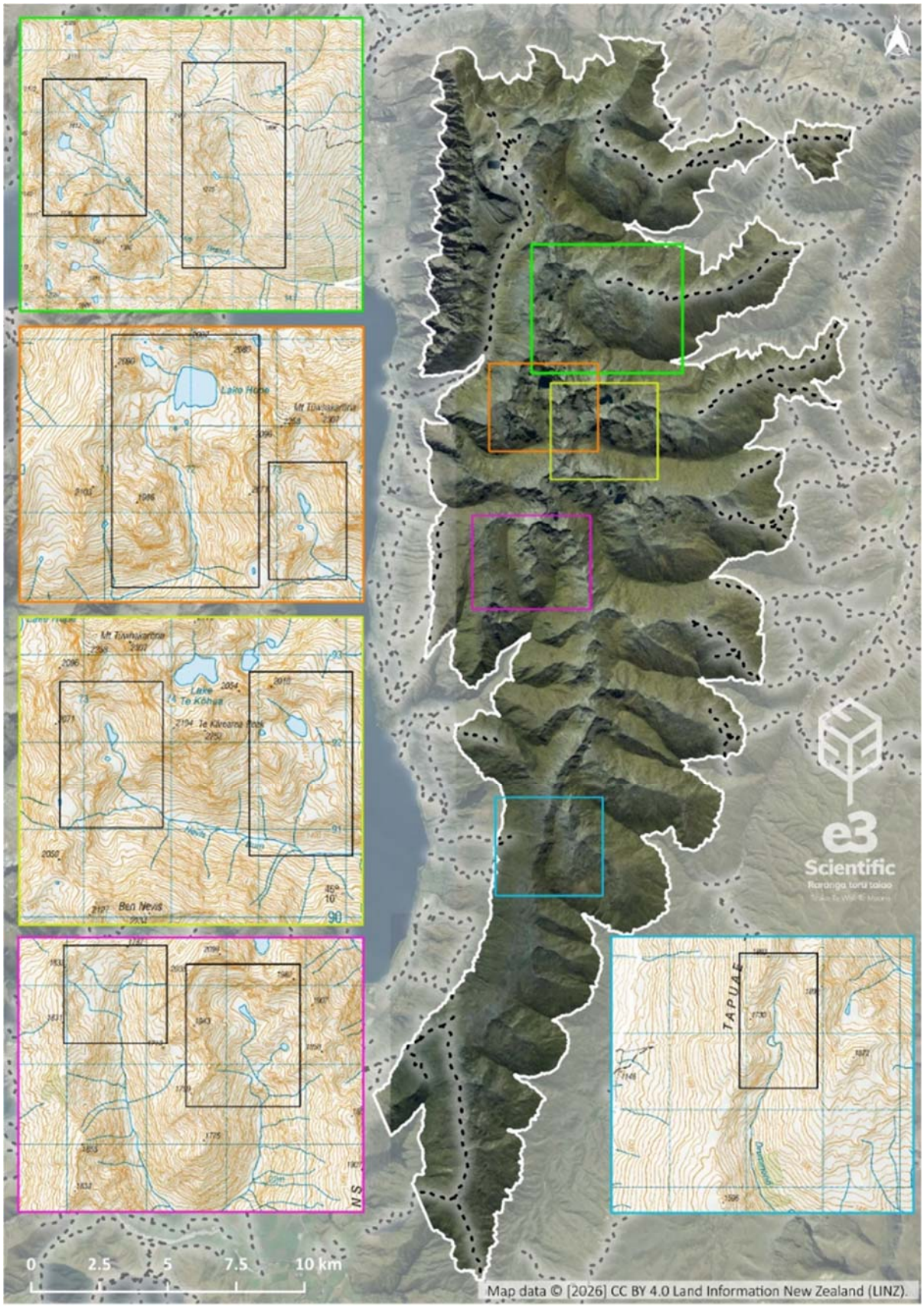


Figure 4: A selection of basins at high elevation with a southern aspect across the Ecological District. These include the upper Doolans Creek Left Branch, a mid-branch of the Doolans Creek Left Branch, Lake Hope valley and another to the east, the uppermost true left branch of the Nevis Burn, the upper left and right branches of Staircase Creek, and the upper end of Drummond Creek. The 1100 m asl mark is shown by while outline.

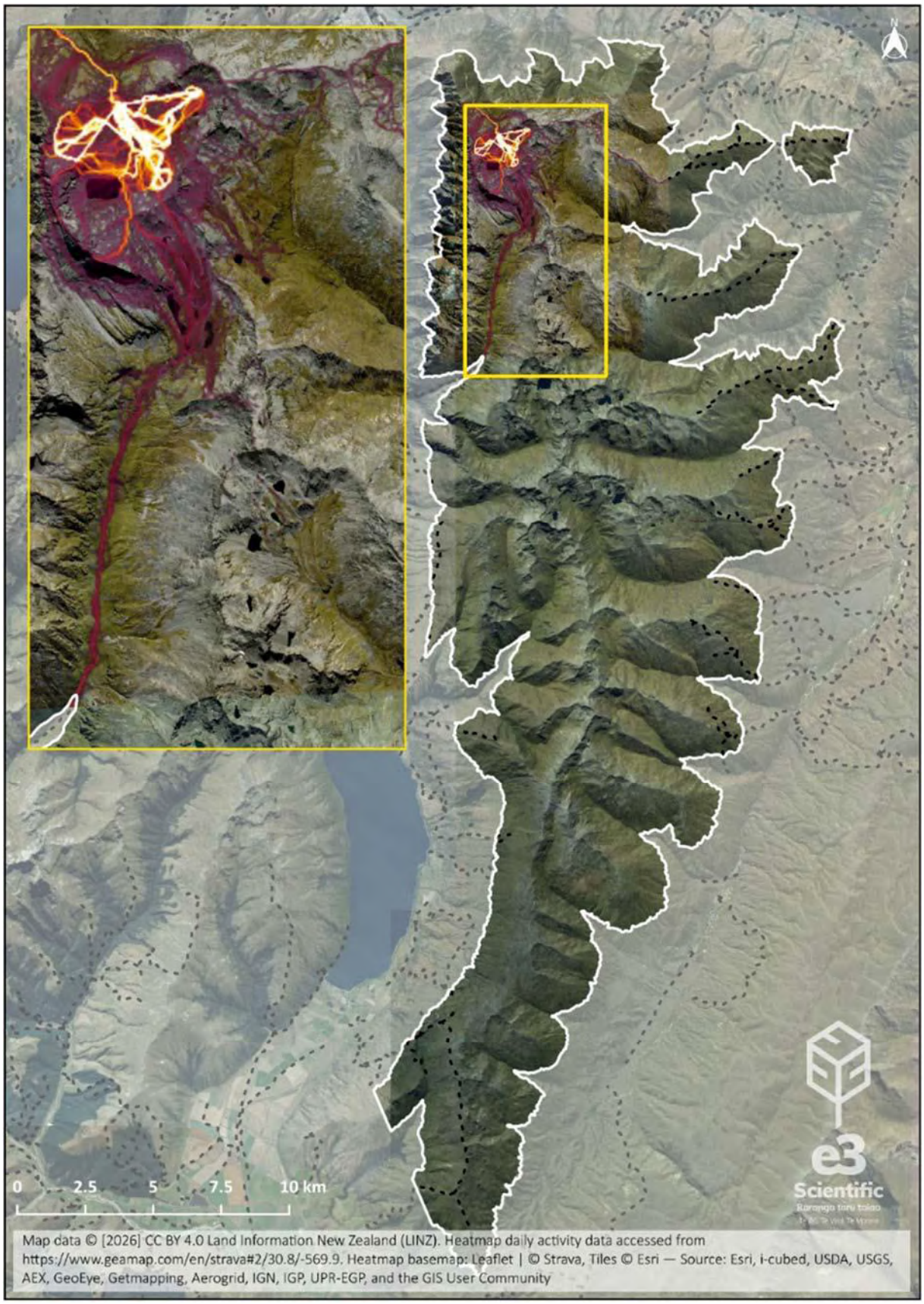


Figure 5: All tracked activity routes from Strava across the Ecological District above 1100 m asl. The 1100 m asl mark is shown by while outline. The brighter the colour the greater the number of activity routes.

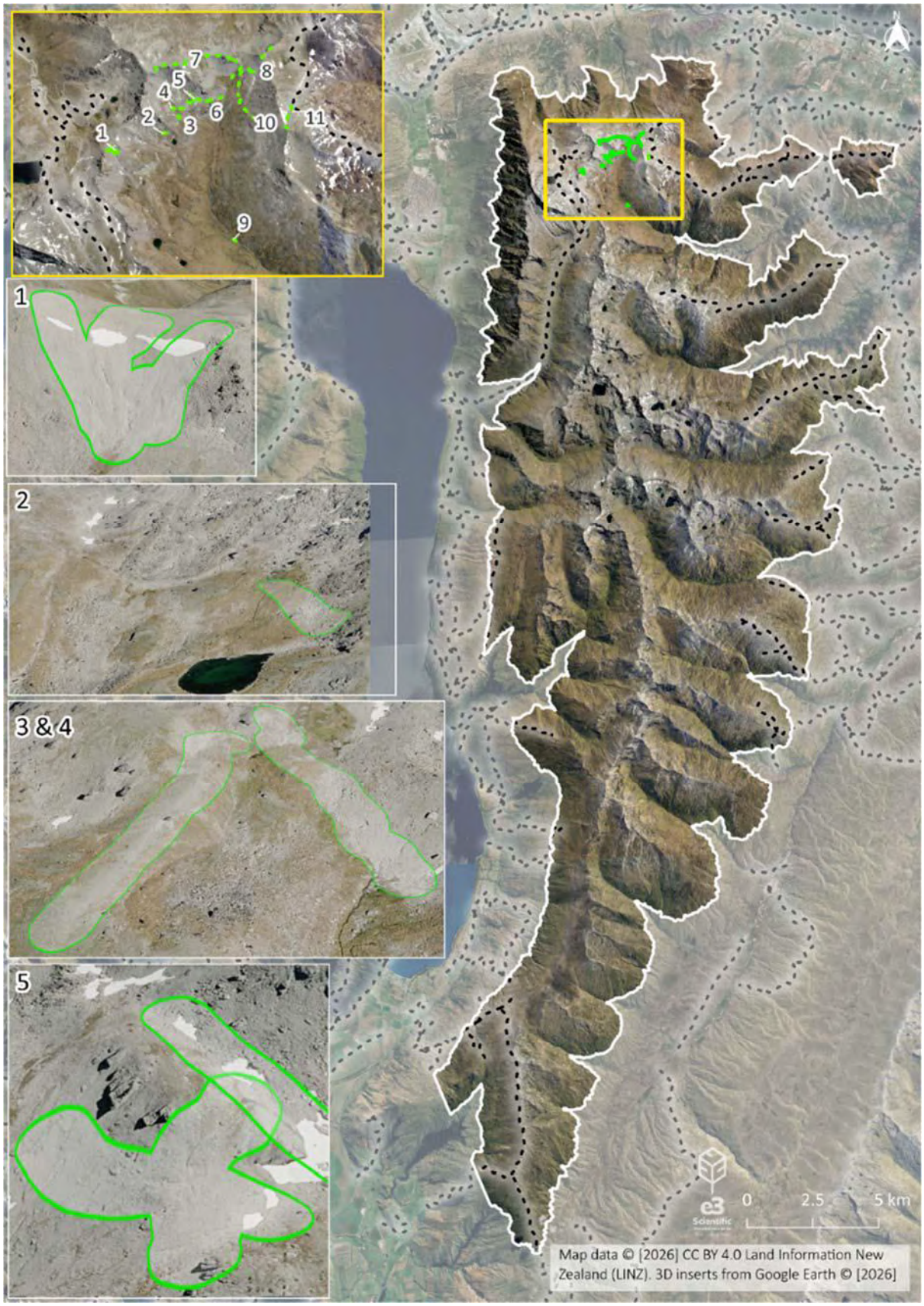


Figure 6: All deliberately formed routes of a lesser quality than a sealed road across the Ecological District (black dashed lines) and visible informal tracks (numbers 1 to 5) surrounding and into the upper Doolans Creek Right Branch basin (green dashed lines and insets) above 1100 m asl. The 1100 m asl mark is shown by while outline.

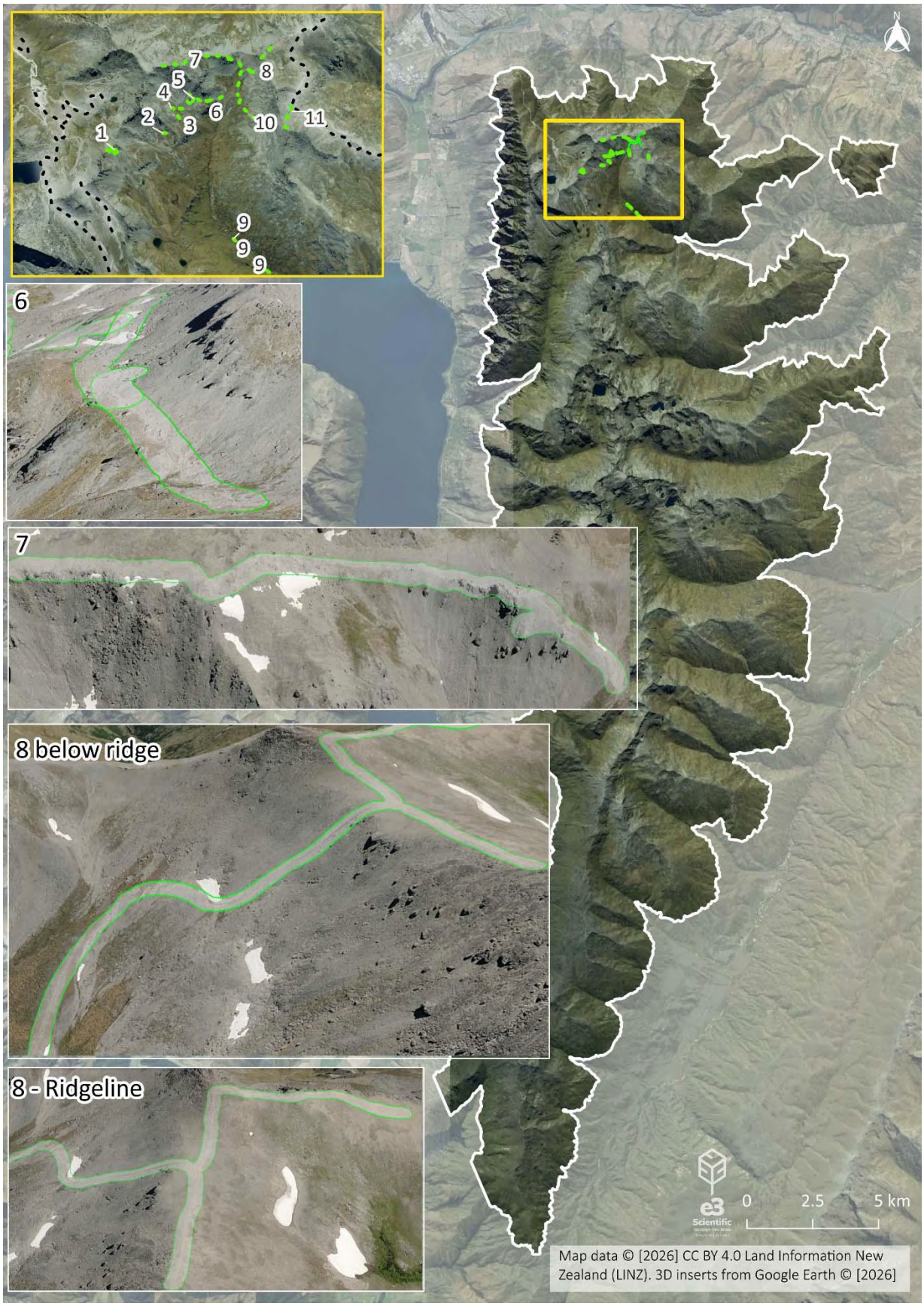


Figure 7: All deliberately formed routes of a lesser quality than a sealed road across the Ecological District (black dashed lines) and visible informal tracks (numbers 6 to 8) surrounding and into the upper Doolans Creek Right Branch basin (green dashed lines and insets) above 1100 m asl. The 1100 m asl mark is shown by while outline.

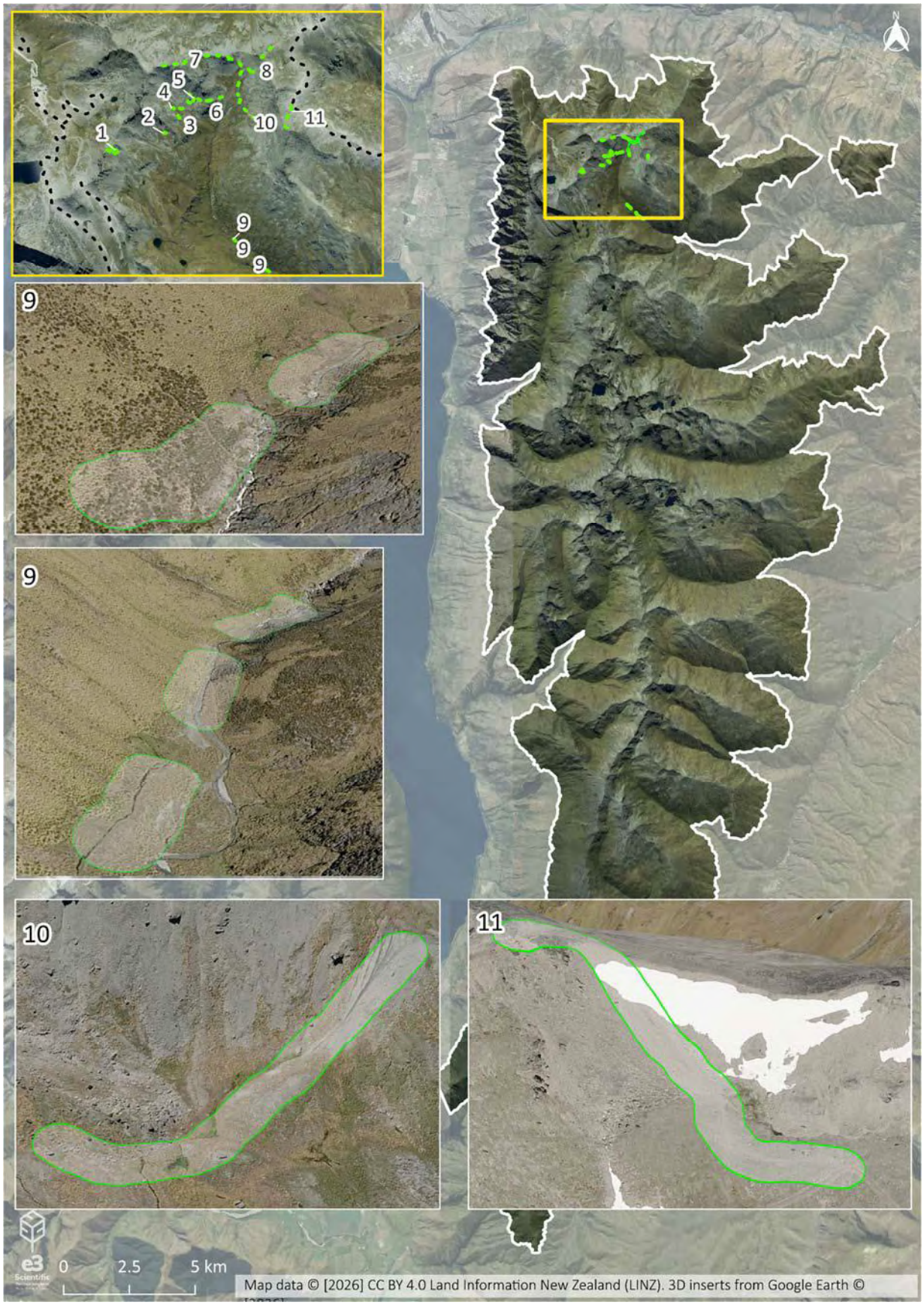


Figure 8: All deliberately formed routes of a lesser quality than a sealed road across the Ecological District (black dashed lines) and visible informal tracks (numbers 9 to 11) surrounding and into the upper Doolans Creek Right Branch basin (green dashed lines and insets) above 1100 m asl. The 1100 m asl mark is shown by while outline.

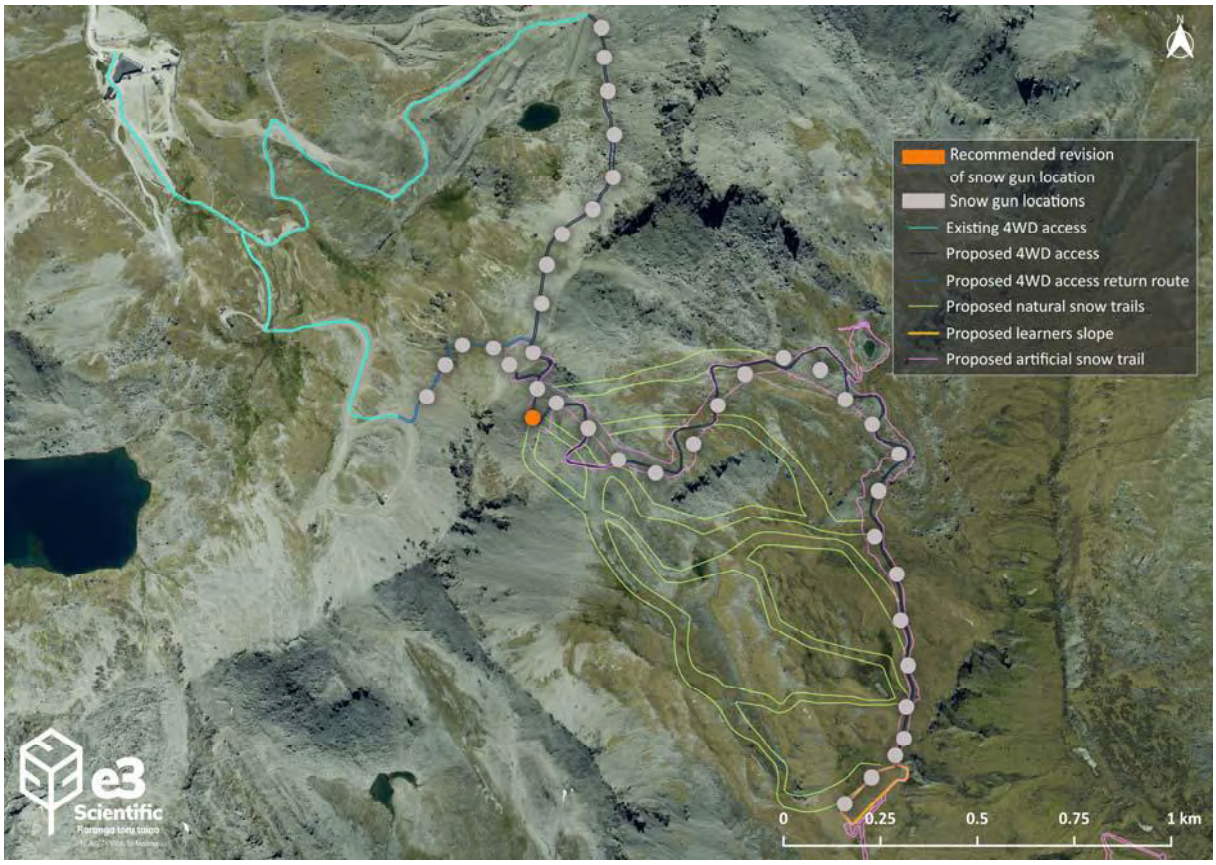


Figure 9: Proposed groomed trail network (green outline).

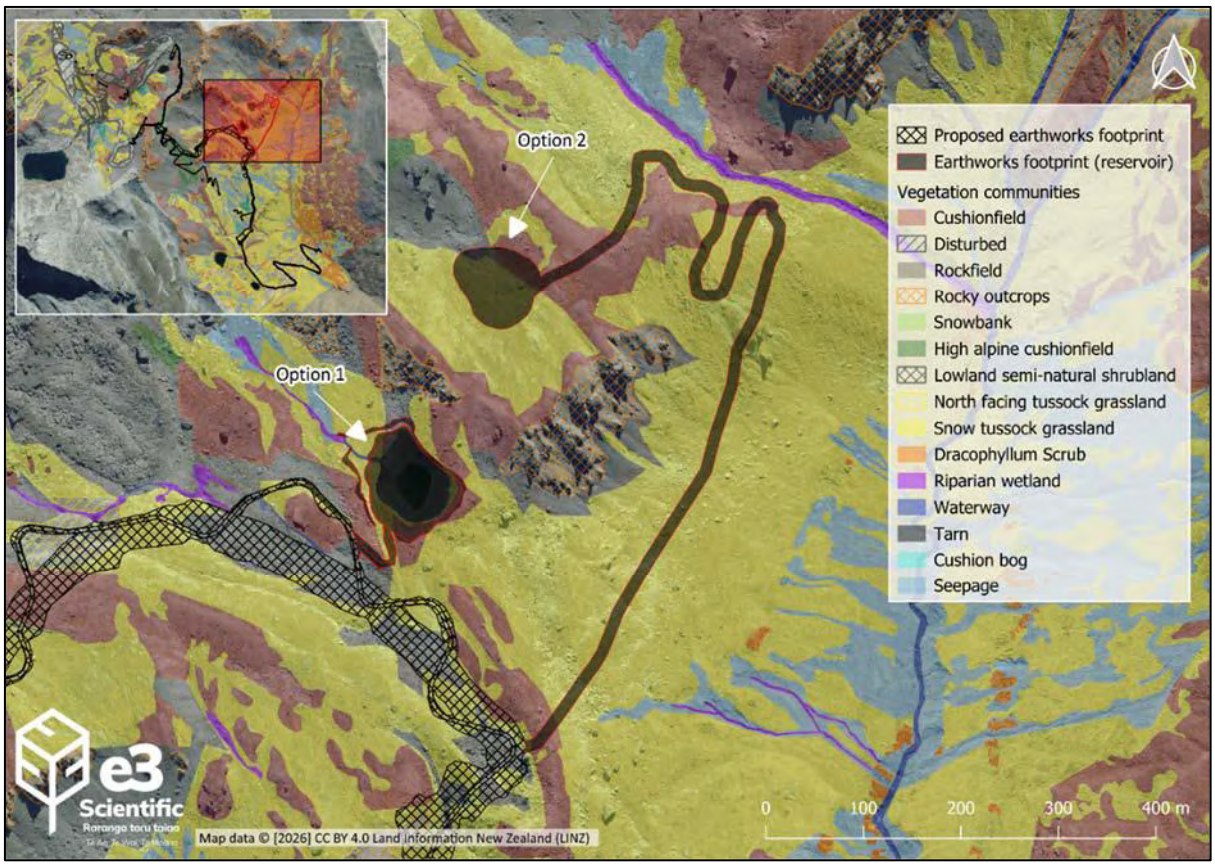


Figure 10: Reservoir locations.

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Appendix A: Naturally uncommon ecosystems – recommendations for updating the list (Brownstein *et al.*, 2025)

Naturally uncommon ecosystems – recommendations for updating the list

Envirolink Grant: 2444-ORC014

February 2025

Gretchen Brownstein, Adrian Monks, Sarah Richardson, Rowan Buxton, Susan Wiser

Manaaki Whenua – Landcare Research

Manaaki Whenua Contract Report: LC4578

Prepared for: Otago Regional Council

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Summary

Project and client

- Otago Regional Council contracted Manaaki Whenua – Landcare Research to refine and update the published list of naturally uncommon ecosystems (NUEs).

Objectives

- To review and make recommendations for updating the list of NUEs.

Methods

- Information was gathered on potential ecosystems to add to, divide, or subtract from the original list of NUEs published in 2007.
- This input was received from ecological experts via email and informal discussions.
- The responses were collated, and two workshops were held to review the suggestions. A set of refinements and additions was proposed.
- These proposed refinements and additions were circulated for additional comment.

Results

- Refinements were suggested for 24 ecosystems.
- Fourteen additions to the list were suggested.
- Eleven refinements (including removing one system) and nine additions to the list are recommended.

Conclusions and recommendations

We recommend the following changes to the list (resulting in a total of 78 NUEs):

- Remove cloud forests.
- Modify the common name of four systems:
    - change ‘braided riverbeds’ to ‘braid plain’
    - change ‘geothermal streamsides’ to ‘geothermal stream and spring margins’
    - change ‘estuaries’ to ‘estuary margins’
    - change ‘heated ground (dry) to ‘geothermally-heated ground (dry)’
    - change ‘hydrothermally-heated ground (now cooled) to ‘previously geothermally-heated ground (now cool)’
    - change ‘lagoons’ to ‘lagoon margins’
    - change ‘tarns’ to ‘tarn margins’
- Combine ‘granitic sand plains’ and ‘granitic gravel fields’ to give ‘granitic sand and gravel fields’.

- Split moraines into two types:
  - ‘moraines (recently formed)’
  - ‘moraines (dry)’.
- Remove the word ‘usually’ from the definition of ‘tarn’.
- Remove the word ‘coastal’ from the definition of ‘seabird-burrowed soils’.
- Add eight systems to the NUE list:
  - ‘boulderfields of quartzose rocks’
  - ‘coastal colluvium’
  - ‘cobble bank wetland’
  - ‘geothermal wetland’
  - ‘dry deflation plains’
  - ‘inland dryland alluvium’
  - ‘inland salt springs’
  - ‘mud volcanoes’.

We also recommend:

- updating the factsheets and guidance documents, as outlined in sections 5.1, 5.2, Appendix 1, and Appendix 2
- revising the diagnostic classifiers to enable ecosystems that are known to be naturally uncommon, but not able to be defined with the current set of diagnostic classifiers, to be incorporated into the NUE framework
- defining how recently created analogue systems should be treated
- carrying out an ecosystem-by-ecosystem threat assessment on the updated list, following the approach used for global ecosystem red listing.

1 Introduction

Otago Regional Council, on behalf of Te Uru Kahika – Regional and Unitary Councils Aotearoa and the Biodiversity Working Group / Terrestrial Ecology Forum, contracted Manaaki Whenua – Landcare Research (MWLR) to refine and update the published list of 71 naturally uncommon ecosystems (NUEs) using the original framework in Williams et al. 2007. The resulting updated list and supporting information will help councils to meet their obligations under the Resource Management Act 1991, and will allow councils to give effect to policy statements such as the National Policy Statement for Indigenous Biodiversity and the New Zealand Coastal Policy Statement 2010, and to align with national directions in Te Mana o te Taiao – Aotearoa New Zealand Biodiversity Strategy 2020.

This project arose as the result of current work[1] to refine the mapping of NUEs across New Zealand, including defining ways to locate and delimit them on the ground. During this process, additional ecosystems not on the 2007 list were suggested, and arguments were made for splitting or modifying others already present. Because the list of NUEs was intended to be a 'first approximation' rather than definitive (Williams et al. 2007), it is appropriate to carry out a review. For this work we use the definition of ecosystem and the framework set out by Williams et al. (2007).

2 Background

2.1 Overview

Williams et al. (2007) define an ecosystem as 'an ecological system formed by the interaction of co-acting organisms and their environment'. NUEs are defined as those that have a total extent of less than 0.5% (i.e. <134,000 ha) of New Zealand's total land area (268,680 km^2). They range from small (e.g. 100 m^2 to a few hundred hectares) but geographically widespread (e.g. coastal dune deflation hollows) to those that are larger (e.g. tens of thousands of hectares) but geographically restricted (e.g. frost flats on the North Island's Volcanic Plateau).

The 71 listed NUEs occur from the sea (e.g. coastal rock stacks) to the mountains (e.g. tarns), although many are found in lowland and coastal regions. Despite being small in overall extent, the often highly specialised, endemic, and diverse flora and fauna in these ecosystems contribute enormously to New Zealand's indigenous biodiversity. Thus NUEs only account for 3–10% of New Zealand's total land area but contain 86% of mainland New Zealand's nationally critical, endangered, and vulnerable plant species, of which 46% are restricted to NUEs (Holdaway et al. 2012).

The primary threats to NUEs are land-use change and land-use intensification. More specifically, the threats encompass removal of native vegetation cover, pressure from exotic animal pests and weeds (especially woody weeds and sward-forming grasses), changes to disturbance regimes, and

[1] Funded by Envirolink.

hydrological regimes and nutrient inputs associated with land-use change. NUEs are also highly vulnerable to the effects of climate change.

Williams et al. (2007) included a framework for defining these ecosystems alongside the initial list. The original intent of the framework was to have a flexible, national-scale system for delineating ecosystems that are often sparsely vegetated based on environmental and biophysical drivers. The seven abiotic classifiers that are considered for NUEs encompass soil age, parent material / chemical environment, particle size, landform, drainage, disturbance regime, and climate.

2.2 Challenges

The primarily abiotic framework has led to some challenges in identifying and delineating NUEs, which needs to be kept in mind when reviewing the list. First, the NUE framework is not a classification of vegetation types. Failing to recognise this this can lead to confusion, because an individual NUE can have more than one vegetation type associated with it. Many of these ecosystems occur across broad environmental gradients, along which their composition can vary continuously, although the functional expression of the environment may be broadly similar (see examples in Wiser et al. 2010 and Richardson et al. 2012). Further, exclusive reliance on vegetation characteristics to identify ecosystems on the ground can result in the mistaken inclusion or exclusion of ecosystems contrary to the NUE's environmentally based definitions, especially when attempting to infer an arrested succession.

For example, gumlands are noted by Williams et al. (2007) as containing vegetation ranging from 'fernland' to 'forest', yet the areas mapped as 'gumland' (e.g. at Kapowairua, by Neal Enright in the 1980s) were excluded from the Clarkson et al. (2011) paper on gumlands (in the 2000s) as NUEs because they contained tall shrublands. The stature and vegetation composition drove this decision rather than physical edaphic features (albeit peat formation does have a biotic origin) listed by Williams et al. (2007). Similarly, 'stable sand dunes' are often considered to be a different ecosystem when forested, rather than focusing on the underlying landform and edaphic origins that can support vegetation of differing stature (Peter Bellingham, MWLR, pers. comm., 2024). Some of the rarest kinds of lowland forest in northern New Zealand are the fragments (tiny) of old-growth forest on dunes on the west coast of the North Island (Woodhill, Pouto, Te Aupouri; Peter Bellingham, MWLR, pers. comm., 2024).

Second, difficulty also arises in interpreting the ecosystem definition on the ground, particularly delineating the extent of each ecosystem (a problem not unique to this typology). In the field, NUEs can have indistinct boundaries, tending towards mosaics and combinations of different physical substrates (e.g. calcareous screes, cliffs, tors, pavements). To maintain a list that applies to systems nationwide, careful thought is needed when forming definitions that are a unique combination of characters yet are wide enough to encompass some variation.

A third issue for consideration is the potential for confounding 'naturally uncommon' and 'once common, now rare'. Williams et al. (2007) acknowledged that historical rarity at a national scale was uncertain for 11 of the currently listed ecosystems. However, a full review of these 'once common, now rare' systems is out of scope for this update. To maintain the integrity of the naturally uncommon list, the original intent of historically rare should be adhered to.

Finally, we are aware that work is being done elsewhere on NUEs (by the Department of Conservation and others) and on the wider question of aligning New Zealand ecosystem classifications with that of the International Union for Conservation of Nature (IUCN) Global Ecosystem Typology[2]; any changes or modifications to the NUE list need to be aligned with these other work streams.

3 Objective

The objective of this project was to review and update the list of NUEs using expert knowledge.

4 Methods

At the start of the project an email was sent to ecologists at regional councils and territorial authorities, the Department of Conservation, universities, QEII National Trust, and ecological consultants to explain the project and gather supporting information on potential ecosystems to add to, divide, or remove from the Williams et al. 2007 list. For potential new or split ecosystems people were asked to provide:

- an example locality
- defining abiotic feature(s) or diagnostic classifiers
- a description of associated vegetation
- photos and/or a general description
- extent and distribution.

The 28 initial responses were collated into a document that was sent out for comment. Ecologists were asked to assess the ecosystems they felt qualified to comment on, and to indicate if they agreed or disagreed with the suggestions and/or make suggestions for further refinements.

After the initial responses were received two workshops were held to review and consider the suggestions (including the information from the initial assessments). During the workshop discussions, additional suggestions were made. For each refinement and addition three questions were addressed:

- Is the definition distinct from all existing defined NUEs?
- Does the definition describe a set of abiotic features that is naturally uncommon?
- Are the definition and the common name consistent with each other?

From the workshops, an agreed set of refinements and additions were proposed. These proposed refinements and additions were circulated for additional comment.

[2] The full list of Ministry for the Environment reports on this subject can be found here: https://environment.govt.nz/publications/national-ecosystem-typology/

5 Results

Of the 30 suggestions considered, nine refinements (including changes in circumscription) and eight additions are being proposed here for the list. The proposals for refinements and additions are given in two sections below, along with the discussion points, actions, and suggestions from the review rounds and workshops. The suggestions not currently supported (along with the reason(s) why) are listed in two appendices (Appendix 1 and Appendix 2). For many of the ecosystems, further details were supplied (photos or more explanation, or a list of published references), and for completeness this information is given in Appendices 3 to 17.

5.1 Proposed refinements

Modifications and refinements were suggested for 24 ecosystems. We propose implementing changes to eleven ecosystems (Table 1). Below is an outline of the reasoning for the proposed changes for each of these eleven ecosystems.

Table 1. The current ecosystem name and the change proposed

Current ecosystem name	*Definition (i.e. diagnostic classifiers) and notes*	*Vegetation structure*	*Change proposed*
Braided riverbeds	Raw–recent/sand–boulders/plain/periodically flooded	Open land, herbfield	Rename to 'braid plain'
Cloud forests	High cloud cover (<1,500 sunshine hours and >200 rain days p.a.)/inland	Forest	Remove from list
Estuaries	Coastal/estuary	Open land, sedgeland, rushland, reedland, herbfield, shrubland, scrub	Rename to 'estuary margins'
Geothermal streamsides	Geothermal-excessive heat/near permanently saturated (but water table not high)	Open land to scrub	Rename to 'Geothermal stream and spring margins'
Granitic sand plains & Granitic gravel fields	Raw/granite/sand–gravel/hillslope, hillcrest (mostly alpine) Raw/granite/gravel/hillslope, hillcrest	Open land	Combine the two ecosystems and rename to 'granitic sand and gravel fields'
Heated ground (dry)	Geothermal-excessive heat	Open land, mossfield, shrubland, scrub	Rename to 'Geothermally-heated ground (dry)'
Hydrothermally-heated ground (now cool)	Geothermal-acid soils, toxic elements	Open land, shrubland, scrub	Rename to 'Previously geothermally-heated ground (now cool)'
Lagoons	Coastal/lagoon	Open land, sedgeland, rushland, reedland, herbfield, shrubland, scrub	Rename to 'lagoon margins'
Moraines	Raw–recent/cobbles–boulders/moraine/(various parent materials)	Open land, shrubland, herbfield, tussockland	Split to 'moraine (recent)' and 'moraine (dry)'
Seabird burrowed soils	Seabirds – burrowing/coastal	Open land to forest	Remove 'coastal' from definition

Current ecosystem name	*Definition (i.e. diagnostic classifiers) and notes*	*Vegetation structure*	*Change proposed*
Tarns	Open water/depression/alpine (usually)	Tussockland, sedgeland, cushionfield	Rename to 'tarn margins' and remove '(usually)' from definition

Note: The ecosystem name, definition, and vegetation structure columns are from Williams et al. 2007.

5.1.1 Braided riverbeds

Change sought

Rename to 'braid plain' to better describe the ecosystem.

Reasons

These highly dynamic ecosystems are characterised by multiple mobile channels that migrate across extensive plains, resulting in a mosaic of vegetation communities and habitat types of various ages. 'Braid plain' would encompass the 'mobile channels across a gravel floodplain, with evidence of recent channel migration within the active riverbed and of historical movement of the active bed across the floodplain' (quote from the factsheet). The term 'braid plain' is used globally to refer to the area over which the channels (braids) of a braided river move. The Braided Rivers Group provide a good illustration of how to differentiate between flood plains and braid plains (see 'Appendix 3 – Braided riverbeds').

Definition/s

No change is required to the definition.

Action points

- There needs to be further clarity about whether the definition will refer to the current, recent (since human settlement) or historical (prior to human settlement) braid plain extent.
- 'Active braided riverbeds' could be another name for this system.
- For defining the extent, we could use the definition of ECan and NIWA, which refers to the area where the river could flow now in the absence of flood control (i.e. the space the river has influence over). They refer to this as the 'topographic extent'.
- Add 'shrubland' and 'woodland' as potential vegetation structure.

Conclusions

- The name change is supported in principle. We just need to clarify the extent (current, recent or historical).
- Add shrubland and woodland vegetation types as potential vegetation structure.

5.1.2 Cloud forests

Change sought

Preferred suggestion: remove from the list.

Alternative suggestion: refine the criteria.

Reasons

Preferred suggestion: remove. True cloud forest only occurs in the tropics and subtropics (Bruijnzeel et al. 2011), so for this reason it should be removed from the list. Globally cloud forests are poorly defined and some definitions include temperate regions (Haggar 1988), but we prefer not to include those from temperate regions. Even if we did, the current climatic definition is too broad, extending well beyond those areas to which the temperate definition is currently applied (the upper parts of Te Hauturu-o-Toi / Little Barrier Island and Te Moehau) to include most of Stewart Island / Rakiura, Fiordland, upland Westland, Mount Taranaki, etc.

Alternative suggestion: rename to 'warm temperate cloud forest' and refine the criteria to:

- sea temperature > 19°C
- potential evapotranspiration 750–950 mm
- annual rainfall 1,400–2,000 mm
- annual sunshine hours 1,700–1,900.

The type locality would then be Waimā range, Northland.

(See 'Appendix 4 – Cloud forest' for further details.)

Definition/s

A refined definition can't be written with current descriptors and no other NUE is defined solely in climatic terms.

Conclusions

There is support for removing 'cloud forest' from the list because the current definition is a vegetation type not an abiotic type, so it does not currently fit into the NUE framework. The proposed descriptors for 'warm temperate cloud forest' are not encompassed by the current set of descriptors. Revising the diagnostic classifiers and adding descriptors is beyond the scope of this project, though it should be considered in a later phase.

5.1.3 Geothermal streamsides

Change sought

Rename to 'geothermal streams and streamsides and spring and margins'.

Reasons

The title for the type 'geothermal streamsides' is a poor descriptor of the habitats it represents. It is also intended (based on the description on the Manaaki Whenua Landcare website) to include hot spring margins that occur in the geothermal streamside ecosystem type. Geothermal streamsides are obviously totally reliant on the presence of a heated stream with associated steam influence on the margins. The name could be altered to reflect the key role of heated streams.

Definition/s

No change required.

Action points

- To align with the IUCN Global Ecosystem Typology (GET) the name should be 'geothermal stream and spring margins'.

Conclusions

Renaming to 'geothermal streams and spring margins' is supported.

5.1.4 Estuaries

Change sought

Rename to 'estuary margins'.

Reasons

Renaming to 'estuary margins' is in line with naming for other edge-of-waterbody systems because the framework specifically pertains to terrestrial ecosystems, excluding permanent freshwater bodies such as ponds, lakes and lagoons, and the aquatic component of water channels and springs below the depth limit of rooted plants (littoral zone). This will support alignment with the IUCN Global Ecosystem Typology (GET).

Definition/s

No change required.

Conclusions

- Renaming to 'estuary margins' is supported by the fact that alignment with the IUCN GET will support future ecosystem threat assessment.

5.1.5 Granitic sand plains

Change sought

Combine ‘granitic sand plains’ and ‘granitic gravel fields’ to ‘granitic sand and gravel fields’.

Reasons

Since publication of the list, work has shown that granitic sand plains and granitic gravel fields are physically indistinguishable (Richardson et al. 2012). The factsheets currently state this. The current definition of 'granitic sand plains' can be applied to both: raw/granite/sand–gravel/hillslope, hillcrest/(mostly alpine).

Action/discussion points

- Replace '(mostly alpine)' with 'alpine'.

Definition/s

raw/granite/sand–gravel/hillslope, hillcrest/alpine

Conclusions

Given the above research this change is recommended.

5.1.6 Heated ground (dry)

Change sought

Rename to ‘geothermally-heated ground (dry)’.

Reasons

The ‘heated ground (dry)’ concept works well within the naturally uncommon ecosystem framework. However, it is suggested that the term ‘geothermal’ is added to the name, as this will make it clear that they are linked to a below ground heat source (at depth, from the Earth’s heat), and not solar radiation, or other human influences.

Definition/s

No change required

Conclusions

This name change is recommended.

5.1.7 Hydrothermally-heated ground (now cool)

Change sought

Rename to 'Previously geothermally-heated ground (now cool)'.

Reasons

The 'hydrothermally-heated ground (now cool)' concept works well within the naturally uncommon ecosystem framework. However, it is suggested that the term 'geothermal' is added to the name, as this will make it clear that they are linked to a below ground heat source (at depth, from the Earth's heat), and not solar radiation, or other human influences.

Definition/s

No change required

Conclusions

This name change is recommended.

5.1.8 Lagoons

Changes sought

- Rename to 'lagoon margins'.
- Split intermittently closed estuaries from permanently open estuaries.

Reason

Renaming to 'lagoon margins' is in line with the naming for other edge-of-waterbody systems, because the framework specifically pertains to terrestrial ecosystems, excluding permanent freshwater bodies such as ponds, lakes and lagoons, and the aquatic component of water channels and springs below the depth limit of rooted plants (littoral zone). This will help to achieve alignment with the IUCN GET.

Splitting 'intermittently closed estuaries' from 'permanently open estuaries' (note that these are types of lagoons not estuaries)[3] could help with the management of these two different systems.

[3] See details of these systems in Hume et al. 2016 and in a report on Otago's intermittently closed estuaries (available on request to the ORC).

Definition/s

The current definition refers to Johnson & Gerbeaux 2004. It might be possible to refer to Hume et al. 2016 instead for the definitions of 'intermittently closed estuaries' and 'permanently open estuaries'.

Conclusions

- Adding 'margin' to the name is supported. A fuller definition and explanation of the range of types should be included in the factsheets.
- Splitting into two types is not supported because it is not possible using the current diagnostic classifiers. Also, the variation would be better captured through description, the factsheet, and guidance.

5.1.9 Moraines

Changes sought

- Split moraines into dry (eastern basins, non-forest) and wet (steep, western, forested) subtypes.
- Alternative suggestion: rename to 'moraines (recently formed)' and add 'moraines (dry)'.

Reasons

The original suggestion was to apply the wet/dry split suggested in Holdaway et al. 2012. However, the current vegetation description does not include forest; rather, it describes eastern dryland moraine vegetation. Also the current definition suggests that the original intention was to include only moraines on undeveloped soils (raw). The 'wet' vegetated moraines are probably not uncommon.

During discussions the vegetated semi-arid moraines were raised as an important and rare system. These could be defined through soil development age (soil chronological age is tricky in arid systems[4]). Intersecting maps of moraines, soil development age, and areas of semi-arid climate (annual water deficit = high to very high, i.e. 200–400 mm) is likely to result in a map of this system. There is also an aspect of drainage associated with it; either excessive or periodically dry could work, because there is no moisture/water-holding capacity in the soils. This system could be described as basin floors that are sparsely vegetated, dry (arid and/or excessively drained) on moraine materials. (See 'Appendix 5 – Moraines' for photos, and the excerpt from the LINZ guide.)

Definition/s

Moraines (recently formed): raw–recent/cobbles–boulders/moraine/(various parent materials)

Moraines (dry): mature/cobbles–boulders/moraine/semi–arid

[4] See excerpt from LINZ technical guide, p. 31: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.landcareresearch.co.nz/assets/Tools-And-Resources/Maps/LENZ/LENZ_Technical_Guide.pdf

Action/discussion points

- Check that an intersection of spatial layers depicting moraines, soil development age, and areas of semi-arid climate results in a map of what we are trying to define.
- Check whether 'excessively drained' should be part of the definition.

Conclusions

- Change 'Moraines' to 'Moraines (recently formed)' and keep the current definition.
- Add a new ecosystem called 'Moraines (dry)' to capture the unique, dry, vegetated moraines if the checks in the action points above are met.

5.1.10 Seabird burrowed soils

Change sought

Remove 'coastal' from the definition because these soils are not confined to the coast.

Reason

There is good evidence that black petrels burrowed in soils on the slopes of Ruapehu and Titiraupenga until the early 20th century, and a Cook's petrel skeleton was found on the Maungaharuru Range (Janet Wilmshurst, MWLR, pers. comm. 2024). The mottled petrel formerly bred in the mountain ranges of the Central North Island, Kaimanawa Mountains, Ruahine Range, and Ruapehu, and throughout the whole of the South Island, including Banks Peninsula (Oliver 1955). There is also evidence of grey-backed storm petrels breeding in Fiordland Mountains (Miskelly et al. 2021). Work on a spatial layer predicting the historical distribution of seabird colonies is currently underway (Bellvé 2023).

It is likely that modern seabird-burrowed soil ecosystems, as found on some offshore islands, are modern artefacts of hyper-concentrated colonies of multiple seabird species, which act as refuges now that most of their former range is too dangerous to nest in because of predatory mammals. Assessment of pre-human vegetation on Tāwhiti Rahi (Poor Knights Islands) shows that they are likely to be artefacts (but still ecologically and culturally very valuable) (Wilmshurst et al. 2014). For many, if not most, northern New Zealand islands with dense seabird-burrowed soils, there is a key imprint of the history of management by mana whenua,[5] including fire, such that the forest vegetation on many (probably most) of the islands comprises successional communities (Atkinson 2004; Bellingham et al. 2010).

Definition/s

seabirds – burrowing

[5] Mana whenua: territorial rights, power from the land, authority/jurisdiction over land or territory, power associated with possession and occupation of tribal land; sometimes used to describe those associated with such rights/authority; or (more loosely) with tribal links to a specific area.

Action points

- How many burrows, and what density, are required in order to be defined as an ecosystem with 'seabird burrowed soils'?
- What happens if the seabird burrows are still present but the seabirds are not (especially as a result of predation); i.e. the active disturbance (sometimes only seasonal) goes but the nutrient legacy remains (along with the structuring of the community that favoured some plant species but not others)?
- This discussion raises important questions about how recently created analogues should be treated in the NUE framework. A simple solution would be to say that if the extent remains under 0.5% then they still count. This is especially important when historical locations are now extinct and the recent ecosystems function in the same way and support the same biota as the now extinct examples.
- Another example of this phenomenon is the Northland gumlands. Some think that all the 'original' gumlands are now extinct and the ones present now were created by humans, but this is at odds with statements in Perry et al. 2014. All the same, gumlands may be an example of a historically rare type and an anthropogenically induced type. If this human disturbance has expanded the extent beyond that defined as naturally rare, then it will be critical to be able to distinguish the two.

Conclusions

Removing 'coastal' from the definition is supported.

5.1.11 Tarns

Change sought

- Rename to 'tarn margins'.
- Refine the definition to 'alpine' rather than 'alpine usually'.
- Factsheet change: remove the reference to moraines in the text, as the water bodies referred to are ephemeral wetlands, not tarns. (From factsheet: 'Tarns on moraines in valleys east of the Main Divide, such as the upper Ashburton and Rangitata catchments, and Mackenzie Basin…').

Reason

Rename to 'tarn margins' because the framework specifically pertains to terrestrial ecosystems, excluding permanent freshwater bodies such as ponds, lakes, and lagoons, and the aquatic component of water channels and springs below the depth limit of rooted plants (littoral zone). This will help to achieve alignment with the IUCN GET (Keith et al. 2020).

Refining the definition to include only 'alpine' rather than 'alpine usually' has limited impact because many (but not all) of the intermontane basin 'tarns' in the eastern South Island will be mapped as kettle holes. However, this proposed change will clarify the definition and align it with international usage. A tarn is defined as a small mountain lake, especially one that collects in a

cirque basin behind risers of rock material or in an ice-gouged depression.[6] Tarns can be associated with outwash[7]. Ice can be jumbled into the outwash on moraine edges, so that a tarn could form in what looks like an outwash surface from above but would effectively have originated in moraine (Ian Lynn, MWLR, pers. comm., 2024). Thus, tarns could form on surfaces near the edge of moraines, but certainly not at the lower end of the outwash gravels.

Definition/s

open water/depression/alpine.

Action/discussion points

- Johnson and Gerbeaux (2004) use the terms 'mountain' and 'uplands' in their definition of tarn.
- In New Zealand the term is used very widely to refer to a small lake that is not coastal.
- Although 'tarn' is not a wetland type (rather it could be one of several types), New Zealand wetland ecologists generally use the term to mean a small body of water in the uplands.
- The word 'tarn' is not used in the New Zealand Lakes ecosystem typology.
- In the GET the closest match is 'small permanent freshwater lakes'. The word 'tarn' is not used.
- We could set size limits for lakes and tarns, keeping both systems on the list (though size limits for water bodies is not one of the classifiers). So as not to miss small lowland waterbodies, we could make 'tarn margin' a subset of 'lake margin'; or we could remove tarn from the list and use 'lake margin' to cover all sizes and elevations.
- Lakes and tarns do differ: tarns potentially have more stable water levels, with no inflow of rivers of any size, and fetch/wave action is not common.
- If tarns are restricted to 'alpine' environments, the intermontane tarns would be captured as 'ephemeral wetland' or 'lake margins'.
- In the factsheet, it should be highlighted that the width of the margin will be variable but it relates to the ephemeral margin of the tarn (i.e. the area of fluctuating water height, which will also be of variable duration). Therefore, tarn margins (and lake margins) are a type of ephemeral wetland but are treated separately because the water levels in the associated water body fluctuate to a lesser degree.

Conclusions

- Renaming to 'tarn margins' is supported.
- Restricting to 'alpine' is supported. 'Lake margins' can capture those tarns that are not in the alpine zone. This would be the simplest way to separate tarns from lakes. The word 'tarn' seems to be mostly a vernacular term.
- The factsheets should be expanded to include more types and type localities.

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[6] https://www.nps.gov/articles/tarns.htm

[7] Outwash plains are glacial stream deposits of stratified drift from melt-water, braided, and overloaded. They occur beyond a glacial morainal deposit.

5.2 Proposed additions

We propose adding eight new ecosystems from the fourteen that were suggested (Table 2). Below is an outline of the reasoning for the proposed additions for each of the eight ecosystems. The list of additions not supported at this time and the reasons are given in Appendix 2.

Table 2. Summary of proposed additions to the list of naturally uncommon ecosystems

Tentative common name	***Definition***	***Vegetation structure***	***Example locality***
Boulderfields of quartzose rocks	raw/quartzose/boulders/talus	Open land, lichenfield, shrubland	Glasgow Range, north Westland
Mud volcanoes	Geothermal/groundwater salinity/periodically high water table/inland	Open land, herbfield	Runaruna, Northland; Waimatā Valley, Gisborne; Waikura Valley, Pōtaka
Coastal colluvium (coastal boulderfields)	raw/boulders/talus/coastal	Open land, herbfield	Banks Peninsula; Boulder Beach, Otago Peninsula
Cobble bank wetland	raw, recent/gravel–cobbles/permanently high water/coastal	Herbfield	Te Kawakawa Rocks, Palliser Bay
Dry deflation plains	raw/sand–gravel/plain/coastal	Openland, herbfield	Napier airport; Mirza Beach
Geothermal wetland	Geothermal – excessive heat/ regularly high water/toxic elements	Sedgeland, Rushland, Herbfield, Reedland, Shrubland, Algal mats	Waikite, Waikato; Parengarenga Wetland, Lake Rotoiti
Inland dryland alluvium	raw, recent/silt–cobble/plains, terraces/excessive drainage/inland, semi-arid	Open land, herbfield	Tekapo River, Mackenzie Basin
Inland salt springs	raw/groundwater salinity/permanently high water table/inland	Herbfield, open land	Wairau Valley, Marlborough

5.2.1 Boulderfields of quartzose rocks

Reason

This ecosystem was mistakenly left off the published list in Williams et al. 2007 but was included in Holdaway et al. 2012. The suggestion is to reinstate it to the published list and make a factsheet for it.

Definition/s

raw/quartzose/boulders/talus

Action/discussion points

None.

Conclusions

Add to the list.

5.2.2 Coastal colluvium (coastal boulderfields)

Reason

Coastal colluvium is a distinctive part of the extensive cliffs to which it is linked. Banks Peninsula is a good example. Here colluvium has been made more extensive from the earthquakes but is still much rarer than cliffs. Colluvium or boulderfields is sparsely vegetated generally, but hosts a distinctive flora of coastal species, especially on sunny aspects (e.g. *Senecio lautus*, *Chenopodium allanii*, *Asplenium obtusatum*), and this might be closest to the Singers & Rogers 2014 vegetation type CL8. Coastal colluvium provides important habitats for penguins and is where the threatened coastal plants *Lepidium agreum* and *Euphorbia glauca* have been recorded.

Definition/s

raw/boulders/talus/coastal

Action/discussion points

- The original proposal was for the type to be restricted to Banks Peninsula, but in workshop discussions it was decided this could be applied New Zealand-wide.
- Although suggestions were originally made for confining this to volcanics, salt spray is likely to be a bigger factor than rock type in selecting species, so this NUE should not be restricted to a rock type.
- 'Colluvium' could be a better name as there is a range of substrate sizes present; or the factsheet needs to define what proportion of substrate should be boulder (similar to how shingle beaches are described).
- Other boulderfield NUEs are based on geology, not proximity to the coast. However, other rocky systems are defined based on coastal vs inland (e.g. ultrabasic cliffs and scarps, and ultrabasic sea cliffs).

Preliminary conclusions

Add to the list.

5.2.3 Cobble bank wetland

Reasons

Cobble bank wetlands are formed behind cobbles that have built up on a rocky coast. They are mostly rain fed, with little surface or groundwater inflow. They are influenced by salt spray, as evidenced by the abundance of *Salicornia quinqueflora*, but, unlike in tidal pools, salt spray is not a daily occurrence. They don't seem to dry out so do not qualify as ephemeral wetlands. There is also no appreciable organic accumulation and so do they not qualify as maritime bogs. If a storm ever breached the cobble bank the water would drain away. Known locations include: Te Kawakawa Rocks south of Ngawi on the eastern tip of Palliser Bay, on the way to Cape Palliser Lighthouse; and Ōkupe Lagoon on the northern end of Kapiti Island, off the Wellington west coast. (See 'Appendix 6 – Cobble bank wetlands' for photos and further information.)

Definition/s

raw, recent/gravel–cobbles/permanently high water/coastal

Action/discussion points

- These formations are probably related to prograding gravel platforms and raised beaches.
- David Barrell (GNS geomorphologist) suggested that this system is a dip between stony beach ridges, akin to a slack between dunes in a dune system, with the difference being the size of the material and energy required to move the material.
- To be consistent with dunes and dune slacks, this system could be described as a stony beach slack. However, it cannot be included with stony beach ridges because that definition refers to 'ridges' as the landform.
- Other thoughts were that it might be a part of 'shingle beaches' (see photos in the appendix), which includes cobbles.

Conclusions

This could be added as a 'stony beach slack' and should be ground-truthed, as we can think of no other good examples of this ecosystem.

5.2.4 Dry deflation plains

Reasons

There seem to be two different systems here that are on opposite ends of a particle size spectrum. At one end is an inter-dune community on a coarse sand or fine gravel lag with potentially palaeo-pavements. This community is often associated with active dune habitats. The plant species include a large range of herbs, many commonly associated with coastal cliffs. *Raoulia* spp. and *Colobanthus* spp. may be indicator species of this habitat type. At Mason Bay, species include *Geranium sessiliflorum* var. *arenanium*, *Raoulia aff. hookeri*, and *Ranunculus recens*, among others. Localities include Mason Bay, Three Sisters at Omaui, Fortrose spit, Kaitorete Spit, and (potentially) Sandfly Bay, Otago

At the other end of the spectrum are flat plains of mobile sand and gravel with ventifacts. The vegetation includes *Pimelea* spp., and localities include Mirza Beach, Marlborough; Napier airport beach; and Kohangapiripiri, Wellington. (See 'Appendix 7 – Dry deflation plains' for photos of both systems.)

Definition/s

raw/sand–gravel/plain/coastal

Action/discussion points

- Note that the definition of 'dune deflation hollows' is raw/sand/depression/excessive drainage/coastal, so the definition doesn't actually mention dunes. Moreover, the factsheet[8] says, 'They often form between a series of sand dunes and when the dunes move further inland they enlarge the terminal deflation hollow behind', so we are not currently saying that they have to be associated with dunes.
- Thus both systems could be dune deflation hollows, just on different scales, because the main action here is wind removing materials until it can't (too wet or too large).
- If both systems are dune deflation hollows, then the name and definition could be expanded to accommodate the sites at Napier airport and Mirza Beach by broadening the name to something like 'Coastal deflation hollows and plains', with a definition of raw/sand–gravel/depression–plain/excessive drainage/coastal.
- David Barrell (GNS) was consulted about the three sites associated with the second system. He would call all three abandoned beaches.[9]
    - Napier airport beach was raised in the 1931 earthquake, and since then has lost the fines (sands) from the top, so that just the stony/gravels are left.
    - Mirza might be 'abandoned' because it was raised at some point in the past, or this may be due to accretion. There are lots of big rivers with source material not that far away, and the ocean has moved further away. Again, the sands on top have blown away leaving an armoured surface.
    - Kohangapiripiri was probably both raised and experienced accretion. The 1855 earthquake raised that area by 4–5 m and there are a couple of big rivers nearby to supply the material. However, it is also still active as you can see a sand dune on top of the old beach in the picture (Appendix 7, Figure A7.4).

Conclusions

- The first system is a 'dune deflation hollow' (which is already in the list), and the factsheets should be expanded to include the examples provided.

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[8] https://www.landcareresearch.co.nz/publications/naturally-uncommon-ecosystems/inland-and-alpine/granitic-gravel-fields/

[9] 'Abandoned beaches' is a geological term for beaches that have been uplifted and are no longer modified by wave action.

- The second system should be added to the list as 'dry deflation plains' because it is not part of active sand dune systems (like the above) and does not fit with shingle or stony beaches (this needs further discussion to confirm).

5.2.5 Geothermal wetland

Reason

Geothermal wetland is a variable habitat type driven by the character of the geothermal system the wetland occurs in, e.g. the water chemistry, temperature variation of different springs or seepages, water depth, altitude, distance inland, landform, and adjoining features such as lakes. While these ecosystems are extremely variable, their geothermal origin is the key abiotic factor influencing plant species presence and distribution. For example, various species occur in geothermal wetlands outside their usual natural range, including species of coastal sites occurring inland, or with unusual latitudinal and elevation ranges such as: sea rush (*Juncus kraussii* subsp. *australiensis*), oioi (*Apodasmia similis*), and arrow grass (*Triglochin striata*). Because of the varied character of this system is best to define it in a broad sense so all the different types are captured. And even at its broadest definition, its estimated that the extent of geothermal wetlands nationally is less than 150 hectares. Representative sites for geothermal wetlands include: Waikite, Waikato; Waihunuahuna springs (edge of Lake Ohakuri); Waipahihi Valley (Wairākei Tauhara Geothermal System); Ngapuna (edge of Lake Rotorua, Rotorua); Parengarenga Wetland (Lake Rotoiti); Waitangi Soda Springs (south of Lake Rotorua). (See 'Appendix 8 – Geothermal systems' for photos and a short report on the Geothermal NUEs by Wildlands.)

Definition/s

Geothermal – excessive heat/regularly high water/toxic elements

Action/discussion points

The concise definition listed for this system needs to be confirmed as its been modified from the full suggested definition of: "Inland (including coastal to alpine), regularly high water table (permanently or ephemerally wet), with elevated temperatures, sourced at depth and also due to overflows, with higher temperatures and different chemistry than natural surrounding land."

Conclusions

Add to the list, need to confirm the definition.

5.2.6 Inland dryland alluvium

Reasons

These are terraces of river-deposited gravel, sand, and silt. They are stable, well-drained plains with thin soils of blown silts and can have frost heave surfaces found in the intermontane basins. Stonefields are occasionally also present. Plants include bryophyte and lichen communities, *Raoulia* and *Pimelea* species, *Festuca novae-zelandiae*, *Melicytus alpinus*. They differ from inland outwash

gravels in that the source material is alluvial rather than fluvioglacial, e.g. these inland alluvial surfaces have been reworked by water. They are distinct from braid plains because inland dryland alluvium is isolated from major active river channels.

Inland dryland alluvium ecosystems have raw or recent soils and always have a high water deficit, either due to a semi-arid climate or excessive drainage. They occur on terraces, plains or low-relief fans, but they are always low relief (<2.5 degrees) as they are reworked by water and have no colluvial (formed by gravity) character.

Where inland, they can be defined by the Central South Island Glacial Geomorphology categories 'Holocene alluvial plain or terrace' and 'Early Otiran or older alluvial plain or terrace', as well as various ages of Otiran (Early, Late, or Latest Late Otiran) and Holocene alluvial fans. The example location is above the Tekapo River. (See 'Appendix 9 – Inland dryland alluvium'.)

Definition/s

raw, recent/silt–cobble/plains, terraces/excessive drainage/inland, semi-arid

Action/discussion points

- Need to check if there is overlap between some inland dryland alluvium that forms terraces and the new definition of 'braid plain'.
- There needs to be a clear explanation of the relationship between inland dryland colluvium, braid plain, and inland outwash gravels to show that these are all distinctive systems.

Conclusions

Add to the list.

5.2.7 Inland salt springs

Reasons

Along the Alpine Fault some spring upwellings rise through salty rock, dissolving salts out of the rocks. Around the springs the ground is salty, and salt-tolerant plants are present. These springs support a marsh of *Triglochin striata*, *Schoenoplectus pungens*, and *Cotula coronopifolia* (Wardle 1991). This differs from the inland saline (salt pans), as the inland saline springs are always wet as opposed to the dry soils of the salt pans. About 10 springs are known in the Wairau Valley, Marlborough. (See 'Appendix 10 – Inland salt springs' for photos.)

Definition/s

raw/groundwater salinity/permanently high water table/inland

Action points

Check if there are other examples from Central Otago. It may be that most of the wet inland saline systems are now gone. There was an active one still evident 5 years ago (albeit weed infested) at the Wilson Road saline site, Central Otago.

Conclusions

Add to the list.

5.2.8 Mud volcanoes

Reasons

Gas-driven mud volcano ecosystems are typically cold, and although mainly mud have characteristic vegetation that can tolerate the high mineral content (e.g. estuarine species *Machaerina juncea*, *Apodasmia similis*, *Samolus repens*, and *Cotula coronopifolia*), though freshwater species are also present. This ecosystem can apparently appear and/or expand with increased tectonic activity, and it has a scattered distribution from Wellington to East Cape and Northland. These have a geothermal element but don't fit any of the current ecosystem descriptions. (See 'Appendix 11 – Mud volcanoes' for further information and references.)

Definition/s

groundwater salinity/periodically high water table/inland

Action/discussion points

Check if 'geothermal' could be part of the definition.

Conclusions

Add to the list.

6 Conclusions and recommendations

We utilised expert knowledge to review and make recommendations for updating the list of naturally uncommon ecosystems (NUEs). This report documents the discussions and information gathered to support that update, including collating the information for systems that we agreed needed revision or adding, and for the suggested revisions and additions that were not supported at this stage. We imagine that as new research is carried out and a better understanding of the systems is gained, the NUE list will again evolve to reflect the new knowledge.

The discussions held during the project, one-on-one, and in workshops helped clarify the original intent in defining the NUEs and how new research has modified our understanding of these ecosystems. These discussions highlighted the robustness of the original work; all that was required

for over half of the suggested refinements and additions was a small amount of clarification on the intent of the original definitions. However, the discussions also signalled that modifications to the diagnostic classifiers could be required to fully incorporate our current understanding of these ecosystems.

The discussions raised important questions about how recently created analogues should be treated in the NUE framework. A simple solution could be to say that if the extent remains under 0.5% then they still count. This is especially important when historical locations are now extinct and the recent ecosystems function in the same way and support the same biota as the now extinct examples. Examples of ecosystems where this should be considered are 'seabird burrowed soils', 'coastal turfs', and 'gumlands'.

We are also mindful that any changes or modifications need to be aligned with the work being done elsewhere on NUEs (by the Department of Conservation and Ministry for the Environment), and on the wider question of aligning New Zealand ecosystem classification with that of the IUCN GET. An ecosystem-by-ecosystem threat assessment should be carried out on the updated list following the approach for global ecosystem red listing – but tailored to New Zealand – as outlined by Keith et al. (2015) and Rodríguez et al. (2015). Again, such work needs to be coordinated with current efforts by the Department of Conservation, Ministry for the Environment, and MWLR.

We recommend the following changes to the list (resulting in a total of 78 NUEs):

- Remove cloud forests.
- Modify the common name of four systems:
    - change 'braided riverbeds' to 'braid plain'
    - change 'geothermal streamsides' to 'geothermal stream and spring margins'
    - change 'estuaries' to 'estuary margins'
    - change 'heated ground (dry) to 'geothermally-heated ground (dry)'
    - change 'hydrothermally-heated ground (now cooled) to 'previously geothermally-heated ground (now cool)'
    - change 'lagoons' to 'lagoon margins'
    - change 'tarns' to 'tarn margins'
- Combine 'granitic sand plains' and 'granitic gravel fields' to give 'granitic sand and gravel fields'.
- Split moraines into two types:
    - 'moraines (recently formed)'
    - 'moraines (dry)'.
- Remove the word 'usually' from the definition of 'tarn'.
- Remove the word 'coastal' from the definition of 'seabird-burrowed soils'.
- Add eight systems to the NUE list:
    - 'boulderfields of quartzose rocks'
    - 'coastal colluvium'
    - 'cobble bank wetland'
    - 'geothermal wetland'

- ‘dry deflation plains’
- ‘inland dryland alluvium’
- ‘inland salt springs’
- ‘mud volcanoes’.

We also recommend:

- updating the factsheets and guidance documents, as outlined in sections 5.1, 5.2, Appendix 1 and Appendix 2
- revising the diagnostic classifiers to enable ecosystems that are known to be naturally uncommon, but not able to be defined with the current set of diagnostic classifiers, to be incorporated into the NUE framework
- defining how recently created analogue systems should be treated
- carrying out an ecosystem-by-ecosystem threat assessment on the updated list following the approach for global ecosystem red listing.

7 Acknowledgements

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Appendix 1 – List of refinements not supported

Below are the refinements that have not received support. Many of these suggestions can be resolved by adding more details to the existing factsheets, which is happening in a parallel Envirolink Tools project.

Table A1.1. List of ecosystems for which the suggested refinement is not supported

Tentative common name	*Definition (i.e. diagnostic classifiers) and notes*	*Vegetation structure*	*Change proposed*
Acid rain systems	Geothermal-acid rain	Open land, scrub, tree, forest	Expand to include all geothermal atmospherically influenced systems and rename to 'Geothermally-derived natural atmospheric systems'
Active sand dunes	Raw/sand/dune/coastal	Grassland, sedgeland, open land	Split into transgressive and semi-stable
Cave entrances *Caves, and cracks in karst* *Sinkholes*	Raw/calcareous/cave entrance Calcareous/subterranean/coastal–alpine Raw/limestone, marble, dolomite/doline	Open land, herbfield none Open land shrubland, shrubland, tussockland, Thousand Acre Plateau, western Nelson	Merge cave entrances with these two systems.
Coastal turfs	Raw/atmospheric salinity/coastal, extreme exposure	Open land, herbfield	Change name to coastal grassland
Ephemeral wetlands	Seasonally high water table/depression	Herbfield, open land	Split into types
Frost hollows	Terrace/>200 frost days per year	Shrubland, scrub	Split into Singers & Rogers types
Inland outwash gravels	Raw–recent/sand–boulders/plain/inland	Open land, herbfield, treeland	Split out the frost hollows
Inland saline (salt pans)	Ground water salinity/semi arid/depression	Herbfield, grassland	Split based on salt type and source
Stable sand dunes	Recent/sand/dune/coastal	Shrubland, grassland, tussockland, herbfield, open land	Split stable dunes into 'grey dune' and 'forested dunes'
Strongly leached terraces	over-mature/sand-gravel/terrace–plain/inland	Open land, herbfield, shrubland	Add >200 frost days per year to definition

Acid rain systems

Change sought

- Expand to include all atmospherically influenced geothermal systems.
- Rename to 'Geothermally-derived natural atmospheric systems' to better describe the ecosystem.

Reasons

Acid rain systems are a sub-type of atmospherically influenced geothermal systems. Due to the rarity of geothermal systems nationally, combining these together may prove more useful from a management perspective and would help to ensure that no rare geothermal ecosystem sub-types are omitted. (See 'Appendix 8 – Geothermal systems' for a short report on Geothermal NUE systems by Wildlands)

Definition/s

No change is required to the definition.

Action points

- Need to clarify that the definition is still fit for purpose.
- Need to clarity if fumaroles should be included in this expanded system

Conclusions

Potentially this change could be made but needs further discussion.

Active sand dunes

Change sought

- Refine the definition of 'active dunes' and add more type localities and associated vegetation to capture the diversity of active dune types in New Zealand.
- Consider distinguishing between larger transgressive dune systems and smaller, more stable systems where mobility is restricted to the seaward margins.

Reasons

The classification is not entirely fit for purpose when used to identify active dunes, because the key abiotic classifiers are aeolian sand transport and geomorphic mobility. This is usually equated with relatively low vegetation cover and the presence of species tolerant to and/or dependant on sand burial. In larger systems (e.g. Mason Bay, Stewart Island / Rakiura), a mosaic of habitats occurs, reflecting spatial and temporal patterns of sand transport and geomorphic disturbance. Some of these habitat types are highly mobile or experience burial, some arise through sand erosion, and others are stable, with vegetation communities that develop through successional processes from dune obligate species to more generalist species. Distinct plant communities are often associated

with each of these habitats, but collectively they define the character of active dunes. Failure to recognise these underlying diagnostic drivers results in this ecosystem type being applied only to depositional (i.e. foredune, sandsheets or constructional dunes) dune types.

A second complication is the distinction between stable and active dune types. Many active dunes contain larger areas of stable habitat, or semi-stable habitats. Active dunes also exist in a wide range of forms, reflecting a wide range of factors including underlying geology, sediment supply and size, wind exposure, and climate. Consideration could be given to developing an alternative list of coastal dune types to distinguish between highly active transgressive types (such as found on windward coasts), more stable lee coast systems (i.e. the east coast of Northland and Bay of Plenty), and geomorphically stable dunes. The plant species associated with active dunes also show a degree of variation around New Zealand, further complicating the development of a clear typology

There may also need to be a clearer distinction made between dunes and dune systems

(See 'Appendix 12 – Active sand dunes' for more information.)

Additional type localities: West coast systems on Stewart Island / Rakiura (e g. Smoky Beach, West and East Ruggedy Beach, Mason Bay, etc.); Fiordland (e.g. Big Bay, Martins Bay, Coal River; Farewell Spit; Kaitorete Spit.

Definition/s

We are not sure that the split between transgressive and stable dunes could be done using the current framework.

Action/discussion points

- Adding more type localities and associated vegetation to capture the diversity of active dune types will be addressed in the Envirolink Tools project.
- A clearer distinction between dunes and dune systems should be added to the factsheets and background information. It might be desirable to define the separate systems that may occur within the broader sand-dune complex. Some of these are already included as NUEs (e.g. 'active sand dunes', 'dune deflation hollows', 'dune slacks', 'damp sand plains').
- We shouldn't be subdividing NUEs based on geography.
- The variability in plant species associated with active dunes around New Zealand further highlights the problem of distinguishing NUEs based on their vegetation composition. It is not surprising that there is compositional variation within individual NUEs. This is what was found for gravel beaches around the country, and it certainly would also apply to all the rock outcrop NUEs. There may also be environmental differences across large geographical ranges – especially in climate – but that doesn't mean it is desirable to recognise all this variation within the NUE typology. The EcoVeg hierarchy (an international system) could help to resolve the tension between types defined based on environment with characteristic vegetation structure(s) and types within these that are differentiated based on species composition (Faber-Langendoen et al. 2014).

Conclusions

Splitting is not supported, but updating/expanding the factsheets and clarifying the definition would be beneficial.

Cave entrances

Change sought

Merge 'cave entrances' with 'caves, and cracks in karst' and 'sinkholes' (keeping 'caves and cracks' and 'sinkholes' as separate systems).

Reasons

Cave entrances are ecotones and should be considered part of the cave or sinkhole ecosystem. The counterpoint would be that 'cave entrances' are more broadly defined than the other two systems, so would result in missing cave entrances that are not associated with karst or sinkholes. Given this, merging of 'cave entrances' with 'caves, and cracks in karst' and 'sinkholes', wouldn't result in a big gain in understanding/classification but could result in some ecosystems being missed.

Definition/s

No change is required for 'caves, and cracks in karst' and 'sinkholes', but the vegetation structure could be updated.

Action points

Double check the original recommendations from the expert.

Conclusions

Don't merge. This is a fact sheet issue, such that we need to clearly define 'subterranean', 'cave', and 'entrance', and clarify how they relate to each other.

Coastal turfs

Change sought

Add 'bedrock' to the definition. Restrict the definition to gravelly/rocky coastal shelves, not the recent deeper soils (e.g. coastal rock shelves around Wellington and at Watsons Beach, Otago).

Reasons

Research published in the last 10 years has shown that sheep and rabbit grazing is a major driver of vegetation composition on headlands with deeper soils (Brownstein et al. 2014; Rogers & Monks 2016). With the removal of grazing, coastal turf sites like Long Point, and Maori Head (Otago), and

Waipapa Beach (Southland) have shifted towards tussockland. These sites could be moved to a new ecosystem called coastal grasslands/tussocklands (see suggested additions below).

Definition/s

raw/bedrock/atmospheric salinity/coastal, extreme exposure

Discussion points

- Pre-human, much of the Otago coastline would have been forested to nearly the cliff edge, so sites like Maori Head and Long Point probably would only have included minor amounts of coastal turfs.
- Although the name suggests turf species only, grasses and herbs are also present in mosaics. In many of our example locations this system has been modified by sheep grazing, which enhanced the competitiveness of turf species, and explains why these systems have only recently appeared as a mosaic (due to the exclusion of browsers).
- These are highly dynamic systems where the main driver is salinity, with herbivory and trampling as secondary drivers. The method, timing, and amount of salt delivered is what primarily selects for the halophytic vegetation.
- On the south coast of the South Island there are loams on headlands that get enough salt spray that halophyte vegetation is selected for. More of these systems might be expected to develop with climate change (i.e. more wind and king tides).
- Pre-human grazing and trampling by birds and sea mammals would have been important (a role now played in part by sheep, cattle and deer), but it is hard to know how extensive that would have been.

Conclusions

The main issue is that the system is named for a vegetation type (turf) when it should be coastal grassland/turf as this is the mosaic that occurs on windy, salty, headlands. However, the name 'coastal turf' is iconic now. Rather than change it, the factsheets could be expanded to explain that the major driver is salinity and that the system is a mosaic of grasses and herbs. This community is of variable extent and part of an ecotone, with vegetation sequences from open short turf into coastal shrubland and coastal forest. Factsheets could also be amended to highlight the secondary importance of trampling and grazing.

Ephemeral wetlands

Change sought

Split into types: kettlehole, schist depression, coastal, and ephemeral runoff channel.

Reasons

Kettlehole ephemeral wetland

- This is a distinct landform of glacial origin.

- The size and distribution of this ecosystem will probably be determined as part of Jane Gosden's PhD.[10]
- Vegetation composition and characteristic species are also likely to be available from Jane's work
- Examples are present on Ahuriri Valley glacial terraces.

Schist depression ephemeral wetland

- This wetland is characterised by small, very shallow depressions in schist geology on gentle ridge crests in low-rainfall zone
- Montane (c. 500–700 m asl) and sparsely vegetated, it is dominated by spring annuals, especially *Myosurus* and *Crassula* spp. (*C. multicaulis, C. mataikona, C. colligata*).
- Examples can be found present at the southern end of Flat Top Hill, near Alexandra, Central Otago

Coastal ephemeral wetland

- This is characterised by damp areas and ephemeral shallow ponds, with a thin layer of organic matter on top of gravels and sands.
- The vegetation is taller *Carex*, flax, jointed rush, and sometimes sparse, woody shrubs.
- This could be an older version of dune slack, similar to the gradient of active to stable dunes.
- Example locations are Waituna and Oreti, Southland.

Ephemeral runoff channel

- These occur in small ephemeral alluvial runoffs over depositional material, often only a few metres wide.
- The vegetation is composed of characteristic turf plants (e.g. *Epilobium angustum*, *Galium perpusillum* and *Lobelia ionantha*).
- Examples can be found in the Mackenzie Basin

(See 'Appendix 12 – Ephemeral wetlands' for photos and further notes.)

Definition/s

- Kettlehole ephemeral wetland: alluvium and till (glacial)/ seasonally high water table
- Schist depression ephemeral wetland: schist/depression/seasonally high water table
- Coastal ephemeral wetland: recent/sand, gravel/seasonally high water table
- Ephemeral runoff channel: alluvial (over depositional material)/ seasonally high water table

Action/discussion points

- These should all be considered variants and included in the guidance and factsheets (other variants are karst and slump types).

[10] This is ongoing work

- Ephemeral runoff channels are unlikely to be environmentally distinct from kettleholes and the biological outcome is very similar.
- North Otago has hundreds of ephemeral wetlands over limestone and sedimentary rock. Alluvial flats typically have ephemeral wetlands too.
- Coastal ephemeral wetland sounds very similar to a dune slack. We note that the description of a dune slack includes 'especially those which periodically hold slack (scarcely moving) water at times of highest tides' (Johnson & Rogers 2003). In a broader sense these ecosystems include dune hollows, deflation hollows, and swales. 'Coastal ephemeral wetland' could be added as a synonym.

Conclusions

The split is not supported. However, the factsheets should be updated to better describe the various types and range of plant communities.

Frost hollows

Change sought

Split into Singers & Rogers 2014 frost flat types (i.e. TI2, TI4, & TI6).

Reasons

There is potential to differentiate by soils, temperature, and water deficit. 'Appendix 14 – Frost hollows' has the details of the Singers & Rogers 2014 ecosystem types.

Definition/s

- TI2: alluvial and till/terrace/>200 frost days per year, semi-arid.
- TI4: recent/terrace, hillslopes, moraine/>200 frost days per year.
- TI6: peat/terrace, depressions/near permanently saturated/>200 frost days per year.

Action/discussion points

- This split would mostly work and could help with this very broadly defined group.
- Splitting (and making the definitions narrower) could result in missing some areas that fall between the newly defined groups.
- The variation could be captured through description and guidance rather than splitting.

Conclusions

The split was generally not supported because it increased the chance of missing important areas and making determining what is a frost hollow more difficult, potentially complicating management of the systems. However, the expanded factsheets could highlight the variation possible in this system (e.g. referring to the Singers & Rogers ecosystem types), including that frost intensity (not frequency of frost) and summer drought are important factors driving the diversity (and mostly non-tall forest potential) in the appearance of frost hollows.

Inland saline (salt pans)

Change sought

Split based on salt type and source.

Reason

The split would recognise differences between clay outwash and erosion pans vs deposited silts/clays. This would split the locations Patearoa and Belmont.

Definition/s

Current definition: groundwater salinity/semi-arid /depression. It is not clear how to write a new definition to fit this split based on the current framework.

Action/discussion points

- This NUE does not have a large geographical range and is already classified as Critically Endangered. These types should be considered variants.
- Make sure the examples are well described in guidance and factsheets.

Conclusions

The split is not supported, but more detail should be added to the guidance and factsheets.

Inland outwash gravels

Change sought

Split out the frost hollows that are discretely nestled within fluvioglacial outwash terraces of the intermontane basins (potential name: 'fluvioglacial outwash frost hollows').

Reasons

They have a distinctly different flora compared to the 'generic' fescue tussock grassland on the deeper soils of the terraces proper. They are characterised by having thin, stony/sandy soil, lacking fescue tussock, and supporting hardy small species such as cushion plants (*Raoulia* spp., *Colobanthus* spp.), *Carex decurtata*, *Anthosachne falcis*, and numerous ephemeral species such as *Agrostis muscosa*, *Myosurus minimus*, *Poa maniototo*, and *Myosotis brevis*. Frost heave of the substrate is a characteristic. (See 'Appendix 15 – Inland outwash gravels' for photos.)

Definition/s

- Fluvioglacial outwash frost hollows: raw, recent/sand, boulders/plain/ inland/>200 frost days per year.
- No change to 'Inland outwash gravels': raw–recent/sand–boulders/plain/inland).

Action/discussion points

- If this is a 'frost hollow' then it already an NUE. If 'frost hollows' are split, then this could be moved into TI2.
- As in sand dunes, this may be another example of a scale issue, such that we have the larger fluvioglacial outwash terraces within which other NUEs are embedded, including ephemeral wetlands.
- If 'frost hollows' are left in with outwash gravels, a topographic landform classifier could be added to capture the bar and channel/swale topography that characterises 'inland outwash gravels'. That would address this proposal to recognise the distinctive hollows and help to distinguish 'inland outwash gravels' from 'strongly leached terraces' (currently the two ecosystems are only distinguished by soil age in the diagnostic classifiers, which is not easy to apply).
- This could be better captured through factsheets and guidance.

Conclusions

- These are probably already NUEs, so a split is not needed.
- We do need to update and expand the factsheets and guidance.

Stable sand dunes

Change sought

Split 'stable sand dunes' into 'grey dune' or 'back dune' and 'forested dunes' to reflect the different secessional stages.

Reason

Dunes can be recently stable (i.e. because of recent invasion by marram) or develop naturally with a characteristic associated plant community. The current definition doesn't distinguish these types well.

The European habitat system has a grey dune ecosystem type (https://en.wikipedia.org/wiki/Grey_dune), distinguishing it from yellow dunes (active dunes) and more well-vegetated stable dunes. This framework could distinguish the relatively open but geomorphically stable plant communities associated with certain types of back dune habitats compared to denser lupin/marram/shrubland stable dune plant communities. These habitats are currently included in active dunes when mapped or excluded. If they are indeed considered a part of the active dune ecosystem type, then this should be made explicit in the factsheets. (See 'Appendix 16 – Stable dunes' for more information.)

Additional example localities include: back dune habitats of Doughboy Bay, Stewart Island / Rakiura; back dune habitats of Farewell Spit; back dune habitats of East Coast, Bay of Plenty; and Northland.

Definition/s

This could be based on age of substrate (raw vs recent soil).

Action/discussion points

- It seems that 'grey dune' is an intermediate state between active and stable. It is probably more appropriate to include this in 'active dunes', but it is also important to consider soil development. If grouped with 'active dunes', these may be recognised as a vegetation type (distinct from differentiating finer-scale NUEs within the sand dune complex).
- The distinction between active and stable is raw versus recent soils. Given that spraying the marram grass can restore these systems to being dominated by native sand binders characteristic of active dunes, this suggests they are not that stable.
- We could follow the European system if the three types (active, grey, stable) can be distinguished using the current environmental descriptors of NUEs. One acid test may be whether the dunes are still mobile (active dunes) or not (stable sand dunes).
- Better guidance should be provided by expanding the factsheets to clarify defining characteristics of stable and active dues, including where 'grey dune' might fit.

Conclusions

There was little support for adopting grey dunes. We suggest that it would be better to clarify the description on the factsheets.

Strongly leached terraces

Change sought

Add the climate qualifier >200 frost days per year to the definition.

Reasons

Frost was noted by Peter Johnson and Brian Molloy as a characteristic of these ecosystems (Johnson & Molloy 1988). They noted that intense cold and frequent frosts prevent the development of beech forest in these ecosystems, and soil frost heave is also a characteristic feature.

Definition/s

over-mature/sand-gravel/terrace-plain/inland/>200 frost days per year.

Action/discussion points

- For the 2007 list there was debate about whether drivers for the leached terraces are primarily low soil fertility and frosts, or just low soil fertility.
- Although these systems are usually in very frosty conditions, the main driver seems to be the unusually low soil fertility.

- Frost could often be associated with 'strongly leached terraces' because of where these systems occur. To evaluate whether the frost days *per se* distinguishes the system from the surrounding landscape, we could measure frost frequency at a range of leached terrace sites and nearby non-leached-terrace sites.
- The 'strongly leached terraces' guidance (lucid key and factsheets) could be expanded to discuss the role of frost.

Conclusions

Expand the description via the factsheets and guidance.

Appendix 2 – List of additions not supported

Below are the suggested additions that were not supported. Some are subset types of current ecosystems, others are biotic rather than abiotic, and one occurs outside the area covered by the framework.

Table A2.1. Outline of the additions that are not supported

Common name	*Definition*	*Vegetation structure*	*Example locality*
Chionochloa acicularis tussockland	Hillslope, plains, depressions/ permanently high-water table	Tussockland	Westland
Coal measures	TBD	Tussockland	Denniston plateau
Coastal grassland/tussockland	Recent/atmospheric salinity/terrace/coastal	Grassland, tussockland, herbfield	Waipapa Point, Southland
Inland Turfs	Silt/regularly high water table/bird and mammals trampling-grazing/inland	Herbfield	Waihola, Otago
Seepy Loess banks	Loess/hillslope, fan/periodically high-water table	Herbfield, open land	Banks Peninsula
Tall sub-Antarctic tussocklands	Recent/atmospheric salinity/coastal/extreme wind exposure	Tussockland	Snares Islands / Tini Heke, Auckland Islands

Chionochloa acicularis tussockland

Reasons

This ecosystem is a split of Singers & Rogers 2014 type WL7. It is restricted to the south-west of the South Island (i.e. Fiordland). An example site is the West Cape area. In a paper by Wardle et al. (1973), they describe the *Chionochloa acicularis* community as: saturated, infertile, silt loam (and peat) over coarse sand in flat depressions. The associated vegetation includes *Gleichenia circinata, Calorophus minor*, and stunted shrubs of *Leptospermum scoparium*.

This system may be a blanket mire. Although Williams et al. (2007) Table 2 doesn't list tussockland, the factsheets do, and Johnson and Gerbeaux (2004) use a picture of the West Cape community to illustrate blanket peatland.

Definition/s

hillslope, plains, depressions/permanently high-water table

Action/discussion points

- This is probably a blanket mire, given the example locality. This community is described as wind-exposed shrub-heath on a raised marine platform.

- Although *C. acicularis* is range restricted it is not rare, and too many locations where it occurs do not fit the definition. This is probably not an ecosystem that is naturally uncommon.

Conclusions

Part of this ecosystem most likely belongs in blanket mire (already on the list). The rest is most likely not naturally uncommon.

Coal measures

Reasons

This ecosystem was suggested as a split from sandstone erosion pavements of the Singers & Rogers 2014 type EP1. The example site is Denniston plateau.

Definition/s

Not provided, to be discussed.

Action/discussion points

- This was discussed during development of the original framework. At the time, Peter Williams did not think this ecosystem was uncommon. The Denniston plateau was captured under 'sandstone erosion pavements'.
- See 'Appendix 17 – Coal measures' for details on defining characteristics and discussions of this ecosystem.
- Possibly some of the confusion around 'coal measures' is due to the naming. The full name is 'coal measures sandstone', but the 'sandstone' tends to get dropped off.
- There is a good overview of coal measures on the Te Ara website: Coal resources – Te Ara Encyclopedia of New Zealand.[11]

Conclusions

These are sandstone erosion pavements (already in the list).

Coastal grassland/tussockland (short)

Reasons

This is found in narrow bands on coastal terraces with extreme exposure and high salinity. Predominantly grassland, dominated by *Poa* spp., it may also include *Puccinellia* spp. and other grass species, and coastal herbs (e.g. *Asplenium obtusatum, Blechnum blechnoides, B. durum, Anisotome lyallii, Hebe elliptica*). In areas with sheep/rabbit grazing, short turf becomes the

[11] https://teara.govt.nz/mi/coal-and-coal-mining/page-2

dominant vegetation type with sparse tussocks (e.g. Maori Head, Dunedin). Examples are present on the coast between Slope Point and Waipapa Beach, Stewart Island /Rakiura, and Tītī / Muttonbird Islands. (See 'Appendix 18 – Coastal grassland/tussockland' for photos.)

Definition/s

recent/atmospheric salinity/terrace/coastal

Action/discussion points

- Although this is naturally occurring to a small extent, it probably occupies the same or similar areas to what we consider to be turf. Therefore, the 'coastal turf' NUE includes this vegetation type.
- This is more widespread now because the forest has been removed. Historically it would have been part of a coastal cliff shrubland mosaic.

Conclusions

This is not a new NUE. Rather, it occupies the same ecosystem space as 'coastal turf'. The factsheets need to clarify that 'coastal turf' can include tussocks and herbs.

Inland turfs

Reasons

Inland turfs are found around waterbody edges, and are induced by grazing, nutrient additions, and compaction by indigenous birds. See Korsten et al. 2013 for further reading.

Location: Waihola, Otago.

Definition/s

silt/regularly high water table/bird and mammals trampling-grazing/inland

Action/discussion points

- This is a part of 'lake margins'.
- The guidance could recognise the influence of avian grazing in these systems.

Conclusions

This is not a new system for the list as they are lake, tarn, and lagoon margins. However, the factsheets should be updated to include refences to avian grazing for the lake, tarn, and lagoon margins.

Seepy loess banks

Reasons

This is a distinctive ecosystem on low-altitude dry hills – winter wet, summer baked. The vegetation includes annual jersey fern (*Anogramma leptophylla*), turnip rooted geranium (*Geranium retrorsum*), *Pauridia glabella* var. *glabella*, and *Leptinella minor*. It is similar to coastal cut 'seepy' loess cliffs, which are a distinctive feature of North Canterbury. The coastal version has an interesting and distinctive flora and is a stronghold for *Sonchus kirkii*.

Definition/s

loess/hillslope, fan/periodically high-water table

Discussion points

These appear to be a variation of 'seepages and flushes'.

Conclusions

These belong in 'seepages and flushes' (already on the list). The factsheet should be updated to cover this type.

Tall subantarctic tussocklands

Reasons

These tussocklands comprise wet, cool temperate, coastal, windy, salt-spray loamfield. Vegetation includes *Poa littoralis* tussockland, *P. tennantiana*, and mega-herbs. They are found on the Snares Islands / Tini Heke, Auckland Islands, Campbell Island / Motu Ihupuku, and the Antipodes Island Group. This is a component of Singers & Rogers 2014 type SA10. The short and tall coastal tussocklands could be sub-types.

Definition/s

recent/atmospheric salinity/coastal/extreme wind exposure

Action/discussion points

- The current NUE typology does not include far offshore islands (except Stewart Island / Rakiura and those very close to the South and North Islands). Including these locations should be a future step in any revision of the diagnostic classifiers as there will need to be broader considerations.
- This is a historically rare ecosystem.

Conclusions

Although distinct, this ecosystem doesn't fit the current framework because the subantarctic islands are outside the geographical range of the current NUE framework.

Appendix 3 – Braided riverbeds

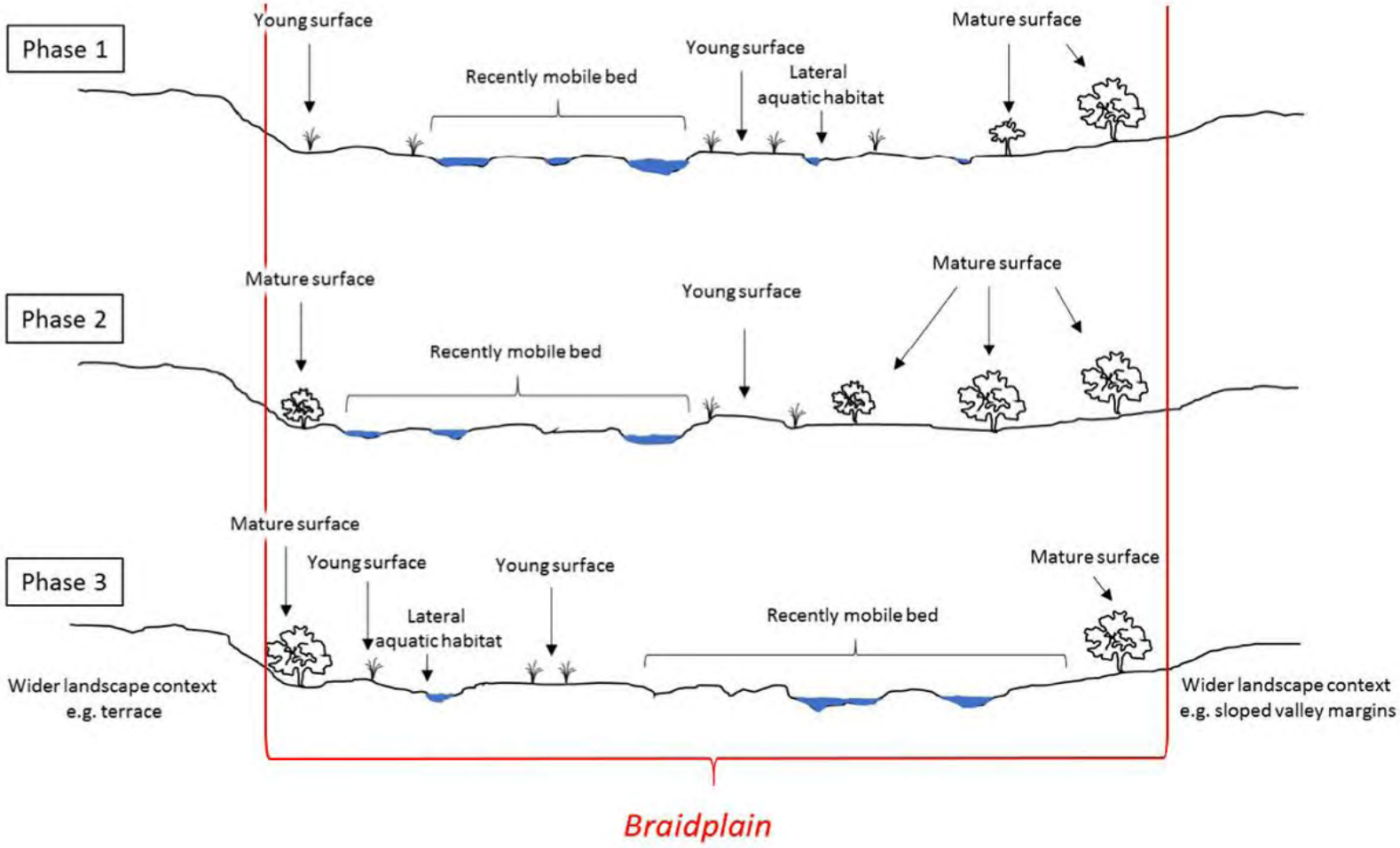


Figure A3.1. Illustration of a braided river within a braid plain.
(Source: https://braidedrivers.org/braidplains/)

Appendix 4 – Cloud forest

Notes Rowan Buxton has collated from various people and sources.

The best summary of cloud forest so far – but only for the Tropics – has some indicators as to what factors might be important in distinguishing cloud forest in New Zealand, but there are many different interpretations.

http://archive.unu.edu/unupress/unupbooks/80670e/80670E00.htm#Contents

The website gives this interpretation:

> Cloud forests include all forests in the humid tropics that are frequently covered in clouds or mist; thus receiving additional humidity, other than rainfall, through the capture and/or condensation of water droplets (horizontal precipitation), which influences the hydrological regime, radiation balance, and several other climatic, edaphic and ecological parameters.

There are various climatic and geographical factors that intervene and influence the elevation limits of the cloud forest bell in the humid tropics (the points below are summarised from https://archive.unu.edu/unupress/unupbooks/80670e/80670E03.htm):

- mean moisture content of the atmosphere
- cloud formation by convective or advective processes
- effect of the trade wind inversion and its variation on cloud formations
- direction and velocity of the prevailing winds
- mass elevation effect (Massenerhebungseffekt)
- size and orientation of the principal mountain ranges (macro-relief)
- micro-relief within mountains, which can have important topoclimatic effects
- mean distance to the nearest sea as a function of prevailing winds
- surface temperature and prevailing water currents of the nearest sea.

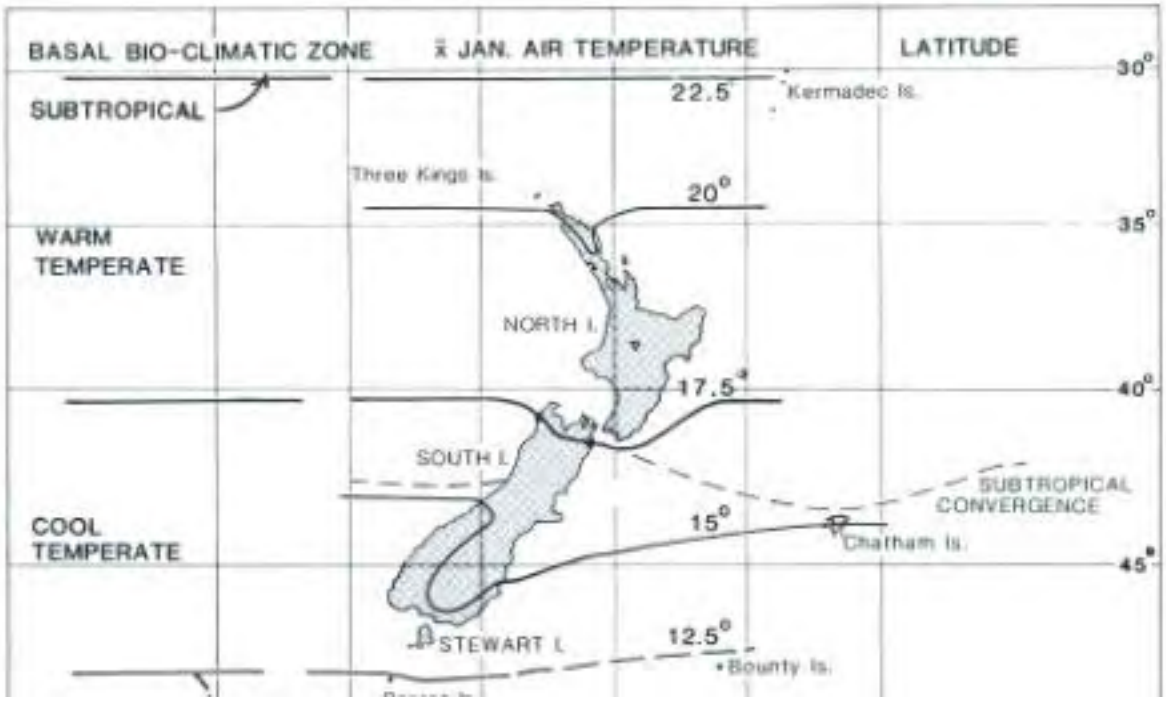


Figure A2.1. The climate zones of New Zealand. (Source: Meurk 1984)

The cloud forest in Northland lies within the warm temperate zone above the subtropical convergence (Meurk 1984). According to Meurk's (1984) diagram (http://www.newzealandecology.org.nz/nzje/free_issues/NZJEcol7_175.pdf) the humid warm temperate zone occurs where potential evapotranspiration is between 750 and 950 mm.

Appendix 5 – Moraines

The suggestions were to:

- either split moraines into dry (eastern basins, non-forest) and wet (steep, western, forested) subtypes.
- or rename 'moraines (recently formed)' and add 'moraines (dry)'.

Comment from review: The first photo shows the moraine that is consistent with the Williams et al. 2007 concept (Figure A5.1). In the other photos below, although the geomorphic origin of these sites is moraine, the soils are far too developed to fit within the definition of moraines in Williams et al. 2007, which is 'raw–recent/cobbles–boulders/moraine' (Figures A5.2 to A5.6). If the concept were this broad these would not be naturally uncommon.



Figure A1.1. Example of newly formed (forming) moraines, Godley Valley. (Photo: Jane Gosden)



Figure A5.2. Lateral moraines near Porters Pass. (Photo: Jane Gosden)



Figure A5.3. Moraines on Glenmore Station. (Photo: Jane Gosden)



Figure A5.4. Forest on glacial deposits near Ōkārito. Other good examples would be the forest down in the Franz Josef and Fox glacier valleys. (Photo: Jane Gosden)



Figure A5.5. The moraines with kānuka forest at Lake Rotoiti, Nelson Lakes National Park. (Photo: Jane Gosden)



Figure A5.6. Moraine deposits above the Hurunui River in North Canterbury. (Photo: Jane Gosden)

Below is the definition of 'raw' and 'recent' soils (LENZ technical guide, p. 31; https://www.landcareresearch.co.nz/assets/Tools-And-Resources/Maps/LENZ/LENZ_Technical_Guide.pdf). Because soil development covaries with rainfall, in dry climates old moraine soils can have the properties of recent soils because the weathering rates are so slow.

Soil age

Soils were classified into two age classes based on their membership in the New Zealand Soil Classification. This describes soil age using morphological features associated with soil development rather than criteria based on chronological ages. As a consequence, soils classified as recent in dry cool environments may be much older than recent soils from warm, wet environments.

Table 2.14: Age classes, their definition and extent

Class	Definition	Area (km²)	Area (%)
Younger	All NZLRI soil units belonging to the Recent or Raw soil orders in the New Zealand Soil Classification, but excluding soils classified as recent because of erosion of an original intact soil	16,210	6.1
Older	All other NZLRI soil units	243,498	91.1

Figure A5.7. Table from the LENZ technical guide showing the definition for soil age classes.

Appendix 6 – Cobble bank wetlands

Like the rest of the Wellington coast, the wetland is on an uplifted wave-cut platform. The wave-cut platform is probably bedrock overlain with the colluvium for surrounding coastal cliffs and alluvium from streams being pushed along in longshore drift.

Thoughts are that the main wetland is either:

- a depression in this platform where water has ponded and vegetation established: this could be a depression between the current and historical storm berms or a depression in the bedrock platform itself, in which case the wetland may be perched and hydraulically separate from the coast, other than the odd wave overtopping and salt spray
- a small indentation at the end of the shore platform where a stony barrier has formed across the front, like a growing spit that has welded to the other side (think of a much smaller version of what happened at Lake Ōnoke), enclosing the feature, and water has ponded and vegetation established, in which case water will be connected with the sea level holding the water table up, and any additional rainwater will eventually percolate through the gravels.

The smaller wetland looks very much like a depression between uplifted historical storm berms.

It is unlikely that wave processes will erode these features, given the high-energy nature of this coastline and the fact that they have been here since the 1940s. Sea-level rise might have something to say regarding the larger wetland, but if anything it would push the barrier further inland and roll over the top of the depression to some degree rather than erode it away. However, it would depend on how high this barrier actually is and if sea-level rise outruns seismic uplift. This is a highly erosive coastline along some stretches and there is no lack of sediment being thrown around for barriers to build up.

When looking for other places like this nationally, start by looking for similar uplifting shore platform type coastlines.

Further reading:

R Gilbert Robert et al. 1984. A survey of coastal environments in the vicinity of Nain, Labrador. Atlantic Geology 20(3): 143–155.

PS Rosen 1979. Boulder barricades in central Labrador. Journal of Sedimentary Research 49(4): 1113–1123. doi: https://doi.org/10.1306/212F78C4-2B24-11D7-8648000102C1865D



Figure A6.1. Te Kawakawa Rocks south of Ngawi on the eastern tip of Palliser Bay; arrows point to the two wetlands. (Source: background image is from Google Earth)

Ōkupe Lagoon on the northern end of Kapiti Island, off the Wellington west coast, is similar in that it is bound by a boulder bank on the coastal edge. It differs in that it has water running off the hill, which feeds it through a small stream. It is doubtful whether the boulder bank is often, if ever, overtopped by the sea, but the salt spray must affect the salinity. If a storm ever breached the boulder bank the lagoon would surely drain. (The workshop noted that the Ōkupe Lagoon example would probably be classified as a 'lagoon margin'.)



Figure A6.2. Ōkupe Lagoon on the northern end of Kapiti Island, off the Wellington west coast, is similar to the one at Te Kawakawa Rocks in that it is bound by a boulder bank on the coastal edge.

Below are some examples of other apparently similar wetlands from the Wellington coastline that are considered part of the shingle beach system, which suggests that cobble bank wetlands are not their own system.



Figure A6.3. Apparently similar wetlands from the Wellington coastline that are considered part of the shingle beach system. (Photo: Rowan Buxton)

Appendix 7 – Dry deflation plains

There would seem to be two different systems here that are on opposite ends of a particle size spectrum. At one end is an inter-dune community on a coarse sand or fine gravel lag with potentially paleo-pavements. At the other end are flat plains of mobile sand and gravel with ventifacts.



Figure A7.1 Mason Bay, Stewart Island /Rakiura: a dune deflation hollow and dry sand plain. (Photo: Teresa Konlechner)



Figure A7.2. Mirza Beach site. (Photo: Susan Wiser)



Figure A7.3. Napier airport site. (Photo: Susan Wiser)



Figure A7.4. Kohangapiripiri, Wellington. (Photo: Susan Wiser)

Appendix 8 – Geothermal systems

Below is a short report prepared by Wildlands to comments on the previously-described geothermal ecosystem types and suggest some changes to names, and also suggest some potential rationalisation of types.

Comments on the Review of Geothermal Aspects of Naturally Uncommon Ecosystems by Manaaki Whenua Landcare Research

Prepared for:	Landcare Research	Reviewed and approved for release by:	Sarah Beadel Senior Principal Ecologist Wildland Consultants Ltd
Author:	Chris Bycroft, Sarah Beadel, William Shaw		
Report No:	7475		
Date:	February 2025		

1.0 Introduction

Manaaki Whenua Landcare Research is updating the classification of Naturally-Uncommon Ecosystems that have previously been described and ranked by:

- Williams *et al.* (2007) provided the rationale for the list.
- The threat status of each ecosystem was assessed by Holdaway *et al.* (2012) using the IUCN red-list criteria.
- The most recent overview of the naturally uncommon ecosystems was prepared by Wiser *et al.* (2013).

These assessments recognised five naturally rare geothermal ecosystems:

- Acid rain systems
- Hydrothermally-heated ground (now cool)
- Heated ground (dry)
- Geothermal streamsides
- Fumaroles

The last four of these were assigned a threat status of 'Nationally Critical' by Holdaway *et al.* (2012).

Geothermal wetland is not included in the above categories. It should also be noted that the above categories identified 15 wetland ecosystem types as being naturally uncommon but geothermal wetland was not one of these. The omission of geothermal wetlands has become quite important when assessing the values of geothermal sites for resource consents and other activities where the loss and decline in condition of this habitat type is a potentially significant issue. We have addressed this by stating that while geothermal wetlands have not been captured in previous assessments, they do nevertheless meet the criteria for a naturally uncommon ecosystem. Geothermal wetlands also provide habitat for many of the special plants that occur in geothermal habitats.

We also provide brief comments on the previously-described ecosystem types and suggest some changes to names, and also suggest some potential rationalisation of types.

At this stage we have not commented on the species included in descriptions of geothermal habitat types currently presented on the Manaaki Whenua Landcare website (https://www.landcareresearch.co.nz/publications/naturally-uncommon-ecosystems/geothermal), but some clearly require updating to be more representative of the species that actually occur in these habitat types. This could be addressed in a future exercise.

2.0 Extent

The most recent estimate for the national extent of geothermal habitat (terrestrial and wetland) is 1,300-1,400 hectares (Wildland Consultant 2020, 2023, and 2024), which means that it is not necessary to split habitats into smaller classes to meet the criteria for a nationally uncommon ecosystem.

Most geothermal habitat occurs in the Waikato Region, as does geothermal wetland. Wildland Consultants (2023) recently mapped and described all geothermal sites in the Waikato Region, identifying *c.*113 hectares of geothermal wetland vegetation and habitat. There are also areas of geothermal wetland in the Bay of Plenty Region and a very small area in the Northland Region.

Based on staff knowledge and recent assessments (Wildland Consultants 2020) at Waimangu (Wildland Consultants 2024), we estimate that there is probably less than 30 hectares of geothermal wetland in the Bay of Plenty Region. Small areas of geothermal wetland occur at other sites throughout New Zealand, but the total area would be very small. Our estimate is that there would likely be less than 150 hectares of geothermal wetland, nationally.

3.0 Threats

There has previously been a number of threats to geothermal wetland sites in the Waikato and Bay of Plenty regions including drainage, conversion to farmland, industrial and urban development, pest plant invasion (particularly willows and alder), forestry activities on margins, development of the underlying geothermal reservoir for electricity generation, flooding due to hydro dam development, impacts of pigs and other pest animals, and herbicide overspray. Many of these factors remain active threats at various sites.

4.0 Variation in Geothermal Wetlands

Factors Influencing Variability

It should be noted that geothermal wetland is an extremely variable habitat type. This variation includes features such as the character of the geothermal system the wetland occurs in, water chemistry, temperature variation of different springs or seepages, water depth, altitude, distance inland, landform, and adjoining features such as lakes. For example, acidity is a key attribute that influences plant species presence (and distribution).

Because of the varied character of sites, it is useful to identify geothermal wetlands in a broad sense, so that all the different types are captured.

Vegetation Structure

Geothermal wetlands are known to support the following vegetation structural classes:

- Sedgeland
- Rushland
- Herbfield
- Reedland
- Shrubland
- Algal mats

5.0 Representative Examples

The following are representative sites for geothermal wetlands:

Waikato Region

- Waikite
- Waiotapu (south end near Lake Ngakoro and Lake Orotu)
- Waihunuahuna springs (edge of Lake Ohakuri)
- Waikato River Springs, near Tutukau Bridge
- Waipahihi Valley (Wairākei Tauhara Geothermal System)
- Tokaanu Lakeshore Wetland

Bay of Plenty Region

- Waimangu – lower valley wetland
- Ngapuna (edge of Lake Rotorua, Rotorua)
- Parengarenga Wetland (Lake Rotoiti)
- Waitangi Soda Springs (south of Lake Rotorua)
- Tukuri

Northland Region

- Ngawha

A selection of site photographs is provided in Appendix 1.

6.0 Key Species

6.1 Vascular plants

Examples of key species associated with geothermal wetlands include (Threatened or At Risk rankings are from de Lange *et al.* 2023):

- *Christella* aff. *dentata* (b) (AK 126902; "thermal") (Threatened-Nationally Endangered).
- *Cyclosorus interruptus* (At Risk-Declining).
- *Thelypteris confluens* (At Risk-Declining).
- *Nephrolepis flexuosa* (At Risk-Naturally Uncommon).

The conservation status of many of these species would be higher if regional rankings were to be applied for the Bay of Plenty, Waikato, and Northland Regions.

Also, various species outside their usual natural range occur in geothermal wetlands, including species of coastal sites occurring inland, or with unusual latitudinal and elevation ranges such as:

- Sea rush (*Juncus kraussii* subsp. *australiensis*).
- Oioi (*Apodasmia similis*).
- Arrow grass (*Triglochin striata*).

6.2 Avifauna

In addition to many common water birds, the following are known to utilise geothermal wetlands (Threatened or At Risk rankings are from Robertson *et al.* 2021).

- *Botauruspoiciloptilus* (matuku-hūrepo/Australian bittern): (Threatened-Nationally Critical).
- *Bowdleria punctata vealeae* (koroātito/North Island fernbird): (At Risk-Declining).
- *Zapornia tabuensis tabuensis* (pūweto/spotless crake): (At Risk-Declining).

7.0 Previous Definitions of Geothermal Wetland

There are existing definitions for geothermal wetland, including:

- "Permanently or intermittently wet areas, shallow water, or land water margins that support a natural ecosystem of plants adapted to wet conditions, and in which some or all of the water is geothermally sourced" (Merrett and Clarkson 1999).

- "A wetland hydrosystem where the dominant function is geothermally heated water. The Resource Management Act (1991) defines geothermal waters as those heated by natural phenomena to 30 degrees Celsius or above. Geothermal wetlands may have water temperatures below this, but must be considered geothermal due to the chemical composition of the water. Geothermal wetlands are permanently or intermittently wet areas, shallow water, or land water margins that support a natural ecosystem of plants that have compositional, structural, and/or growth rate characteristics determined by current or former inputs of geothermally derived water." (Clarkson *et al.* 2004).

- "A hydrosystem where volcanic activity produces hot surface waters, or heated soils (30 C or more) or where geothermal chemistry affects wetland habitats." (Johnson and Gerbeaux 2004).

8.0 Suggested Definition of Geothermal Wetland

To provide a description of geothermal wetland, we have followed the layout used to describe naturally uncommon ecosystems, e.g. Williams *et al.* 2007, Holdaway *et al.* 2012, Wiser *et al.* 2013, and on the Manaaki Whenua Landcare website:

> Inland (including coastal to alpine), regularly high water table (permanently or ephemerally wet), with elevated temperatures, sourced at depth and also due to overflows, with higher temperatures and different chemistry than natural surrounding land.

9.0 Comments on other geothermal ecosystem types

<u>Geothermal Steamy Habitat</u>

Merrett and Clarkson (1999) used the term 'Atmospheric Influence' and identified two types.

(a) regular toxic gas emissions to the extent that vegetation growth is negatively influenced (e.g. Whakaari/White Island), or

(b) a warm micro-climate created by hot-springs discharge (e.g. the fern *Christella* aff. *dentata* ("thermal") occurs along the margins of hot streams where the atmosphere is influenced by steam).

Acid rain could still be a sub-type under type (a) above but, due to the rarity of geothermal systems nationally, combining these together may prove more useful from a management perspective and would help to ensure that no rare geothermal ecosystem sub-types are omitted.

The title for the type 'geothermal streamsides' is a poor descriptor of the habitats it represents. It is also intended (based on the description on the Manaaki Whenua Landcare website) to include hot spring margins that occur in the geothermal streamside ecosystem type. Geothermal streamsides are obviously totally reliant on the presence of a heated stream with associated steam influence on the margins. The name could be altered to reflect the key role of heated streams.

'Hydrothermally-heated ground (now cool)' and 'heated ground (dry)' work well within the naturally uncommon ecosystem framework. However, it is suggested that the term 'geothermal' is added to these titles, as this will make it clear that they are linked to a below ground heat source (at depth, from the Earth's heat), and not solar radiation, or other human influences. Suggested titles are.

- Previously geothermally-heated ground (now cool).
- Geothermally heated ground (dry).

A summary of suggested changes to geothermal habitat type names from Williams *et al.* 2001; Holdaway *et al.* 2012; and Wiser *et al.* 2013 is presented in Table 1.

Table 1 – Suggested name changes for naturally rare ecosystems as per Williams *et al.* (2001); Holdaway *et al.* (2012); Wiser *et al.* (2013).

Uncommon Ecosystems (Williams *et al.* 2001; Holdaway *et al.* 2012; Wiser *et al.* 2013)	Wildlands Recommendation
Hydrothermally-heated ground (now cool)	Previously geothermally-heated ground (now cool)
Heated ground (dry)	Geothermally-heated ground (dry)
Geothermal streamsides	Geothermal streams and streamsides and spring and margins
Fumaroles	Fumaroles
Acid rain systems	Geothermally-derived natural atmospheric systems
Not assessed	Geothermal wetland

Other Geothermal Habitats

Other geothermal habitat types 'missing' from the five currently-recognised rare geothermal ecosystems include:

- Mud pools.
- Geothermal lakes.



Acknowledgements

This work was initiated during a discussion at the New Zealand Ecological Society conference field trip to Waimangu in November 2024. During the discussion useful discussion was had with Scott Jarvie (Otago Regional Council) and Susan Wiser (Landcare Research). Subsequent discussion occurred with Gretchen Brownstein Landcare Research. We also thank William Shaw and other Wildlands staff for useful discussion and Waikato Regional Council and Bay of Plenty Regional Council, including their staff, who have initiated much of the field work we have undertaken at geothermal sites in the last 20-30 years and has been very helpful in formulating our ideas on geothermal habitats and other naturally rare ecosystems.

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Appendix 1: Example photographs of geothermal wetlands



Plate 1 – A relatively large geothermal wetland occurs at the southern end of the lake Ngakoro, Waiotapu, Waikato Region. The wetland provides habitat for special plant and bird species. Photograph: Chris Bycroft/Wildland Consultants 2023.



Plate 2 — Geothermal wetlands occur on the margins of Lake Ohakuri at Waihunuhu Inlet, Orakei Korako Geothermal System, Waikato Region.
Photograph: Chris Bycroft/Wildland Consultants 2023.



Plate 3 – There are relatively large areas of geothermal wetland in the Waikite Valley located in the Waikato Region. The wetland provides habitat for many of the special geothermal fern species. Photograph: Chris Bycroft/Wildland Consultants 2023.



Plate 4 — Geothermal wetland at Otumuheke Stream in 2012. The springs in this wetland have retreated down the valley due to subsidence. Most of the wetland has since dried up and it is no longer wetland. Previously well over 1,000 *Cyclosorus interruptus* plants were present. Photograph: Chris Bycroft/Wildland Consultants 2012.



Plate 5 — Geothermal wetlands at Tukuri near the township of Kawerau, Bay of Plenty Region. Photograph: Sarah Beadel/Wildland Consultants 2024.



Plate 6 — Mats of algae occur on geothermal sinter near a small geyser at Waimangu, Bay of Plenty Region. Ferns such as *Nephrolepis flexuosa*, usually a species of warmer climates, occurs on wetland margins.
Photograph: Sarah Beadel/Wildland Consultants 2024.



Plate 7 — Geothermal wetland at Waimangu, Bay of Plenty Region. Photograph: Chris Bycroft/Wildland Consultants 2024.



Plate 8 — Geothermal wetland alongside the Tarawera River, Tarawera Forest, Bay of Plenty Region. Photograph: Chris Bycroft/Wildland Consultants 2019.

Appendix 9 – Inland dryland alluvium

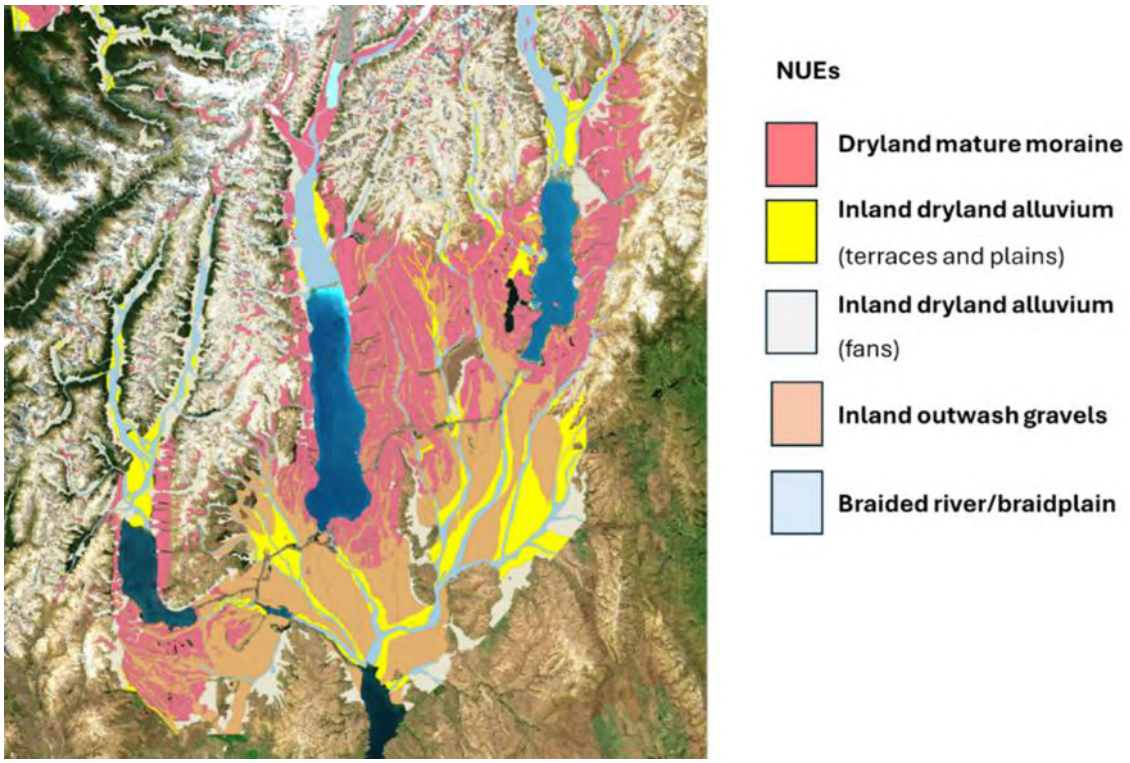


Figure A9.1. Map showing the location of inland dryland alluvium terraces and plains (yellow) and fans (light grey). (Polygons layer from: https://data.gns.cri.nz/csigg/map.html. Background imagery: https://data.linz.govt.nz/layer/95677-nz-imagery-survey-index/)



Figure A9.2. Vegetation patterns are related to soil depth in inland alluvial terraces, Mackenzie Basin. (Photo: Susan Walker)



Figure A9.3. Bryophyte and cushion plant communities in inland alluvial terraces, Mackenzie Basin. (Photo: Susan Walker)



Figure A9.4. Terraces near Pukaki airport. There is definitely some patterning, with slightly deeper soils perhaps in the swales between the drier-looking ridges. This is probably quite different from the alluvial terraces on the Canterbury plains and elsewhere, but it's unclear what the main driver is. (Photos: Rowan Buxton).

Appendix 10 – Inland salt springs

All photos are from Wairau Valley, Marlborough.



Figure A10.1. Inland salt spring vegetation patterns. (Photo: Mike Aviss)



Figure A10.2. Inland salt spring. (Photo: Mike Aviss)



Figure A10.3. *Samolus repens* around an inland salt spring. (Photo: Mike Aviss)

Appendix 11 – Mud volcanoes

Further reading:

BW Hayward, D Francis 2013. New Zealand's small mud volcano heritage" Geological Society of New Zealand Newsletter.

Nga Maunga Korero Ō-tū-pō-tehetehe – The Lake of Taikehu: https://maungakorero.wordpress.com/maunga-korero/issue-13-patangata/o-tu-po-tehetehe-the-lake-of-taikehu/

JR Pettinga 2003. Mud volcano eruption within the emergent accretionary Hikurangi margin, southern Hawke's Bay, New Zealand. New Zealand Journal of Geology and Geophysics 46(1): 107–121.



Figure A11.1. Mud volcano, Waimatā valley, Gisborne. (Photo: Bev Clarkson)



Figure A11.2. Mud volcano, Ōtōpōtehetehe Lake, near Pōtaka, Gisborne region. (Photo: Paul Cashmore)



Figure A11.3. Mud volcano, Ōtōpōtehetehe Lake, near Pōtaka, Gisborne region. (Photo: Paul Cashmore)

Appendix 12 – Active sand dunes

Further information can be found here: http://tinyurl.com/Activedunes

Associated vegetation:

- dune environments (constructional, high to moderate sand mobility): species include *Spinifex sericeus, Ficinia spiralis, Poa billardierei*
- less mobile habitats: species include *Coprosma acerosa, Pimelea lyallii, Pimelea villosa, Lachnagrostis billardierei, Acaena pallida*.

Appendix 13 – Ephemeral wetlands



Figure A13.1. Kettlehole ephemeral wetland on Ahuriri Valley glacial terraces. (Photo: John Barkla)

In Jane Gosden's kettlehole work she included some other tarns in the definition, even though they do not have a glacial origin when you look at GNS maps of glacial deposits and don't strictly fit the criteria for a kettlehole geologically. However, she suspects they are still of glacial origin and have had subsequent processes occur over the top (such as earthquake faulting for two tarns in Marlborough, or Holocene alluvial processes for three in Southland/Otago).

She now has a full extent and distribution for kettleholes, mapped as polygons and tarn centres (currently progressing for publication). Her work suggests that kettleholes are the most widespread/abundant of the ephemeral wetlands (in the South Island at least). However, they still fit the definition for naturally uncommon (<0.05% of land area).



Figure A13.2. Example of a tarn formed by fault action in the Molesworth Recreation Reserve near Lake Sedgemere. This ecosystem is ecologically similar to a kettlehole tarn, even if its origin isn't strictly glacial. (Photo: Jane Gosden)



Figure A13.3. Example of a tarn with Holocene deposits as its youngest geological deposit. This ecosystem also functions as a kettlehole tarn, even if its origin is not strictly glacial. (Photo: Jane Gosden)



Figure A13.4. Schist depression ephemeral wetland at the southern end of Flat Top Hill, near Alexandra, Central Otago. (Photo: John Barkla)



Figure A13.5. Ephemeral wetland in a temporary runoff channel. (Photo: Jane Gosden)

Ephemeral wetlands are often part of other wetland systems. The larger lakes around Lake Sedgemere in the Molesworth Recreation Reserve provide good examples of this type. Jane didn't include them in her kettlehole study because they function differently hydrologically. Jane suspects the ephemeral wetlands of the North Island are more likely to be like this.

The workshop commented that the lake edges are already included under lake margins and tarn margins, which are known to share species with the turfs of ephemeral wetlands.



Figure A13.6. A good example of an ephemeral wetland on the edge of other wetland systems. The photos are from Lake Sedgemere in the Molesworth Recreation Reserve (not far from Sedgemere Hut). This example illustrates how complicated some of these uncommon ecosystems are when they blend into something else or form mosaics. (Photo: Jane Gosden)

Appendix 14 – Frost hollows

The following is an excerpt from Singers & Rogers 2014, Appendix 3, with the four types that equate to frost hollows.

Ecosystem unit and code name	*Description*	*Distribution current and historic*	*References*
TI2: Kānuka, Olearia scrub/treeland	Scrub and treeland of kānuka, and species of Olearia, Carmichaelia and Melicytus, with korokia, matagouri, mountain tauhinu, prostrate kōwhai and lianes (e.g. Muehlenbeckia), and locally Leonohebe cupressiodes. Early successional derivatives include short tussock grasslands of species of Poa, Festuca, Deyeuxia and Rytidosperma, with inter-tussock prostrate herbfield species.	Driest inter-montane basins on Holocene terraces of Marlborough to Otago (e.g. Mackenzie and Heron Basins) with > 200 mm annual water deficit (Leathwick et al. 2003). Soils described by Molloy (1998: 24–25 & 157–158). Largely only highly degraded secondary derivatives remain, which are dominated by prostrate shrubland, short tussock grassland and scabweed herbfield.	McGlone & Moar (1998), McGlone (2001) and Rogers et al. (2005: 53). Includes rare ecosystem: frost hollows (Williams et al. 2007).
TI4: Coprosma, Olearia scrub [Grey scrub]	Scrub of two different variants: 1. on free-draining stony soils, with species including Carmichaelia, Coprosma, Olearia, Hebe, Corokia cotoneaster, mānuka, matagouri, and species of the lianes Muehlenbeckia, Rubus and Clematis; and 2. on poor-draining silty soils, with species such as Coprosma (C. propinqua, C. pedicillata), Pittosporum obcordatum and Olearia (O. polita, O. virgata). Early alluvial successions are dominated by short tussock grasslands (species of Poa, Festuca, Deyeuxia and Rytidosperma).	In the South Island, post-glacial river terraces, colluvial slopes and recent moraines west and east of the Main Divide, and in frost-prone areas further afield. In the North Island, localised in frosty hollows and river and stream margins. Often colloquially called 'grey scrub' or 'frost flats'. Many species are common to both types and both types can occur together as mosaics on the different alluvial landforms/soils. Often occurs as secondary shrubland on a wide range of previously forested landforms. Enters the humid zone in central ranges.	Equivalent to Matagouri shrubland class of Wiser & Hurst (2008). Wardle (1991: 207–211), Clarkson & Clarkson (1994), Molloy et al. (1999) and Rogers et al. (2005). Includes rare ecosystem: frost hollows (Williams et al. 2007).
TI5: Bog pine, mountain celery pine, silver pine scrub/forest	Scrub and short forest with several local variants, including mountain celery pine and bog pine, locally with silver pine, pink pine, yellow silver pine, pāhautea and Westland tōtara, and often with divaricating shrubs and Dracophyllum spp.	Central North Island (e.g. Kaimanawa Mountains) and western Tongariro National Park (e.g. Waimarino Plains). In the South Island, predominantly Nelson Lakes to Westland (e.g. upper Howard River). Locally also on levee and margins of wetlands.	Equivalent to G20 type of Nicholls (1976). Wardle (1991: 193–195). Includes rare ecosystem: frost hollows (Williams et al. 2007).
TI6: Red tussock tussockland	Tall tussock grassland of abundant red tussock with inter-tussock herbfield / short tussockland and prostrate shrub species. Early alluvial successions are dominated by short tussockland of Poa, Festuca, Deyeuxia and Rytidosperma species. Typically includes an embedded, complex mosaic of bog and fen wetlands on organic soils.	In the North Island, restricted to the volcanic plateau, from the Hauhungaroa Range south to Erua and the Kaimanawa Mountains on alluvial terraces and headwater basins, to southern Ruahine. In Northwest Nelson, occurs with wire rush (e.g. Gouland Downs and Thousand Acres Plateau) and with C. rigida in eastern Fiordland. Occurs on valley floors in Westland (e.g. Toaroha and Landsborough Rivers) and Fiordland (e.g. Takahe Valley).	Elder (1962: 22), Evans (1969a), Druce et al. (1987), Wardle (1991: 226), Grove (1994), Mark & Dickinson (1997) and Mark et al. (2003: 193 & 200–202). Includes rare ecosystem: frost hollows (Williams et al. 2007).

The following is an excerpt from Singers & Rogers 2014, Table 2, for temperatures greater than minus 9°C, cold air inversion topography.

Moisture	*Landform and soils*	*Ecosystem code*
Semi-arid	Mosaic of hummocky moraines and peri-glacial outwash, and alluvial terraces and plains with stony, semi-arid soils, e.g. Tekapo soils	TI1
	Terraces with recent semi-arid alluvial and pallic soils, e.g. Fork or Molyneaux soils	TI2
Sub-humid	Terraces and plains with recent deep pumice soils, e.g. Poronui and Kaingaroa soils	TI3
	Terraces, hillslopes and glacial moraines with alluvial, poor- and free-draining recent soils	TI4
Humid	Terraces, depressions and montane plateaus with recent volcanic, alluvial and podzol soils	TI5
	Montane to subalpine terraces and montane plateaus with poor-draining and organic soils	TI6

Appendix 15 – Inland outwash gravels

The following are photos of a fluvioglacial outwash ecosystem in the Mackenzie Basin with frost hollows.



Figure A15.1. A fluvioglacial outwash ecosystem with frost hollows throughout. (Photo: Nick Heads)



Figure A15.2. A fluvioglacial outwash ecosystem intermixed with frost hollows. (Photo: Nick Heads)

Appendix 16 – Stable dunes

Potential proposed split – grey dune and forested stable dune ecosystem.

The European habitat system has a grey dune ecosystem type (https://en.wikipedia.org/wiki/Grey_dune), distinguishing it from yellow dunes (active dunes) and more well-vegetated stable dunes.



Figure A16.1. Example of a potential grey dune from the east coast, Northland. Type species: *Ficinia nodosa, Calystegia soldanella*, non-thrifty dune building species (*Spinifex sericeus* and *Ficinia spiralis*), *Muehlenbeckia complexa*, and various non-native species. The defining characteristics are low sand mobility, some soil development, and low and relatively open vegetation cover.
(Photo: Teresa Konlechner)



Figure A16.2. Example of a grey dune from Farewell Spit. (Photo: Teresa Konlechner)



Figure A16.3. Example of a grey dune at Doughboy Bay, Stewart Island / Rakiura.
(Photo: Teresa Konlechner)

Appendix 17 – Coal measures

There is a good overview of coal measures on the Te Ara website: Coal resources – Te Ara Encyclopedia of New Zealand

Background

The Denniston plateau is often selected as an NUE because of the distinctive landscape and biota. This raises two questions: what type of ecosystem is the Denniston plateau, and is it naturally uncommon?

What is a coal measure?

Coal measures are simply coal-bearing strata. They can be old (Carboniferous) or relatively recent (Tertiary). They can be close to the surface or at great depth. Some are tilted, others are in horizontal planes. They are not an NUE in themselves because they do not define what's at the surface (i.e. the terrestrial ecosystems we see). In New Zealand, coal measures are *usually* Tertiary, and they are *sometimes* associated with deposits of conglomerates, sands, and finer-grained sedimentary rocks that *can be* exposed at the surface. These exposed rocks *can* form erosion pavements, and it is these pavements that are naturally uncommon ecosystems.

What is a sandstone erosion pavement?

Flat or gently tilting, eroded, exposed and cemented sandstone above a coal measure.

Conclusion

Because not all coal measures support erosion pavements it would be clearer if we referred to sandstone erosion pavements rather than coal measures. In north-west Nelson and on the West Coast we have tended to use 'coal measures' and 'sandstone erosion pavements' interchangeably, hence the confusion.

Outstanding questions

In 2012 we visited a suite of sandstone erosion pavement sites in north-west Nelson. We collected sediment cores from all of them to test the hypothesis that some areas of these exposed pavement ecosystems can be an artefact of fire, deforestation, and soil erosion. The full trip report and pollen and charcoal analyses are available from Janet Wilmshurst (MWLR).

Appendix 18 – Coastal grassland / tussockland



Figure A18.1. Example of coastal grassland, Waipapa Point, Southland. (Photo: John Barkla)



Figure A18.2. Example of coastal grassland, Maori Head, Dunedin. (Photo: Gretchen Brownstein)

Appendix 19 – List of contributors

The following people made suggestions for revisions to the list, and/or provided information to inform our thinking, and/or participated in the workshop discussions, and/or provided comments on and reviews of earlier versions. The list is in alphabetical order.

Warwick Allen, Mike Aviss, John Barkla, David Barrell, Sarah Beadel, Annabel Beattie, Peter Bellingham, Rowan Buxton, Chris Bycroft, Ciaran Campbell, Paul Cashmore, Bev Clarkson, Richard Ewans, Jane Gosden, Nick Heads, Mike Hilton, Scott Jarvie, Teresa Konlechner, Clement Lagrue, Kelvin Lloyd, Ellery Mayence, Adrian Monks, Peter Johnson, Brian Rance, Jill Rapson, Sarah Richardson, Geoff Rogers, William Shaw, Robyn Simcock, Roger Uys, Susan Walker, Susan Wiser, Debra Wotton