IN THE ENVIRONMENT COURT
AT CHRISTCHURCH

IN THE MATTER OF the Resource Management Act 1991 and

IN THE MATTER OF appeals under clause 14 of the first schedule to the Act

BETWEEN

FEDERATED FARMERS OF NEW ZEALAND (INCORPORATED)
MACKENZIE BRANCH
ENV-CHC-2009-000193

MOUNT GERALD STATION LIMITED
ENV-CHC-2009-000181

MACKENZIE PROPERTIES LIMITED
ENV-CHC-2009-000-183

MERIDIAN ENERGY LIMITED & GENESIS LIMITED
ENV-CHC-2009-000184

THE WOLDS STATION LIMITED
ENV-CHC-2009-000187

FOUNTAIN BLUE LIMITED & OTHERS
ENV-CHC-2009-000190

R, R AND S PRESTON & RHOBOROUGH DOWNS LIMITED
ENV-CHC-2009-000191

HALDON STATION
ENV-CHC-2009-000192
Appellants

AND **MACKENZIE DISTRICT COUNCIL**
Respondent

STATEMENT OF EVIDENCE OF NICHOLAS JOHN HEAD
On behalf of DIRECTOR-GENERAL OF CONSERVATION
DATED 9 September 2016

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1. INTRODUCTION

1.1 My name is Nicholas John Head. I am currently employed by the Department of Conservation ("**DOC**") as the plant ecology advisor for DOC's Southern Service Centre, where I have worked for the past 21 years. Previously I was employed by the Crown Research Institute, Landcare Research New Zealand Ltd, as a botanist for the Rabbit and Land Management Programme and Semi-Arid Lands Programme, based in Alexandra.

1.2 I have a Master of Science (Hons) degree in plant ecology from Lincoln University and a BSc with a double major in plant ecology and physical geography from the University of Canterbury.

1.3 My role involves ecological and botanical work for DOC's Southern Service Centre, with a particular focus on threatened plants and ecosystems, and those of ecological significance. Regarding the latter, I was part of Environment Canterbury's ecologists' working party to develop ecological criteria for the Canterbury Regional Policy Statement ("**RPS**"). I was also responsible for the preparation of DOC's best practice guidelines for assessing significant ecological values[1] of which I am a co-author. I have presented evidence on ecological matters in numerous hearings at the district and regional level, including in the Environment Court.

1.4 From a practical perspective, I have extensive field experience assessing, recording and reporting on botanical matters throughout New Zealand, with a particular focus on eastern South Island dryland ecosystems. I have also undertaken many botanical assessments ranging in size from greater than 20,000 hectares to less than one hectare. These include being involved in three Protected Natural Area Programme ("**PNAP**") surveys in Canterbury that used a standard scientific approach to assess significant ecological values. I also have surveyed many sites that form the basis of Significant Natural Areas ("**SNAs**") in numerous district plans and I have prepared many successful land protection proposals in Canterbury.

1.5 As part of Tenure Review I have undertaken botanical assessments on 23 pastoral leases in the Mackenzie Basin, occupying more than 200 thousand hectares and covering a considerable portion of the Mackenzie Basin floor. This includes surveying (fully or in part) almost all of the areas classified as Scenic Grasslands, Lakeside

[1] Davis, M.; Head, N. J.; Myers, S. C.; Moore, S. H. 2016. Department of Conservation guidelines for assessing significant ecological values. Department of Conservation, Wellington, 71p

Protection Areas, and the areas that were classified High and Medium Visual Vulnerability Areas in earlier versions of PC13

1.6 The properties I have surveyed in the Mackenzie Basin include Sawdon Station, Mt Hay Station, Balmoral Station, Holbrook Station, Irishmans Creek Station, Glenmore Station, Braemar Station, The Wolds Station, Maryburn Station, Simons Pass Station, Mt Dalgety Station, Mt Gerald Station, Grampians Station, Black Forest Station, Gurragmore Station, Streamlands Station, Stony Creek Station, Kirkliston Station, Omahau Hill Station, Ferintosh Station, Quailburn Station, and Twin Peaks Station.

1.7 I am involved with research on the management of threatened plant species and rare ecosystems. An example is recently published research on the Tekapo Scientific Reserve[2]. That research involves undertaking in-depth studies on threatened species populations and ecosystem health over time and assessing responses to various management actions.

1.8 I provide a wide range of botanical and ecological advice to DOC staff and the public generally. I have published numerous articles on threatened plant species and ecosystems; some of these are included in the "References" to my evidence.

2. CODE OF CONDUCT

2.1 I have read the code of conduct for expert witnesses as contained in the Environment Court's Practice Note 2014. I have prepared my evidence in accordance with the Code and agree to abide by it when I give oral evidence before the Hearings Panel.

2.2 The data, information, facts and assumptions I have considered in forming my opinions and the reasons for those opinions are set out in my evidence to follow. I confirm that my evidence is within my area of expertise, except where stated otherwise. I have not omitted to consider material facts known to me that alter or detract from the opinions I express in this statement of evidence.

2.3 DOC has authorised me to provide evidence on behalf of the Director General of Conservation and to do so in an independent capacity in accordance with the Code.

[2] Walker, S.; Comrie, J.; Head, N.; Ladley, K. J.; Clarke, D. 2016. Hawkweed invasion does not prevent indigenous non-forest vegetation recovery following grazing removal. *New Zealand Journal of Ecology,* 40(1) 137 - 149.

3. SCOPE OF EVIDENCE

3.1 I have studied the relevant biodiversity documents as set out in the references attached to my evidence and have reviewed the submission lodged by the Director-General of Conservation on Plan Change 13 ('**PC13'**).

3.2 My statement of evidence addresses and provides information on matters within my area of expertise that are relevant to the Director-General's submission. In particular I will:

(a) Provide context relating to indigenous biodiversity in New Zealand and the relevance of PC13 to New Zealand's biodiversity commitments, goals and priorities;

(b) Clarify the ecological significance of the Mackenzie Basin by describing the framework for assessing significant ecological values in New Zealand, including New Zealand land environments, threatened land environments and the national priorities for the protection of indigenous biodiversity on private land;

(c) Provide an ecological overview of the Mackenzie Basin from pre-human to present day;

(d) Discuss known sites of ecological value in the Mackenzie Basin; including significant botanical values identified by tenure review, naturally rare ecosystems, threatened ecosystems and threatened plants;

(e) Outline the extent of ecosystem loss occurring in the Mackenzie Basin and discuss other threats to indigenous ecosystems;

(f) Consider Plan Change 13's provisions in so far as they are relevant to effects on indigenous biodiversity and ecosystems;

(g) Provide a summary of the main points and a conclusion.

4. EXECUTIVE SUMMARY

4.1 The Mackenzie Basin mostly comprises naturally rare, glacial-derived ecosystems that are not replicated to any similar extent elsewhere in New Zealand, or the rest of the world. These ecosystems support a distinctive biota, including providing habitats for a disproportionally high number of threatened species.

4.2 Although many remaining indigenous ecosystems are depleted and can include very sparse vegetation, those that have yet to be intensively developed are likely to contain significant indigenous vegetation and significant habitats of indigenous fauna (herein referred to as 'significant ecological values') when determined in accordance with accepted standards for assessing ecological significance.

4.3 Many of the significant ecological values present in the Mackenzie Basin meet the criteria for classification as national priorities for the protection of indigenous biodiversity in New Zealand[3], because they support indigenous vegetation on naturally rare ecosystems, threatened ecosystems, and/or provide habitats for threatened flora and fauna.

4.4 Despite the significant ecological values identified in the Mackenzie Basin, the majority of values present are not protected and are vulnerable**.**

4.5 Substantial ecosystem loss has occurred in the Mackenzie Basin, primarily as a result of intensive agricultural development. Only the Tekapo and Pukaki (upper) Ecological Districts retain extensive sequences of undeveloped naturally rare ecosystems, but these are also threatened with land use change.

4.6 Despite the losses that have occurred and are occurring, the Mackenzie Basin stands out nationally as one of the few remaining places that retains landscape scale connectivity of indigenous low-lying ecosystems that have been largely lost and fragmented elsewhere in New Zealand.

4.7 PC13 potentially plays an important role in the protection of significant ecological values present in the Mackenzie Basin because there is an inherent relationship between natural landscapes and indigenous biodiversity.

4.8 The Scenic Grasslands, Lakeside Protection Areas and Roadside Corridors, within which controls on agricultural intensification are proposed, represent a very small

[3] Protecting our places: Introducing the national priorities for protecting rare and threatened biodiversity on private land. Available at https://www.biodiversity.govt.nz/land/guidance/

proportion of the significant ecological values present in the Mackenzie Basin. They do not account for some of its most notable significant values such as the connectivity of the undeveloped and naturally rare basin floor ecosystems.

4.9 A definition of tussock grasslands is recommended to better recognise its ecological character.

5. CONTEXT - THE RELEVANCE OF PLAN CHANGE 13 TO NEW ZEALAND'S BIODIVERSITY GOALS AND PRIORITIES

5.1 In my experience there is an inherent relationship between natural landscapes and indigenous biodiversity. Almost invariably, the intrinsic qualities of natural ecosystems underpin many of the attributes which help define natural and/or 'outstanding' landscapes.

5.2 Landscape scale, in terms of large size and landform connectivity, is integrally related to ecological significance and sustainability, as bigger natural areas support greater diversity and are more resilient[4]. As a result, the protection of large interconnected natural areas is a key conservation objective nationally and internationally. However, the opportunities to achieve this are now limited in modern day New Zealand given the extensive loss and fragmentation that has occurred especially to low-lying[5] ecosystems.

5.3 The Mackenzie Basin stands out nationally as one of the few remaining places that retain landscape scale connectivity of indigenous low-lying ecosystems. The tussock grasslands, which contribute to the distinctive look and feel of the Mackenzie Basin, comprise a complex mosaic of indigenous ecosystems that collectively support the Mackenzie Basin's diverse and distinctive 'dryland' species biome. In the case of the Mackenzie Basin's ecology, the whole is more important than its individual parts.

5.4 Given the relationship between landscapes and the ecosystems which underpin them, in this evidence I propose to outline the context within which significant ecological values are protected in New Zealand. The Mackenzie Basin needs to be considered as part of the broader context, as do the effects of land use changes.

5.5 New Zealand has evolved a biologically unique flora and fauna owing to long periods of isolation from other land masses. The rate of endemism for New Zealand species (i.e. species that are found only in New Zealand) is remarkably high; 85% of plants, 45% of birds, 100% of land mammals and reptiles, and 90% of invertebrates are endemic to New Zealand[6].

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[4] O'Connor, K. K.; Overmars, F. B.; Ralston, M. M. 1990. Land Evaluation for nature conservation. A scientific review compiled for application in New Zealand. *Conservation Sciences Publication Number 3.* Department of Conservation, Wellington.

[5] Low-lying = flat and/or land of gentle relief at lower altitudes that is more easily developed

[6] Ministry for the Environment & Department of Conservation 2000. The New Zealand Biodiversity Strategy. Department of Conservation, Wellington, New Zealand.

5.6 New Zealand has one of the worst records of indigenous biodiversity loss in the world. A disproportionately high number of species are directly threatened with extinction (22% of the New Zealand flora, 61% of birds, 83% of reptiles, and at least 5% of invertebrates)[7]. A higher proportion of New Zealand's vertebrate species are currently threatened with extinction than in any other country[8].

5.7 In 1992 New Zealand ratified the International Convention on Biological Diversity, which sought to halt the decline of indigenous biodiversity and ensure its sustainable management. Despite that intention, the ongoing decline of native species and ecosystems continues and is a pervasive environmental issue[9].

5.8 The loss of indigenous species and habitats is widespread but it has been most severe in lowland (sea level to 500m) and montane environments (between 500m and 900m). The dry eastern parts of the South Island, where the topography and climate have been particularly attractive for agricultural development, are among the areas that have been most susceptible to species and habitat loss.

5.9 Indigenous ecosystems remaining in these dry eastern parts of the South Island have typically been reduced into small, highly fragmented and modified remnants. Generally, they are poorly protected. For example, on the Canterbury Plains, less than 0.5% of the land area remains in native cover[10]. Coinciding with this pattern of degradation, the majority of New Zealand's rare and threatened species occur in low altitude remnants mostly on private land.

6. THE NEW ZEALAND BIODIVERSITY STRATEGY ("NZBS")[11]

6.1 The NZBS was prepared by the New Zealand Government in response to the on-going decline of indigenous biodiversity and to fulfill commitments made under the International Convention on Biological Diversity in 1992. The purpose of the NZBS was

[7] Hitchmough, R. (Comp.) 2002. New Zealand Threat Classification System Lists - 2002. Threatened species occasional publication 23 210 p. Department Conservation, Wellington.

[8] Bradshaw, C. J., Giam, X., & Sodhi, N. S. (2010). Evaluating the Relative Environmental Impact of Countries. PLoS One, 5(5), e10440. http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0010440

[9] Ministry for the Environment 1997. The State of New Zealand's Environment, 1997. Ministry for the Environment Wellington; Ministry for the Environment & Department of Statistics. 2015. Environment Aoteraroa 2015. MfE 1215.

[10] Meurk, C. D.; Steven, J. 1996. Low and High Plains Ecological District, Plains Ecological Region, Canterbury. Department of Conservation unpublished report, Christchurch. 119 p

[11] Ministry for the Environment & Department of Conservation 2000. The New Zealand Biodiversity Strategy. Department of Conservation, Wellington, New Zealand. The NZBS can be downloaded from www.biodiversity.govt.nz/picture/doing/nzbs/contents.html

to establish a strategic national approach to halt this decline and sustainably manage New Zealand's biodiversity.

6.2 The four goals of the NZBS are aspirational, with Goal 3 (Halt the decline in NZ's indigenous biodiversity) being specifically relevant. Goal 3 seeks to:

> *Maintain and restore a full range of remaining natural habitats and ecosystems to a healthy functioning state, enhance critically scarce habitats, and sustain the more modified ecosystems in production and urban environments; and do what else is necessary to…*
>
> *Maintain and restore viable populations of all indigenous species and subspecies across their natural range and maintain their genetic diversity.*

7. THE NATIONAL PRIORITIES FOR THE PROTECTION OF INDIGENOUS BIODIVERSITY ON PRIVATE LAND (NATIONAL PRIORITIES)

7.1 In 2007, the Minister of Conservation and the Minister for the Environment, issued a statement of national priorities for the protection of indigenous biodiversity on private land (the National Priorities). The Ministers' statement of the national priorities highlights the urgency needed to halt the decline of New Zealand's rarest and most threatened ecosystems and species. The National Priorities are intended to provide a better framework for decision-making about biodiversity on private land. They are expected to be of particular use to local authorities, when exercising their responsibilities for protecting indigenous biodiversity on private land under the Resource Management Act ("**RMA"**) 1991.

7.2 The four national priorities are summarised below:

> ***National Priority 1***
>
> *To protect indigenous vegetation associated with land environments, (defined by Land Environments of New Zealand at Level IV), that have 20 percent or less remaining in indigenous cover.*
>
> ***National Priority 2***
>
> *To protect indigenous vegetation associated with sand dunes and wetlands; ecosystem types that have become uncommon due to human activity.*
>
> ***National Priority 3***
>
> *To protect indigenous vegetation associated with 'originally rare' terrestrial ecosystem types not already covered by priorities 1 and 2.*
>
> ***National Priority 4***

To protect habitats of acutely and chronically threatened indigenous species.

7.3 A summary and a full report in relation to the National Priorities are available for download from the New Zealand Biodiversity website[12].

8. FRAMEWORK FOR ASSESSING SIGNIFICANT ECOLOGICAL VALUES IN NEW ZEALAND

8.1 In terms of identifying significant areas of indigenous vegetation and significant habitats of indigenous fauna, and prioritising the protection of New Zealand's most important sites, it is useful to understand the background to assessing significant ecological values in New Zealand, and the consequent use of criteria for assessing their significance in terms of section 6(c) of the RMA 1991.

8.2 The ecological significance of sites is determined by applying standard assessment criteria within an appropriate biogeographical scale and context, considered to be the Ecological District ("**ED**")[13]. The assessment criteria, which are explained in more detail in the evidence of Mr Harding are: representativeness, diversity and pattern, rarity and special features, naturalness, size and shape, buffering/surrounding landscape and boundaries, and long-term ecological viability (the latter 3 are often combined into a broader *Ecological Context* criterion).

8.3 These criteria and ED framework have evolved from the Protected Natural Areas Programme[14] ("**PNAP**"). The PNAP was initiated in 1981 by the (then) National Parks and Reserves Authority in response to concerns that New Zealand's protected natural area system did not represent the full range of natural diversity, and that natural areas were continuing to be lost. It provides an objective and scientific method to identify significant ecological values and prioritise protection of areas in which those values are found in New Zealand. It continues to be used (or variants of it[15]) as the basis for determining the relative significance of indigenous biodiversity throughout New Zealand. For example, the assessment criteria in the Canterbury Regional Policy

[12] Protecting our places: Introducing the national priorities for protecting rare and threatened biodiversity on private land. Available at https://www.biodiversity.govt.nz/land/guidance/

[13] The ecological character of New Zealand has been divided into areas of similar ecological character called Ecological Regions ("**ER**") by a scientific panel. ERs are further subdivided into ecological districts ("**ED**") that differentiate finer scale patterns of climate, geology and landforms. There are 85 ERs and 268 EDs in New Zealand (McEwen 1987). The ED scale is the accepted framework that underpins ecological significance assessment criteria that are used to determine ecologically significant sites, such as the criteria outlined in the Canterbury RPS and the DOC assessment guidelines.

[14] Kelly, G. C.; Park, G. N. eds 1986. The New Zealand protected natural areas programme: a scientific focus. Biological Resources Centre Publication No 4. Wellington, Department of Lands and Survey. Pp. 63-87.

[15] Assessment criteria definitions vary somewhat from the original PNAP and between regional/district plans. Most have also been updated to account for the 4 National Priorities (typically included within the *Rarity* criterion).

Statement, and the Department of Conservation's assessment guidelines, are based on the PNAP assessment framework[16].

8.4 **Land Environments of New Zealand**

8.5 Over the last decade, Land Environments ("**L.E.**") of New Zealand[17] have been developed as a tool to provide a more quantitative structural framework to help determine areas of similar ecological character throughout New Zealand. They are based on national geomorphology and climate information. L.E. can be used to predict the likely pre-human pattern of terrestrial ecosystems (patterns and gradients) and indigenous biodiversity[18]. Four levels of detail are available, i.e., 20 (National-scale), 100, 200 or 500 (Regional to District-scale) environments (levels I, II, III and IV).

8.6 **Threatened Land Environment Classification**

8.7 L.E. can also be used to identify where threatened and poorly protected indigenous ecosystems are most likely to occur. The Threatened Environment Classification[19] ("**TEC**") uses the national land cover database[20] (**"LCDB**") to determine the extent of remaining indigenous land cover (synonymously 'indigenous vegetation') in each land environment, combined with an assessment of how much of the total land area of an environment is legally protected.

8.8 Category 1 L.E. are those that retain less than < 10% cover of indigenous vegetation. Category 2 L.E. retain 10- 20% cover of indigenous vegetation. L.E. in Category 3 retain between 20% and 30% indigenous cover. Category 4 L.E. are those that retain more than 30% indigenous vegetation but have less than 10% of their total land area protected, and Category 5 have between 10-20% protected.

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[16] The Canterbury RPS merged the *Naturalness* criterion into *Diversity and Pattern*, whereas DOC retained the *Naturalness* criterion in its guidelines as per the PNAP standard.

[17] Leathwick, J.; Wilson, G.; Rutledge, D.; Wardle, P.; Morgan, F.; Johnston, K.; McLeod, M.; Kirkpatrick, R. 2003. *Land Environments of New Zealand*. David Bateman, Auckland. 184p.

[18] Ministerial Advisory Committee 2000b. Biodiversity and private land: final report of the Ministerial Advisory Committee. Ministry for the Environment, Wellington.

[19] Walker, S.; Cieraad, E.; Grove, P.; Lloyd, K.; Myres, S.; Park, T. Porteous, T. 2007: Guide for Users of the Threatened Environment Classification. (Version 1.1, August 2007). Landcare Research Limited.

Cieraad, E.; Walker, S.; Price, R.; Barringer, J. 2015. An updated assessment of indigenous cover remaining and legal protection in New Zealand's land environments. Short Communication. *New Zealand Journal of Ecology* 39(2):0-0;

Walker, S.; Cieraad, E; Barringer, J. 2015. The Threatened Environment Classification for New Zealand 2012: a guide for users. Landcare Research, 27 p. Landcare Research New Zealand ltd, Dunedin. Wildlands Consultants Ltd. 2013

[20] The LCDB uses satellite imagery to identity patterns of vegetation (and other land cover) at the relatively broad scale.

8.9 The TEC also forms the basis of National Priority 1 for the protection of indigenous biodiversity on private land "*To protect indigenous vegetation associated with land environments … that have 20 percent or less remaining in indigenous cover*". This focus on L.E. in which indigenous cover has been most reduced, recognises that as habitat loss increases, the loss of indigenous biodiversity accelerates. This is because as habitats become smaller and more fragmented, they become less resilient and increasingly vulnerable to degradation from mechanisms such as edge effects.

8.10 Edge effects are one of the most pervasive threats to remnant habitats. They include both biotic and abiotic influences, such as weed and animal pest invasion or changed humidity from wind incursion. Often biotic and abiotic effects occur in tandem. For example, animals browsing native vegetation can open forests up to wind exposure which changes forest humidity and light that in turn promotes weed invasion into the forest core. Smaller remnants are disproportionally affected by edge effects because they have higher edge to interior ratios (large edge relative to core). The net result for reduced habitats is that their component species are lost at an accelerating pace[21].

9. ECOLOGICAL OVERVIEW OF THE MACKENZIE BASIN

9.1 The Mackenzie Basin[22] is located in South Canterbury between the main ranges of the Southern Alps, and the Dalgety, Grampians, Benmore and Kirkliston ranges. On the national scale, inter-montane basins are uncommon[23]. Biogeographically, three are broadly similar to the Mackenzie Basin, being the Heron, Upper Clutha, and Waimakariri[24]. The Mackenzie Basin is by far the largest and most complex of all them all[25]. Only the Heron and the Mackenzie Basins retain indigenous ecosystems to any large extent, especially those that comprise the basin floors.

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[21] Cieraad, E.; Walker, S.; Price, R.; Barringer, J. 2015. An updated assessment of indigenous cover remaining and legal protection in New Zealand's land environments. Short Communication. *New Zealand Journal of Ecology* 39(2):0-0

[22] For the purposes of this evidence the Mackenzie Basin encompasses the Waitaki District council jurisdiction which is sometimes referred to as the Waitaki Basin.

[23] Speight (1914) identified 8 inter-montane basins but he included Hanmer, Culverden, Mid–Waimakariri and upper Pareora Basin, but these all occur at low altitude and have almost entirely lost their indigenous cover.

[24]The Wamakariri Basin does not have extensive fluvio-glacial alluvial outwash surfaces that are a feature of the Mackenzie Basin especially.

[25] Kitson A. E.; Thiele E. O. 1910. The Geography of the Upper Waitaki Basin, New Zealand. The Geographical Journal Vol. 36, No. 5 (Nov., 1910), pp. 537-551 Published by: geographicalj DOI: 10.2307/1777341 Stable URL: http://www.jstor.org/stable/1777341;

Speight, R. 1914. The Intermontane Basins of Canterbury. Art XXXVI— Transactions and Proceedings of the New Zealand Institute for the Year 1914, Volume 47. Alexander Turnbull Library, Wellington, New Zealand. http://natlib.govt.nz/records/1034542

9.2 The Mackenzie Basin largely comprises glacial topography characterised by moraines and low-lying, fluvio-glacial outwash ecosystems (herein referred to as *alluvial outwash*). It encompasses 3 EDs (Tekapo, Pukaki, Omarama) that reflect the finer scale environmental gradients associated primarily with altitude changes and different ages of glacial deposition. EDs are shown in Map 1 in Appendix 2 attached to this evidence.

9.3 Climatic extremes are a feature of the Mackenzie Basin, with cold winters, hot dry summers and semi-arid annual precipitation especially in east[26]. These climatic conditions give the Mackenzie Basin its ecological ('desert'[27]) character that supports a distinctive biota which is not represented to the same extent elsewhere in New Zealand (or the world). It provides habitats for several local endemic species (only found in the Mackenzie Basin), and is a stronghold for many nationally threatened species, which I discuss in more detail in Section 15.

9.4 Analysis of pollen cores[28] shows that from the end of the last ice age around 17000 BP[29], the vegetation of the Mackenzie Basin was dominated by tussock grasslands and associated herbaceous species. Those species were the primary colonisers of new surfaces exposed as ice melted and retreated. Over time a complex mosaic of low 'forest', shrublands and grasslands developed across the basin floor which reflected broad patterns of altitude, climate, soils and rainfall.

9.5 Prior to human arrival the vegetation of the Mackenzie Basin is thought to have comprised mixed conifer associations of Hall's totara, celery pine and bog pine that occupied the moist fertile sites to the leached, infertile sites respectively. Small leaved angiosperm scrub (*Olearia, Coprosma*, matagouri etc) and short tussock (fescue and silver) predominated on sites where there was excessive drainage or very low rainfall, such as on the more recent alluvial outwash surfaces and in drier eastern parts of the basin. Beech forest (mountain and silver) dominated the wetter western ranges. At

[26] McEwen, W. Mary (editor), 1987. *Ecological regions and districts of New Zealand*. Third revised edition. New Zealand Biological Resources Centre Publication No. 5 (in four parts). Department of Conservation, Wellington.

[27] Cockayne, A. H. 1915. Some economic consideration concerning montane tussock grasslands. *Transactions and Proceedings of the Royal Society of New Zealand 1868-1961*, 48: 154-165.

[28] McGlone, M.S. 2001. The origin of the indigenous grasslands of south eastern South Island in relation to pre-human woody ecosystems. *New Zealand Journal of Ecology 25*: 1-15.

[29] Barrell, D. J. A.; Read, S. A. L. 2014. The deglaciation of Lake Pukaki, South Island, New Zealand—a review. New Zealand Journal of Geology and Geophysics, Vol. 57(1), 86–101, http://dx.doi.org/10.1080/00288306.2013.847469

higher altitudes, the vegetation was a mixture of sub-alpine shrublands, tussock grasslands and alpine herbfield, much the same as it is today.

9.6 Studies of buried charcoal and pollen suggest that natural fires were infrequent and had a localised influence on vegetation patterns. Nonetheless, disturbance was part of the natural ecology of the Mackenzie Basin; it was certainly exacerbated with the arrival of humans. The pattern of disturbance was due to harsh climatic extremes, such as drought, frost, cold, heat and wind which are all important influences on plant growth. Widespread disturbance by large birds (moa etc.) is also thought to have had a major influence on the evolution of the native species that occupied dryland ecosystems[30].

9.7 Adaptations in the Mackenzie basin flora to cope with high levels of environmental stress are expressed by high levels of dormancy, seasonality in growth (such as spring annual lifecycle[31]), short stature, leaflessness, cushion and mat form, and spikey forms, etc. 'Depleted' (disturbed/open/bare and stony) basin floor habitats for indigenous biodiversity are also reflected by the disproportionately high number of rare and threatened species that occur in these habitats (refer Appendix 1).

9.8 With the arrival of Mãori around 800 years ago[32] came increased and repeated burning. This resulted in the widespread loss of low forest and conifer scrub across the Mackenzie basin floor and surrounding slopes[33]. It caused a corresponding increase in short tussock grasslands, red tussock grasslands, and dry scrub communities, which expanded across the basin floor. Snow tussock descended down-slope to occupy previously forested and/or scrubby lower slopes below the tree-line (~1200m).

9.9 When the first Europeans arrived in the Mackenzie Basin around 1850 they encountered an extensive plain of tussock and scrub. The Surveyor-General, Thomson described the area as *"extensive plains, covered with grass of generally*

[30] Rogers G., Walker, S. 2002. Taxonomic profiles of rarity in the New Zealand vascular flora. *New Zealand Journal of Botany* 40: 73-93.

[31] 'Spring annuals' is the generic term used to describe a group native plant species that only appear briefly in spring when they germinate from seed which represent a dormant stage over the extremes of summer and winter. Several species of orchids found in the Mackenzie Basin demonstrate these traits, as well as including highly threatened plants species such as the New Zealand mouse-tail (*Myosurus minimus subsp novae-zealandiae), Ceratocephala pungens,* pygmy forget-me-not (*Myosotis brevis*) and pygmy goose foot *(Dysphania pusilla*).

[32] Wilmshurst, J.; Hunt, T.; Lipo, C.; Anderson, A. 2012. High-precision radiocarbon dating shows recent and rapid initial human colonization of East Polynesia. *Proceedings of the National Academy of Sciences* 108: 1815-1820.

[33] There is no oral history from local Maori that there was ever extensive woody cover in the Mackenzie Basin (Gillespie 1958), indicating that the predicted extensive cover of low forest and shrublands was eliminated very early on probably by Maori burning.

scanty growth"[34]. Von Haast, in 1862, commented that the basin floor was a great tawny expanse of low tussock grassland which merged into snow grass at higher altitudes. Dense thickets of matagouri and spear-grass occurred among tussock and along river banks. Matagouri, in particular, was common and increased to the west with increasing rainfall. Fescue tussock was the dominant grassland community, as it still is today – with blue tussock, plume grass and blue wheat grass common[35]. Extensive dune lands were also apparent; they were described by the Surveyor-General as a "*desert of sand*", and Chapman (1884[36]) noted the presence of moa bones that had been exposed by wind erosion.

9.10 European settlement has resulted in continuing ecosystem modification. Pastoralism, in combination with the introduction of rabbits in the 1860s and exotic plant species, has caused widespread depletion of native dryland ecosystems throughout the Mackenzie Basin. Nevertheless, ecological resilience has been a feature of the Mackenzie Basin's ecology; descriptions of the denuding of the land can be found in a number of early accounts[37], along with anecdotal reports of phases of recovery occurring in between phases of depletion.

9.11 Ecological recovery is most clearly demonstrated from a recent study in the Tekapo Scientific Reserve[38]. That study documents that on the removal of stock grazing, and with the implementation of rabbit control and wilding pine control, there has been a notable recovery of short tussock grasslands and associated native species on what were very depleted moraine and alluvial outwash ecosystems. The study also demonstrated that, contrary to widespread belief, hawkweed (*Pilosella officinarum*[39])

[34] Thomson, J. T. 1858. Lecture on the Province of Otago: its description, resources and capabilities. Otago Witness, July 1858.

[35]von Haast, J. 1879. Geology of the Provinces Canterbury and Westland, New Zealand. A report compiling the results of official explorations. Times Office, Christchurch, New Zealand.

Wilson, R. K. 1949. The Mackenzie Basin. A regional study in the South Island High country. Unpublished MSc thesis. University Canterbury.

[36] Thomson, J. T. 1873. On the Glacial Action and Terrace Formations of South New Zealand. *Transactions and Proceedings of the New Zealand Institute for the Year 1914, Volume 6*, 301-332. Alexander Turnbull Library, Wellington, New Zealand. http://rsnz.natlib.govt.nz/volume/rsnz_06/rsnz_06_00_004760.html.

Chapman, F. 1884. Notes on Moa Remains in the Mackenzie Country and other Localities. *ART. XVII - Transactions and Proceedings of the Royal Society of New Zealand 17:* 172-178. Alexander Turnbull Library, Wellington, New Zealand. http://rsnz.natlib.govt.nz/volume/rsnz_17/rsnz_17_00_003540.html

[37] Appendix to the Journals of the House of Representatives. 1910. Canterbury Pastoral Runs Classification. National Library of New Zealand. https://atojs.natlib.govt.nz/cgi-bin/atojs?a=d&cl=seach&d=AJHR1910-I.2.1.4.25&sr...

[38] Walker, S.; Comrie, J.; Head, N.; Ladley, K. J.; Clarke, D. 2016. Hawkweed invasion does not prevent indigenous non-forest vegetation recovery following grazing removal. *New Zealand Journal of Ecology,* 40(1) 137 - 149.

[39] Formerly called *Hieracium pilosella*, common name mouse-ear hawkweed.

is not an intractable threat to indigenous biodiversity, as hawkweed will succumb to regenerating native species given sympathetic management.

9.12 More recently, especially since about 2000, intensive agricultural practices using cultivation and irrigation have caused widespread and permanent loss of natural ecosystems and indigenous biodiversity across the Mackenzie Basin. The extent of those losses are discussed in Section 16 of my evidence, and illustrated in Maps 5 & 6 in the appendices.

10. SIGNIFICANT ECOLOGICAL VALUES IN THE MACKENZIE BASIN

10.1 Despite modification of the native plant communities present in the Mackenzie Basin, in my experience most ecosystems that have not been intensively developed typically retain significant ecological values that are significant when assessed in accordance with standard ecological significance criteria, such as those in the Canterbury Regional Policy Statement.

10.2 For example, fescue tussock grasslands and scattered native shrublands are the characteristic vegetation in plant communities on undeveloped moraine and alluvial outwash landforms in the Mackenzie Basin (see Photos 2 and 3, Appendix 2). Although those plant communities always contain exotic species, such as mouse-ear hawkweed, they are representative of what was typical of the ED (and L.E.) prior to European arrival.

10.3 Representativeness is a key criterion for determining ecological significance in New Zealand. In highly modified Ecological Districts and Land Environments, plant communities that are 'Representative' of the vegetation that was present at around 1840 (European arrival) are usually considered to be significant. Although the plant communities in the Mackenzie Basin lack some of the structural dominance of the grasslands and woodlands thought to have been present in earlier times, they do retain species thought to reflect the general composition of the previous indigenous cover[40].

10.4 It should be noted that what is generally described as "tussock grasslands" at the landscape scale in the Mackenzie Basin typically comprises a mosaic of plant

[40] McGlone, M.S. 2001. The origin of the indigenous grasslands of south eastern South Island in relation to pre-human woody ecosystems. *New Zealand Journal of Ecology 25*: 1-15

Walker S., Lee, W.G. 2000: Alluvial grasslands in south-eastern New Zealand: vegetation patterns, long-term and post-pastoral change. *Journal of The Royal Society of New Zealand 30 (1*): 69-103.

Walker, S., Lee, W.G., Rogers, G.M. 2003: Post-pastoral succession in inter-montane values and basin of eastern South Island, New Zealand. Science for Conservation 227. Department of Conservation, New Zealand.

communities. The species present reflect subtle eco-tones associated with the Mackenzie Basin's naturally-stressed glacial-outwash dryland habitats. Areas of stonefield and herbfield with very sparse vegetation are an inherent component of the tussock grassland ecosystem. These depleted native plant communities are most evident in the numerous depressions and channels that are a feature of the Mackenzie Basin's outwash ecosystems (see Photos 1,2, and 3, Appendix 2).

10.5 I therefore agree with Mr. Harding's evidence, in which he remarks that in Scenic Grassland Areas "*Ecologically, this vegetation is not all "grassland", as normally defined (e.g. Atkinson, 1985)*. It includes areas of shrubland, tussockland, herbfield, stonefield and loamfield (bare ground)" [41].

10.6 Furthermore, the 'depleted' Scenic Grassland areas in the Mackenzie Basin support a diverse and often distinctive assemblage of small native plant species (herbs, grasses, sub-shrubs and mosses), including many nationally 'at risk' and threatened species. Even the most denuded alluvial outwash surfaces are likely to retain significant ecological values providing habitats for threatened species. For example, they provide significant habitat for indigenous fauna, such as the threatened banded dotterel (nationally vulnerable)[42].

10.7 Consequently, I agree with Mr. Harding's opinion that "*most undeveloped (i.e. uncultivated and un-irrigated) areas on glacially-derived landforms (moraines and outwash terraces) in the Mackenzie Basin are likely to meet the RPS criteria for SONS, except where vegetation is substantially modified by over-sowing, top-dressing, grazing, or wilding conifer spread. Severely degraded sites will, in many cases, meet the RPS criteria for SONS as these sites provide habitat for threatened plant and animal species*" [43].

10.8 Ecological connectivity is an important feature of the Mackenzie Basin (though in some parts I acknowledge that it is significantly reduced). This means that retaining the remaining linkages is an imperative. It is well documented in both national and international research that larger interconnected ecosystems are necessary for the maintenance (and evolution) of indigenous biodiversity[44]. Among other things, large

[41] M A C Harding, evidence-in-chief 15 July 2016 para 72.

[42] O'Donnell CFJ 2013. The significance of Ohau Downs alluvial outwash plain, Mackenzie Basin, for banded dotterel and other bird species. Department of Conservation File Report DOCDM-130975. Department of Conservation, Christchurch.

[43] M A C Harding, evidence-in-chief 15 July 2016 para 31.

[44] O'Connor, K. K.; Overmars, F. B.; Ralston, M. M. 1990. Land Evaluation for nature conservation. A scientific review compiled for application in New Zealand. *Conservation Sciences Publication Number 3.* Department of Conservation, Wellington.

interconnected ecosystems typically have higher species diversity with more viable populations. This is because of the greater range of environmental gradients and associated habitats present that have greater resilience owing to improved ecological functioning. Aspects of ecological functioning include natural plant succession, the existence of corridors for species movement and the ability of ecosystems to absorb and recover from disturbance.

11. CURRENT UNDERSTANDING OF ECOLOGICAL VALUES IN THE MACKENZIE BASIN

11.1 Knowledge of specific sites' ecology in the Mackenzie Basin is mixed and somewhat dated. Initial surveys undertaken by the New Zealand Wildlife Service and Department of Scientific and Industrial Research (DSIR) identified significant sites of wildlife interest (SSWI) and wetlands of ecological and regional importance (WERI) respectively; chiefly habitats for water fowl. The subsequent PNAP survey of the Mackenzie Ecological Region[45] identified 'Recommended Areas for Protection' ('**RAP'**) that were considered to be the very best examples of natural ecosystems that characterised each ED. However, many of those sites identified as RAPs were considered too small by the scientific advisory committee[46], so size extensions were recommended for many.

11.2 From my understanding of the Plan, SSWI, WERI and RAP form the basis for the identification of the majority of sites of natural significance ('**SONS**') in the Mackenzie District Plan. Yet collectively, SONS represent only a small proportion of significant ecological values present in the Mackenzie Basin. Moreover, several sites have been lost to development since their identification.

11.3 Since the mid 1990's, tenure review surveys of many pastoral leases have been undertaken across the majority of the Mackenzie Basin. These surveys, that use rapid assessment techniques[47], have identified many significant ecological values. The information gained from tenure review surveys has contributed considerably to our overall understanding of the Mackenzie Basin's significant ecological values at the local, regional, and national scale. Nevertheless, many of the values identified remain

[45] Espie, P. R.; Hunt, J. E.; Butts, C. A.; Cooper, P. J.; Harrington, W. M. A. 1984. Mackenzie Ecological Region New Zealand Protected Natural Area Programme. Department of Lands and Survey, Wellington, New Zealand.

[46] Cooper, P.J. (ed) 1986. Pukaki and Ben Ohau District PNAs New Zealand Protected Areas Programme. A report detailing information collected during the 1983-84 survey of the Mackenzie Ecological Region concerning areas proposed for protection. Department of Lands and Survey, Christchurch, New Zealand.

[47] Early tenure surveys tended to be conservative and used variable assessment techniques. In some case substantial areas that would certainly be significant by today's thinking were not identified and subsequently given freehold title.

unprotected, and/or may not be protected if given freehold title through the tenure review process. Substantial areas had significant ecological values identified during tenure review have been lost as a result of subsequent agricultural intensification.

11.4 Map 2 and Map 3 in Appendix 2 show the 'significant inherent' botanical and landscape values (**'SIVs'**) identified by tenure review surveys on Mackenzie Basin properties that form the majority of the basin floor in the Mackenzie District. They show the close relationship between botanical values and landscape values. They also demonstrate the relatively intact sequences of moraine and alluvial outwash ecosystems present. Map 3 shows the land protection outcomes from completed tenure reviews. It shows that substantial areas that had identified SIVs, have been given freehold title with no protection of values present.

12. THE NATIONAL PRIORITIES FOR PROTECTION AND THE MACKENZIE BASIN

12.1 Over the last decade, research on New Zealand's naturally rare and threatened ecosystems and species has put the significant ecological values of the Mackenzie Basin into a national perspective. That perspective has focused the attention of the scientific community on the ecological importance of the Mackenzie Basin as a stronghold for some of New Zealand's most distinctive, rare and threatened ecosystems and species, as is discussed in the following sections.

13. MACKENZIE'S NATURALLY RARE ECOSYSTEMS

13.1 Naturally rare ecosystems[48] are environmentally distinct areas that comprised less than 5% of New Zealand's land area prior to human settlement. They often have highly specialised and distinctive assemblages of species including relatively high proportions that are endemic, rare and threatened.

13.2 The Mackenzie Basin contains several nationally rare ecosystems that remain relatively undeveloped. They include inland alluvial surfaces, moraines, ephemeral wetlands (kettleholes), inland dunes and braided rivers[49].

13.3 The extent and variety of naturally rare ecosystems present in the Mackenzie Basin is not replicated elsewhere in New Zealand. Collectively these ecosystems occupy almost all the basin floor, where they occur contiguously across relatively intact

[48] Williams, P. A.; Wiser, S.; Clarkson, B.; Stanley, M.C. 2007. New Zealand's historically rare terrestrial ecosystems set in a physical and physiognomic framework. *New Zealand Journal of Ecology*, 31(2): 119–128 (2007).

[49] Also present to a more minor extent are 'lake margins', 'seepages and flushes'.

ecological sequences[50]. They support a disproportionately large number of threatened plant species (as outlined in Section 15 of my evidence). In my opinion, this makes them nationally significant.

13.4 The threat status of New Zealand's naturally rare ecosystems[51] has been assessed in accordance with the International Union for the Conservation of Nature (IUCN) criteria. This assessment highlights the vulnerability of these naturally rare ecosystems. Their threat status is classified as follows:

(a) Outwash gravels - critically endangered;

(b) moraines – vulnerable (the Mackenzie Basin moraines were noted as being critically endangered);

(c) Inland sand dunes – critically endangered;

(d) ephemeral wetlands - critically endangered;

(e) braided rivers – endangered.

13.5 Map 4 in Appendix 2, shows the extent of inland alluvial surfaces and moraine ecosystems in the Mackenzie Basin, as determined from New Zealand's geomorphological maps[52]. Inland dunes and ephemeral wetlands occur within these two broader classifications, but they have not been mapped owing to the difficulty of depicting them at this scale, because of their relatively small size and scattered distribution. Braided rivers are apparent as linear corridors.

13.6 ***Inland alluvial surfaces*** (Photo 1 and 2, Appendix 2) comprise outwash fans and plains. They are characterised, broadly, by fescue tussock grasslands, patchy shrublands of predominately matagouri and porcupine shrubs, sparsely vegetated herbfields and stonefields. Despite being generally uniform in appearance (and typically modified from a long history of human activity) these ecosystems contain a high degree of habitat subtlety as a result of micro-topographical changes in substrate

[50]Owing to extensive ecosystem losses and fragmentation that has occurred in the Mackenzie Basin, especially in the Omarama and Pukaki EDs, the most intact ecological sequences remaining occur in the Tekapo ED.

[51] Holdaway, R.J.; Wiser, S.K.; Williams, P.A. 2012. Status assessment of New Zealand's naturally uncommon ecosystems. *Conservation Biology*, 2012.

[52] Barrell, D.J.A.; Andersen, B.G.; Denton, G.H.; Smith Lyttle, B. 2013: Glacial geomorphology of the central South Island, New Zealand - digital data. GNS Science Monograph 27a. GIS digital data files + explanatory notes (17 p). Lower Hutt, New Zealand.

GNS QMAP seamless digital data 2013. Geological Map of New Zealand 1:250 000. Lower Hutt, New Zealand. GNS Science.

and aspect associated with numerous glacial meltwater channels and depressions[53]. They provide habitats for New Zealand threatened 'desert flora', such as 'spring annuals' and breeding habitats for banded dotterels.

13.7 ***Inland dunes*** are characterised by highly disturbed surfaces reflective of wind eroded dunes. Cushion fields and low shrubs are the conspicuous native cover, which also includes a high diversity of small specialist, dryland native species. There is a high degree of fine-scale habitat diversity associated with dune aspect and deflation hollows, which are characteristic of these ecosystems. Many of the Mackenzie Basin's inland sand dunes were flooded when the lakes were raised for hydro-power. Those remaining typically occur as part of inland alluvial surfaces, or among lateral moraines.

13.8 ***Moraines*** (Photo 3 and 4, Appendix 2) comprise a complex glacial topography of undulating and conical hillocks, often dissected by melt-water channels**.** Large protruding boulders (erratic) are a feature of moraine ecosystems. They support a mosaic of dryland plant communities typified by fescue tussock grasslands, small leaved (and 'micro') shrublands, mixed with diverse herbaceous associations. Plant community composition can change markedly on individual moraines depending on aspect, slope and rockiness.

13.9 ***Ephemeral wetlands*** ("kettleholes") (Photo 4, Appendix 2) are associated with moraines. They occur in moraine depressions where seasonal variation in rainfall and evaporation leads to ponding in winter and spring and often complete drying in summer months. They contain distinctive flora characterised by highly diverse native plant (turf) communities that include numerous threatened plant species. The most extensive and best examples (in New Zealand) occur in the Mackenzie Basin, which reflects the large extent of moraine deposits present.

13.10 In commenting on the conservation significance of ephemeral wetlands and their turfs, Johnson and Rogers (2003[54]) note that "*despite their scattered occurrence and small total area in New Zealand, ephemeral wetlands are diverse in their plant communities, extremely rich in their flora, and clearly important as the sole or principal habitat for a high proportion of threatened plant taxa"*. In my opinion that is an accurate assessment; I would add that New Zealand wetland turf plants and their communities

[53] Maziels, J. 1989. Differentiation of late Pleistocene terrace outwash deposits using geomorphic criteria: Tekapo valley, South Island, New Zealand. *New Zealand Journal of Geology and Geophysics*, *Vol.* 32: 225-241

[54] Johnson, P and Rogers, G. 2003: Ephemeral wetlands and their turfs in New Zealand. Science for Conservation 230. New Zealand Department of Conservation.

may be unique and therefore significant in a global context for they appear to have no analogues in the Northern Hemisphere.

14. IMPORTANT LAND ENVIRONMENTS IN THE MACKENZIE BASIN

14.1 Land Environments of New Zealand ("LE") classifies the moraines as mostly occurring within the Central Dry Foothills (E4), with most of the alluvial outwash ecosystems as Eastern South Island Plains (N6 & N7). Those L.E. reflect the rain-shadow ecologies of inland Canterbury and Central Otago.

14.2 Table 1 shows the relative proportions of each L.E. in the Mackenzie Basin. It illustrates, at a national level, the ecological distinctiveness of the Mackenzie Basin with over 90% of the alluvial outwash ecosystems (N6. 1a; N1 .1b) and 88% of N7.1a, occurring in the Mackenzie Basin (minor areas occur in Central Otago). Similarly, the majority of moraine ecosystems (E4.1a; E4.1b) occur within the Mackenzie Basin (70% & 60% respectively).

14.3 **Table 1: Principle land environments, threat categories and proportions in the Mackenzie Basin and protected nationally.**

L.E. IV and threat category (Cieraad et al 2015)	***Total Area L.E. in NZ***	***Total area of L.E. (and % occurring in Mackenzie)***	***Percentage L.E. protected nationally***
E4. 1a Category 2: 10-20% indigenous cover left	31,800	22,200 **(70%)**	**21%**
E4.1b Category 3: 20-30% indigenous cover left	116,300	68,800 **(60%)**	**14%**
N5. 1a Category 1: < 10% indigenous cover left	90,600	5,000 **(5%)**	**1%**
N6.1a Category 4: >30% indigenous cover left: <10% protected	15,300	14,100 **(93%)**	**7%**
N6.1b Category 4: >30% indigenous cover left: <10% protected	58,800	54,400 **(92%)**	**4%**
N6. 2a Category 2: 10-20% indigenous cover left	18,800	3,500 **(19%)**	**5%**
N7.1a Category 2: 10-20% indigenous cover left	5,500	4,900 **(88%)**	**4%**

14.4 This analysis also shows that the Mackenzie Basin's naturally rare ecosystems are very poorly protected as they are not present to any great extent on public conservation land. That state of affairs is consistent with the national predicament, where rare ecosystems are often present only on land that is attractive to and available for development.

14.5 Of the alluvial outwash ecosystems (N6.1a; N6. 1b; N7.1a) that comprise the majority of the Mackenzie Basin floor, only 7%, 4%, and 4% (by area) respectively are protected in New Zealand. Moraine ecosystems (E4.1a; E4.1b) fare slightly better at 21% and 14% respectively, but given their scarcity and importance as habitat for some of New Zealand's indigenous biodiversity, they remain poorly protected and vulnerable to loss**.**

15. THREATENED PLANTS IN THE MACKENZIE BASIN

15.1 New Zealand's threatened species are classified according to their imminent risk of extinction, by a panel of scientific experts. The latest revision of New Zealand's threatened plants' classifications was published in 2012[55]. From that review it is evident that the Mackenzie Basin is notable for containing a large number of New Zealand's threatened plant species, with at least 81 species classified as threatened or at risk recorded from the basin floor habitats alone[56] (Table 2), including several species that are essentially limited to the Mackenzie Basin.

15.2 The high number of threatened and at-risk plant species present reflects the distinctiveness and rarity of the basin's ecosystems, which support many specialised 'dryland' species with limited distributions outside the Mackenzie Basin. The primary threat to species is habitat loss caused by land use change, particularly the intensification of agricultural land use[57].

15.3 The list of threatened plants that occur within the Mackenzie Basin 'floor' habitats is attached in Appendix 1.

[55] de Lange, P.J.; Norton, D.A.; Courtney, S.P.; Heenan, P.B.; Barkla J. W.; Cameron E. K.; Hitchmough, R. Townsend, A.J. 2009. Threatened and uncommon plants of New Zealand (2008 Revision). *New Zealand Journal of Botany 47*: 61-96. Revision of the 2012 rankings is currently in progress and recommendations have been made to increase the threat rank of many of the species in the Mackenzie Basin floor habitats owing to the threat of habitat loss.

56 The total of 81 plants is for species that occur on the ecosystems in the basin floor. The total does not include threatened or at-risk plants that occur more broadly such as in mountain environments, in beech forests and on limestone.

[57] Walker, S., Price, R., Rutledge, D., Stephens, R., T; Lee, W.G. 2006: Recent loss of indigenous cover in New Zealand. *New Zealand Journal of Ecology 30:* 169-177.

Table 2: Number of Threatened Plants recorded in the Mackenzie Basin floor habitats (2012 Threatened Plant Revision).

Species Threat Rank	Numbers of Species (brackets = total number nationally in each threat category)
Nationally Extinct	1 (8) rediscovered 2015
Nationally Critical	8 (155)
Nationally Endangered	10 (62)
Nationally Vulnerable	12 (72)
Declining	25 (102)
Naturally Uncommon	24 (627)
Data Deficient	1 (77)
Total	81 (1103)

16. EXTENT OF ECOSYSTEM LOSS IN THE MACKENZIE BASIN

16.1 The extent of ecosystem loss that has occurred within the Mackenzie Basin between 2000 and 2016 is shown in Map 5 and Map 6 (Appendix 2), and in Table 3 below. These data were obtained using LCDB version IV[58] [59](**"LCDB IV**") to map the extent of ecosystem loss and indigenous vegetation remaining[60]. Data checking and further refinements were undertaken using the latest Google Earth™ and aerial photographs available. Local DOC staff were also asked to 'ground-truth' the data and identify recent areas of cultivation, and areas incorrectly identified as either exotic or native cover[61]. Further analysis has been undertaken to assess the extent of ecosystem loss

[58] LCDB IV can be viewed at: https://lris.scinfo.org.nz/layer/423-lcdb-v41-land-cover-database-version-41-mainland-new-zealand/metadata/

[59] Landcare Research New Zealand Ltd Infomatics Team. 2015. LCDB v4.1 - Land Cover Database version 4.1, Mainland New Zealand, version date 2015-06-30.

[60] Exotic/developed cover classes used as follows ('Built-up Area (settlement)', 'Deciduous Hardwoods', 'Exotic Forest', 'Forest - Harvested', 'Gorse and/or Broom', 'High Producing Exotic Grassland', 'Mixed Exotic Shrubland', 'Orchard, Vineyard or Other Perennial Crop', 'Short-rotation Cropland', 'Surface Mine or Dump', 'Transport Infrastructure', 'Urban Parkland/Open Space')

[61] Some areas defined as 'High Producing Exotic Grassland' in LCDB are land that has been over-sown and top-dressed (ostd) but not cultivated or irrigated. As a result, these areas contain a higher proportion of exotic 'pasture' species compared to similar ecosystems that remain undeveloped. However, because they have not been intensively developed (irrigation/cultivation), they may also retain native species and significant ecological values. Large areas of moraines south of Lake Oahu and between Lake Pukaki and Tekapo fall into this category.

that has occurred between 2000 and 2016 on inland alluvial surfaces and moraines, and in each ecological district**.**

Table 3: Indigenous vegetation remaining on naturally rare ecosystems in the Mackenzie Basin and extent of loss (Hectares).

Ecosystem per ED	Exotic Ha 2000	Exotic Ha 2016	Indig. Ha 2000	Indig. Ha 2016.	Indig. Ha lost	% lost between 2000-2016
Moraines	**11,400**	**18,400**	**52,200**	**45,100**	**7,000**	**13%**
Omarama ED	2,000	4,700	7,200	4,500	2,700	**37%**
Pukaki ED	2,000	2,900	4,200	3,300	894	**22%**
Tekapo ED	7,300	10,800	40,800	37,400	900	**8%**
Alluvial outwash Gravels	**16,500**	**38,300**	**87,000**	**65,300**	**21,800**	**25%**
Omarama ED	5,700	14,200	18,000	9,500	8,500	**47%**
Pukaki ED	7,600	19,000	53,800	42,500	11,300	**21%**
Tekapo ED	3,100	5,100	15,200	13,200	2,000	**13%**

16.2 This analysis demonstrates that widespread destruction and ecological fragmentation of the alluvial outwash and moraine ecosystems has occurred since 2000. The Omarama ED, in particular, has been most dramatically affected with 47% of the alluvial outwash ecosystems destroyed between 2000 and 2016, additional to that already lost prior to 2000. Similarly, large losses have occurred on the moraine ecosystems, with proportionately the largest losses (37%) also occurring in the Omarama ED.

16.3 From my observation, the majority of these losses have resulted from changes in farming methods: My understanding is that change has occurred with little scrutiny of the significant ecological values that may have been affected, despite there being areas that were considered to have supported significant ecological values.

16.4 One example is the almost complete destruction of the Twizel-Omarama Grasslands listed in APPENDIX C (1) of the Waitaki District Plan. That area was considered to have had nationally significant ecological values before changes in farming methods resulted in its conversion to irrigated pasture. It was described in the Waitaki District Plan as follows:

> *"Twizel-Omarama Grassland - Large corridor of semi-natural short-tussock grasslands with a good degree of naturalness. Sparsely dotted with native*

shrubs and open low vegetation. Important area of short tussock grassland with good diversity of inter-tussock herbs. Invertebrate values are of significance. In terms of size, visibility and condition, it is of national significance".

16.5 In my opinion, the widespread conversion of dryland ecosystems that has been occurring in the Mackenzie Basin has undoubtedly resulted in the substantial and permanent loss of significant indigenous biodiversity; much of it would likely have complied with the criteria for being a national priority for protection.

16.6 The extent and pace of land-use change that has already occurred in recent years, highlights the very real risk that ongoing land-use change in the Mackenzie Basin will result in extensive and permanent losses of indigenous ecosystems and species that are still present and which exist nowhere else.

17. OTHER KEY THREATS TO INDIGENOUS ECOSYSTEMS IN THE MACKENZIE BASIN

17.1 Key threats to the Mackenzie Basin's indigenous ecosystems include weeds and animal pests, especially wilding conifers and rabbits. These are persistent and serious threats and if left unchecked, will cause substantial depletion of ecosystems and species. Nevertheless, the impacts of weeds and animal pests can be negated and ecological damage is reversible if pest species are controlled to satisfactorily levels.

17.2 I share Mr. Hardings' view that other herbaceous weeds, such as hawkweed, although common and widespread throughout the Mackenzie Basin, are less of a concern[62]. For example, hawkweed prevalence and persistence typically reflects land-use practices (often historical) associated largely with burning and rabbit plagues, exacerbated by excessive stock grazing.

17.3 Studies such as that at the Tekapo Scientific Reserve[63], demonstrate that with management that facilitates ecological recovery, native species will prevail among hawkweed. In the case of the documented recovery in the Tekapo Scientific Reserve[64],

[62]Paragraph 48 -48 Harding, evidence in-chief.

[63] Discussed in paragraph 9.11 of this evidence.

[64] Walker, S.; Comrie, J.; Head, N.; Ladley, K. J.; Clarke, D. 2016. Hawkweed invasion does not prevent indigenous non-forest vegetation recovery following grazing removal. *New Zealand Journal of Ecology,* 40(1) 137 - 149.

recovery of native species was facilitated by stock removal, and rabbit and wilding pine control.

17.4 I concur with Mr. Harding's opinion that browsing and grazing animals has been one of the most pervasive causes of degradation to indigenous ecosystems in the Mackenzie Basin[65]. Nonetheless, I acknowledge the impacts of stock grazing will vary depending on the type[66] and number of stock, type of ecosystem, combined with the legacies of historical land use. In my experience, even though most of the alluvial outwash ecosystems are extensively depleted, they retain significant ecological values and require careful and sensitive management to maintain and regenerate indigenous cover. Moraine ecosystems appear to have greater resilience and have generally more intact indigenous cover, but they too have been modified under pastoral management and require sensitive management to maintain their ecological integrity.

17.5 In my opinion, over-sowing and topdressing is also a direct threat to indigenous ecosystems, especially tussock grasslands. Over-sowing and topdressing increases the cover and abundance of exotic herbs and grasses, such as browntop. This alters the plant community composition toward greater exotic species dominance owing to the competitive exclusion of native species. Fertiliser application can also facilitate the growth and spread of woody species such as native matagouri and exotic sweet briar, which in turn encourages herbicide or mechanical clearance to control them, causing further losses of indigenous biodiversity and ecological integrity.

17.6 I note that Mr. Craig in his evidence (paragraph 38), states that *"In grasslands succession is usually arrested through grazing or cropping (hay for example). Periodic burning also arrests succession…within the Wolds grazing and selected grassland improvement via weed control, top-dressing and over-sowing keeps succession at bay".* This is an oversimplification of the role extensive grazing has in woody succession in the Mackenzie Basin. In my experience, although grazing can suppress the growth of palatable species, it has not been effective at halting the spread of woody weeds such as conifers across the Mackenzie Basin. As mentioned in section 16 of my evidence, over-sowing and topdressing are direct threats to indigenous ecosystems, and can also facilitate the spread of woody weeds. Moreover, agricultural development and intensive grazing used as a means to control weeds will also cause

[65] Harding evidence in chief paragraph 44-46.

[66] Cattle are considered worse than sheep.

complete loss of the indigenous ecosystem, which in terms of a conservation strategy, is akin to cutting down native forest to control possums.

17.7 Natural succession is indicative of healthy ecosystem functioning. In the Mackenzie Basin it takes on added relevance given the widespread depletion, especially of native woody cover, that has occurred to the indigenous ecosystems present. Native shrubs are an inherent part the tussock grassland ecosystem. Consequently, the regeneration and expansion of native shrub species is a highly desirable conservation objective. Research in the Tekapo Scientific Reserve has demonstrated the ability of very depleted ecosystems to naturally recover given sensitive management. But, the recovery of native shrubs in the Mackenzie Basin's dryland environments is a very long term process and will most likely occur very gradually over decades.

18. PLAN CHANGE 13 AND PROTECTION OF SIGNIFICANT ECOLOGICAL VALUES

18.1 In her evidence, Ms. Smith has discussed PC13's regime for the management of agricultural intensification (cultivation, irrigation, top-dressing, over-sowing and/or direct drilling), in Scenic Grasslands (SGs), Scenic Viewing Areas (SVAs) and Lakeside Protection Areas (LPAs), and within tussock grassland within 1km of SH8 and specific tourist roads as well as the rest of the Mackenzie Basin outstanding natural landscape.

18.2 In my opinion the identified SGs, SVAs and LPAs, correspond with areas in which significant ecological values are present. Mr. Harding has stated he assessed many of these areas from the roadside[67]; I agree with his assessment that these areas are likely to be significant. I assessed most of them for tenure review, and was able to carry out more thorough inspections. As a result, I can confirm Mr Harding's assessments of the presence of significant ecological values.

18.3 Nevertheless, collectively SGs, SVAs and LPAs comprise a relatively small and piecemeal proportion of the bulk of significant ecological values that have been reliably identified in the Mackenzie Basin. Not least, the SGs, SVAs and LPAs do not adequately account for the largely intact sequences of undeveloped moraine, outwash, and alluvial gravel ecosystems (and contingent significant ecological values), that comprise the bulk of the Mackenzie Basin's outstanding landscape. As I have outlined in sections 8 and 9 of my evidence, the landscape scale connectivity of these nationally

[67] Harding evidence in chief paragraph 58

rare ecosystems is a very important ecological attribute of the Mackenzie Basin, that I consider to be of national significance.

18.4 Mr. Harding (paragraphs 33 – 43), in my opinion, has also correctly identified many of the significant ecological values present outside SGs, SVAs and LPAs, within the area he describes as South and East of SH8. I have surveyed many of the pastoral leases that comprise this area and I have identified extensive significant ecological values present relating, in part, to naturally rare ecosystems and habitats for numerous threatened plant species present. Areas of particular significance include:

a) the extensive alluvial outwash plain south of SH8 across Sawdon Station, Holbrook Station and Grays Hills Station (see Photo 1 and 2, Appendix 2);

b) the moraine and outwash sequences east of SH8 across DOC reserve, Simons Pass Station, Maryburn Station and The Wolds Station.

18.5 In addition, areas west and NW of SH8 that I have assessed as having significant ecological values include the moraine and outwash ecosystems across The Wolds Station, Maryburn Station, Irishmans Creek Station, Balmoral Station, Glenmore Station and New Zealand Defence land (formerly Braemar Station) (see Photos 3 & 4, Appendix 2).

18.6 I agree with Mr. Harding's observation that there are also likely to be significant ecological values present in areas that are currently identified for potential development, such as farm base areas. This discrepancy is exacerbated owing to the limited number of Sites of Natural Significance (**'SONS**') that are currently listed in the Mackenzie District Plan, and because some survey data is incomplete, out of date, or unreliable.

18.7 Furthermore, in my opinion, the current definition of *indigenous vegetation* in the Mackenzie District Plan is problematic. This is because there are substantial areas that are likely to support significant ecological values that may be deemed not to meet the current Mackenzie District Plan definition of indigenous vegetation. Large areas outside the SONS, SVA, LPA and SG are likely to fall into this category. For example, in many circumstances the indigenous cover of a significant site (in its entirety) will not exceed 30%, neither will the dominant (tussock) cover exceed 20% - usually it is much

less. As I have outlined (paras 9.6 - 9.10), areas of sparse and depleted vegetation are an inherent part of 'tussock' grassland ecosystems in the Mackenzie Basin.

18.8 It is more likely that the number of indigenous plant species present on a site will meet the definition's threshold of *30% of the total number of species present*, especially if non-vascular native species (mosses and lichens) are included. This aspect of the definition is typically overlooked and its correct application depends on thorough surveys being done at the right time of year. As a result, these areas will be more vulnerable to loss owing to a lack of proper scrutiny of the potential values present in conjunction with land use changes, which poses a considerable threat to indigenous ecosystems in the Mackenzie Basin.

18.9 One way to remedy the absence of information, is for proper ecological surveys to be carried out in conjunction with all development proposals, including in areas identified as farm base areas and proposed irrigation sites. An exception could be made for areas that have been appropriately identified as having no significant ecological values present.

18.10 Another remedy could be to define 'tussock grasslands' to more accurately recognise that tussock grassland ecosystems comprise a mosaic of vegetation types, including typically bare/stony patches, shrubs, and mixed exotic and native herbfield. As discussed above, sparse vegetation cover is associated with frost hollows, stony drought prone soils, etc. Such areas are an inherent part of tussock grasslands that can also support the rarest and most threatened biodiversity.

18.11 A definition of tussock grassland could be "*areas generally supporting* native *tussock grasses but typically comprising a mosaic of vegetation types that could include considerable areas of bare/stony ground, mixed exotic/native herbfield, native shrubs, and exotic species such as browntop and hawkweed*."

18.12 I agree with Mr. Harding's observation regarding the exclusion of subdivision fencing from the definition of pastoral intensification[68]. Subdivision fencing has the potential to confine stock within smaller areas resulting in increased grazing pressure on indigenous vegetation. Increased stock numbers can cause elevated nutrient levels which in turn can cause detrimental changes to indigenous ecosystems such as

[68] Harding evidence in chief paragraph 87.

enhancing the growth of exotic species and the loss of native species, as I have discussed in sections 16 and 17.

19. SUMMARY AND CONCLUSIONS (SEE SECTION 4 - EXECUTIVE SUMMARY)

Nicholas Head

9 September 2016

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21. APPENDIX 1: LIST OF THREATENED AND AT RISK PLANTS IN HABITITS THAT OCCUR IN BASIN FLOOR MORAINE AND OUTWASH HABITATS.

Extinct

Dysphania pusillum (refound 2015)

Nationally Critical

Carmichaelia curta
Ceratocephala pungens
Chaerophyllum colensoi var. delicatulum
Chenopodium detestans
Crassula peduncularis
Leptinella conjuncta
Pseudognaphalium ephemerum
Triglochin palustris

Nationally Endangered

Cardamine (a) (CHR 312947; "tarn")
Centipeda minima subsp minima
Crassula multicaulis
Wurmbea novae-zelandiae
Lagenifera montana
Leonohebe cupressoides
Lepidium sisymbrioides
Lepidium solandri
Myosurus minimus subsp. novae-zelandiae
Ranunculus brevis

Nationally Vulnerable

Carex cirrhosa
Carex rubicunda
Carmichaelia kirkii
Hypericum rubicundulum
Isolepis basilaris
Sonchus novae-zelandiae f. novae-zelandiae
Lachnagrostis tenuis
Myosotis brevis
Olearia fimbriata
Rytidosperma merum
Senecio dunedinensis

Declining

Aceana buchananii
Aciphylla subflabellata
Amphibromus fluitans
Carex albula
Carex tenuiculmis

Carmichaelia corrugata
Carmichaelia crassicaulis subsp crassicaulis
Carmichaelia nana
Carmichaelia uniflora
Carmichaelia vexillata
Convolvulus verecundus
Coprosma acerosa
Coprosma intertexta
Coprosma virescens
Deschampsia cespitosa
Hypericum involutum
Lobelia ionantha
Luzula celata
Muehlenbeckia ephedroides
Olearia lineata
Parahebe canescens
Pimelea sericeo-villosa subsp pulvinaris
Pterostylis tanypoda
Pterostylis tristis
Raoulia monroi
Rytidosperma telmaticum

Data Deficient

Carex decurtata

Naturally Uncommon

Achnatherum petriei
Agrostis imbecilla
Anthosachne falcis
Botrychium australe
Carex berggrenii
Celmisia graminifolia
Centrolepis minima
Colobanthus brevisepalus
Convolvulus fracto-saxosa
Einadia allanii
Epilobium angustum
Euchiton paludosus
Hebe pimeleoides subsp faucicola
Korthalsella clavata
Leonohebe tetrasticha
Leptinella serrulata
Leucopogon nanum
Montia angustifolia
Montia erythrophylla
Myosotis uniflora
Pimelea prostrata
Pimelea sericeo-villosa subsp alta

Plantago obconica
Pleurosorus rutifolius
Ranunculus maculatus
Raoulia beauverdii

22. APPENDIX 2 - LIST OF MAPS AND PHOTOS

Map 1 – Ecological Districts in the Mackenzie Basin

Map 2 – Significant Inherent Botanical and Landscape Values (SIVs) identified from Tenure Review Surveys

Map 3 – Extent of SIVs protected from completed Tenure Review Surveys.

Map 4 – Extent of naturally rare ecosystems (moraines and inland alluvial outwash gravels) in the Mackenzie Basin.

Map 5 - Ecosystem loss depicted in 2000

Map 6 – Ecosystem loss depicted in 2016

List of Photos

Photo 1 – Alluvial outwash surface showing complex patterning of stable silt bars and sparsely vegetated channels

Photo 2 – Close up of indigenous vegetation characteristic of silt bar and sparsely vegetated stony channels

Photo 3 – Moraine ecosystem which characteristic erratics (rocks) and indigenous tussock grassland

Photo 4 – Ephemeral wetlands (kettlesholes) among moraines