BEFORE THE CANTERBURY REGIONAL COUNCIL

IN THE MATTER OF the Resource Management Act 1991

AND

IN THE MATTER OF resource consent applications by various parties to take and use water in the Upper Waitaki Catchment

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STATEMENT OF EVIDENCE OF SUSAN WALKER
Dated: 1 DECEMBER 2009

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INTRODUCTION

1. My full name is Susan Walker. I am a professional plant ecologist employed by Landcare Research, a Crown Research Institute focusing on the conservation and restoration of indigenous terrestrial ecosystems. I have worked for Landcare Research as a permanent employee for the past 10 years.
2. I hold MSc (1994) and PhD (1997) degrees in plant ecology from the University of Otago. I have published 44 peer-reviewed scientific papers and book chapters in the international and national literature, and produced 25 internally reviewed contract reports.
3. My primary fields of expertise are the ecology and conservation management of indigenous grassland and shrubland vegetation and plants in southern New Zealand, and biodiversity assessment, conservation prioritisation and achievement reporting, including assessment of significance, quantitative biodiversity measurement, and mitigation (or 'offsets'). I have published scientific papers and written reports about the ecology and conservation of rare ecosystems, threatened plants, evolutionary patterns of richness, radiation and endemism, threats to biodiversity from climate change, and challenges for market-based biodiversity policy approaches, among other subjects. I am regularly engaged to write contract reports, give oral presentations, and provide advice to central and local government agencies such as LINZ, DOC, MfE and regional councils on topics related to biodiversity conservation. I am principal author of publications about the Threatened Environment Classification for New Zealand and its User Guide. The classification is the foundation for the first of the four government national priorities for protecting rare and threatened native biodiversity on private land, promulgated by the Ministry for the Environment in April 2007 (MfE 2007; summarised in Attachment 1).
4. My ecological research and field experience has a particular focus on the terrestrial biodiversity in the dry eastern rainshadow zone of the South

Island ('drylands') as defined by Rogers et al. (2005), and especially the ecology, conservation management, and restoration of its more modified ecosystems, including those of the Mackenzie Basin and wider Upper Waitaki. My postgraduate studies investigated temporal changes in dryland grassland and shrubland ecosystems. I continue to study and publish on their ecology, including their responses to management, invasion, and past and future trajectories. I lead an eight-year research programme 'Restoring dryland biodiversity though woody dominance' within the FRST-funded collaborative Outcome Based Investment 'Sustaining and Restoring Biodiversity', in which the Department of Conservation, the QEII National Trust, and regional councils are formal partners.

5. I have ecological field and survey experience in the consent area of the Mackenzie Basin and surrounds, and my research programme has ongoing experimental ecosystem restoration projects in the Basin.
6. I have read the Environment Court's Code of Conduct for Expert Witnesses as set out in the Environment Court Consolidated Practice Note 2006, and I agree to comply with it.
7. My qualifications as an expert are set out above. I confirm that the issues addressed in this brief of evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed. Data sources and methods I used in the preparation of this evidence are detailed in Attachment 2.

SCOPE OF EVIDENCE

8. My evidence shows that the applications to irrigate in the Upper Waitaki (hereafter referred to as the Mackenzie Basin) will have substantial adverse effects on the region's significant terrestrial biodiversity. I will focus on vascular plants and vegetation, which is my main area of expertise. I will describe:
   - The geographic and environmental scope of my evidence ('the Mackenzie Basin')

- The abiotic environment
- The ecological history of the terrestrial ecosystems, focusing on vegetation and change
- Present-day terrestrial ecosystems and biota, with a focus on flora
- Direct and indirect (off-site) effects of irrigation on the indigenous terrestrial ecosystems and species, and likely effects of this particular application
- Past and recent loss of terrestrial indigenous biodiversity affected in the context of national biodiversity loss
- The present extent of protection for biodiversity in the Mackenzie Basin
- The significance of terrestrial biodiversity affected by this application

Finally, I will summarise my main points. Note that my evidence relates to all Upper Waitaki areas affected by these applications except where specific applications are named.

Geographic and environmental scope of evidence

9. Here I refer to the Upper Waitaki areas affected by these applications as 'the Mackenzie Basin'. I define this area as the extent of the LENZ Level I Environments E, N, J and K within or immediately adjacent to the Mackenzie Ecological Region (McEwen 1987; see Attachment 3). This zone encompasses all environments affected by these applications (excluding associated infrastructure).

10. LENZ (Land Environments of New Zealand; Leathwick et al. 2003) is a national landscape classification that groups together sites with similar environmental character. The climate, soil, and landform factors used to construct the classification have been selected for their importance in influencing plant growth. Therefore, the classification can be used to indicate sites likely to have similar potential ecosystem character. These sites are not necessarily identical in all respects, but in their natural state will have supported broadly similar groups of species and comparable biological interactions and processes.

11. Land environments are classified at four nested national levels. Level I is the most general, and I use it for summary information here. Level IV is the most detailed, and the most appropriate for assessing vulnerability of remaining biodiversity because it best depicts potential patterns of biodiversity and past clearance (Walker et al. 2008). Here, I use Level IV to present statistics on land cover loss and legal protection. More detail about LENZ is appended in Attachment 4.

12. Note, because I have used the LENZ environments affected by the applications to define the extent of the Mackenzie Basin, the statistics presented in my evidence relate directly to areas of similar environmental and therefore ecological character.

13. As defined above (paragraph 9), the total land area of the Mackenzie Basin is approximately 301,000 ha (Table 1; mapped in Attachment 3) or 1.16% of all New Zealand land. The higher portion (about 134,900 ha, or 45%) of the Basin is mainly LENZ Level I Environment E (Central Dry Foothills), which extends to about 1200 m elevation (hereafter 'Foothills' environments). Its median elevation is about 700 m (Table 1). The lower portion (about 142,800 ha, or 47%) is mainly LENZ Level I environment N (Eastern South Island Plains, hereafter 'Plains'), lying almost entirely below 800 m elevation (median elevation about 500 m). LENZ Level I environments K (Central Upland Recent Soils) and J (Central Well Drained Recent Soils) together cover about 8% of the Basin, and both occur mainly between 400 and 800 m elevation. For brevity, I will often refer to environments J and K together as 'Recent soil' environments here.

Table 1. LENZ Level I Environments within or immediately adjacent to the Mackenzie Ecological Region used here to define the Mackenzie Basin

Environment (LENZ Level I)	**Referred to here as**	**Land Area in Mackenzie Basin (ha)**	**Median elevation (m)**
E (Central Dry Foothills)	'Foothills'	134,900	700
J (Central Well Drained Recent Soils)	'Recent soils'	4,600	600
K (Central Upland Recent Soils)	'Recent soils'	18,600	600
N (Eastern South Island Plains)	'Plains'	142,800	500

14. About 68% of the land area proposed for irrigation[1] (c. 16,960 ha) is within 'Plains' environments (Lenz Level I N), 27% (c. 6,700 ha) is within higher elevation 'Foothills' environments (Lenz Level I E), and the remaining 5% (c. 1300 ha) is in 'Recent soils' environments (Lenz Level I J and K; Table 2). Forty-six Level IV environments occur in the Basin within these four Level I environments, and 36 have more than 100 ha within it (Attachment 5).

Table 2. Land areas proposed for irrigation in this application and their proportion within LENZ Level I Environments used to define the Basin.

Environment (LENZ Level I)	**Referred to here as**	**Land area (ha) proposed for irrigation in the Mackenzie Basin[1]**	**% of total land area proposed for irrigation in the Mackenzie Basin**
E (Central Dry Foothills)	'Foothills'	6,700	68.2
J (Central Well Drained Recent Soils)	'Recent soils'	50	0.2
K (Central Upland Recent Soils)	'Recent soils'	1,250	5.1
N (Eastern South Island Plains)	'Plains'	16,960	26.5

[1] Land proposed for irrigation refers to the areas considered in this Upper Waitaki Resource Consent Hearing, based on data supplied by the Department of Conservation on 28 Oct 2009. Estimated areas are rounded to the nearest 10 ha. Note that no estimates are included of additional areas that would be affected by associated infrastructure such as roads, sheds, canals and pipelines, as these data were not provided by the Department.

15. The Land Types classification of Lynn (2004) is more generally used for landscape and geomorphology analyses, and is based on the same soil and landform information as LENZ. My classification of the Basin into 'Foothills' and 'Plains' is broadly equivalent to Land Types H3 and H4 of Lynn (2004). As Table 3 shows, my ‘Foothills’ environments correspond approximately to the higher ‘Glacial and Fluvial Basin Floor’ Land Type H3, and my ‘Plains’ environment corresponds to the lower ‘Basin Floor Outwash Plains’ Land Type H4 of Lynn (2004). My ‘Recent soils’ environments are equivalent to the meander floodplain, valley fill swamp, terrace and moraine backswamp landform components of H3, the braided

[1] Based on spatial information for application areas supplied by the Department of Conservation on 28 October 2009

floodplain and meander floodplain and backswamp landform components in H4 of Lynn (2004).

Table 3. Proportions of Lynn (2004) H3 and H4 land types within LENZ Level I environments in the Mackenzie Basin as defined in my evidence.

Environment (LENZ Level I)	Referred to here as	Percent in Lynn (2004) Land Type
E (Central Dry Foothills)	'Foothills'	75% in H3 and 25% in H4
J (Central Well Drained Recent Soils)	'Recent soils'	48% in H3 and 52% in H4
K (Central Upland Recent Soils)	'Recent soils'	56% in H3 and 44% in H4
N (Eastern South Island Plains)	'Plains'	96% in H4

ABIOTIC (PHYSICAL) ENVIRONMENT

16. The abiotic environment of the Mackenzie Basin (Attachment 6) is one of New Zealand’s most distinctive: a high, inland basin totally derived from glacial landforms, with a seasonally dry, continental climate characterised by short warm summers and some of New Zealand's coldest winters. The climatic extremes of drought, frost, cold, heat, and wind, often combined with shallow, stony and infertile soils, create a highly stressful environment that has given rise to a distinctive, stress-tolerant terrestrial indigenous plant and animal biota. The indigenous biological diversity (hereafter biodiversity) of the Basin is consequently very distinctive in a national context.

ECOLOGICAL HISTORY OF THE MACKENZIE BASIN

Evolutionary history

17. The distinctiveness of the biodiversity of the Mackenzie Basin is a consequence of both the environment and the Basin history of relative isolation through the Pleistocene glaciations. This led to the evolution of many species and subspecies that are endemic to the Basin, especially in the least mobile groups (particularly invertebrates and non-diadromous[2] fishes).

[2] The term non-diadromous refers to fish that do not need a marine phase to their life cycle

Holocene vegetation

18. At the end of the last ice age (ca 18,000 years ago), the vegetation of the Mackenzie Basin was dominated by grasslands and associated herbs that primarily colonised new surfaces as ice retreated. A complex mosaic of forest, scrub, shrubland and grassland then developed reflecting regional and local gradients of climate and soils (McGlone 2001).

19. Immediately prior to human arrival (ca 800 years ago), the podocarps Hall's totara, celery pine and bog pine probably dominated a continuum from low forest in moist fertile sites to scrub on highly leached dry infertile sites. Small-leaved angiosperm (i.e. non-podocarp) scrub (of *Olearia*, *Coprosma* and *Hebe* species, and matagouri) and short (*Fescue* and *Poa*) tussock and other small native grasses likely grew on shallow, excessively well-drained soils in drier areas, and on regularly disturbed sites such as recent floodplain and outwash surfaces. High proportions of the Basin's rare and threatened native plant and invertebrate species occur in short, open vegetation on similarly high-stress and/or disturbed habitats today, which suggests these habitats were well represented in the vegetation matrix for thousands of years.

Human-induced change

20. Buried charcoals and pollen suggest natural fires were infrequent and separated by thousands of years before human settlement (McGlone & Moar 1998; Rogers et al. 2007). It is likely that these fires locally reduced podocarp shrubs, altered canopy composition, and temporarily increased short grasses (McGlone & Moar 1998). Extensive and repeated burning commenced only with the arrival of Maori around 800 years ago (McGlone & Moar 1998), causing a sudden widespread loss of conifer scrub on the basin floor and of forest on the surrounding slopes, from which there has been little subsequent recovery. Short tussock grasslands, red tussock grasslands and dry shrubland communities correspondingly expanded dramatically from previously restricted sites on the basin floor, and snow tussock descended down-slope to occupy areas previously under forest and shrubland cover below the regional treeline (which lies between 1200 m and 1400 m in the Mackenzie Ecological Region). Human hunting led to

the extermination of numerous moa species and the Haast's eagle (*Harpogornis moorei*). However, Maori introduced no plant weed species.

21. When Europeans first arrived around 1850, the basin floor landscape was an extensive plain of indigenous tussock and scrub, described by von Haast (1862) as a 'great tawny expanse of low tussock grassland' which merged into 'snow grass' at higher altitudes. He vividly records extensive wetlands, dense shrubland thickets and speargrass on the basin floor. Fescue tussock (*Festuca novae-zelandiae*) dominated the short tussock grasslands, as it still does today, with blue tussock, plume grass and blue wheat grass (*Poa*, *Dichelachne*, and *Elymus* species) common.

22. European settlement continued the modification of the vegetation. Grazing of stock from the late 1850s (O'Connor & Kerr 1978), fire, and introductions of rabbits and numerous exotic plant species, have caused a general depletion of native ecosystems throughout the Mackenzie Basin. Large areas of tall tussock grasslands were transformed to short tussock grasslands, accompanied by decreases in the stature and density of the tussocks and increases in unpalatable and/or grazing-tolerant non-native plants (Connor 1964; O'Connor 1982) such as *Rumex acetosella* and the flatweed *Hieracium pilosella* (Treskonova 1991).

23. Biotic changes in the Mackenzie Basin are ongoing, and many native species are now regionally threatened and declining; they are often concentrated in small refuges and have reduced regeneration, as a consequence of (among other things) fire, herbivory by hares, sheep, and rabbits, herbicide sprays, drainage, eutrophication, pollution, competition from weeds, and habitat modification and clearance for hydroelectricity, transport, peri-urban settlement, agriculture and forestry.

24. Despite these human-induced changes, less-developed land in the Mackenzie Basin generally retains much of the natural character observed by the first Europeans. Tussock grasslands, shrubland and wetland plant communities dominated by native species still cover extensive connected sequences of glacial landforms. Currently they are shorter, markedly less woody, more invaded by exotic plants, and less rich in native species, but they still support a high diversity of native plants and animals. The species

assemblages are often distinctive to the Mackenzie Basin, and reflect natural environmental variation and subtle micro-habitats associated with the Basin's natural dryland ecosystems. They are national strongholds for numerous indigenous species that are threatened or naturally uncommon at a national level. In my evidence, I refer to these as 'less-developed' community types.

25. In recent decades, wilding conifers have spread into many parts of the Basin from plantations, eliminating indigenous communities where they have not been controlled. Since 1990, there has also been a trend to convert the grasslands of the Mackenzie Basin to improved exotic pasture, through oversowing, direct drilling and topdressing of the tussock grasslands, and, more recently, cultivation and irrigation. More than any previous farming activity, these methods remove the indigenous terrestrial flora and invertebrate fauna and replace them with more rapidly growing exotic pasture and feedstock species.

PRESENT-DAY TERRESTRIAL ECOSYSTEMS AND BIOTA OF THE MACKENZIE BASIN

Naturally rare ecosystems

26. New Zealand's naturally rare ecosystems (also known as 'originally rare' or 'historically rare' ecosystems) are those that were rare before human colonisation of New Zealand. They typically comprise less than 5% of New Zealand's land area, and often have highly specialised and diverse floras and faunas characterised by relatively high proportions of either endemic or nationally rare species (Williams et al. 2007). National Priority 3 for protecting rare and threatened native biodiversity on private land (MfE 2007) is '*to protect indigenous vegetation associated with "originally rare" terrestrial ecosystem types not already covered by priorities 1 and 2*'. The national list of such ecosystems is available on the Landcare Research website.

27. The Mackenzie Basin supports the highest density and area of naturally rare ecosystems of any region in New Zealand of similar size. Indeed, the

remaining indigenous ecosystems of the Basin are almost wholly made up of six of the 72 naturally rare ecosystems identified throughout New Zealand, namely moraines, inland outwash surfaces, inland sand dunes, braided rivers, ephemeral wetlands (or kettleholes) and tarns (Williams et al. 2007). These ecosystems contain distinctive assemblages of plant and animal species that are adapted to an extreme abiotic environment and are generally small, slow-growing and drought-tolerant. They support numerous nationally threatened plants and regionally endemic invertebrates.

28. A key feature of these naturally rare ecosystems is that they occur together in continuous mosaics across little-fragmented sequences of largely undeveloped glacial landforms: their ecological context remains relatively intact and connected. To my knowledge, there is no other place in New Zealand where these rare ecosystems occur to such an extent and in natural sequences in a relatively low lying landscape. In contrast, most naturally rare ecosystems in New Zealand's more mesic lowland and montane zones have already been lost to development, and remaining examples are typically isolated. I describe these rare ecosystems and associated wetlands of the Basin in Attachment 7.

29. This interconnected complex of naturally rare ecosystems, and associated wetlands and freshwater habitats together support the distinctive biodiversity of the Mackenzie Basin. The biodiversity dependent upon the maintenance of sizeable areas of connected and relatively undeveloped habitat here includes populations of regionally endemic and threatened invertebrate and freshwater fish, and internationally important populations of migratory wading birds, gulls and terns in addition to the mostly New Zealand endemic and nationally endangered dryland plant habitats and species that are the focus of my evidence.

THREATENED AND AT RISK FLORA OF THE MACKENZIE BASIN

30. Protection of the habitats of indigenous threatened species is a national priority (MfE 2007; Appendix 1). The Mackenzie Basin's grasslands, shrublands and wetlands support numerous indigenous plant species

known to be threatened or naturally uncommon at a national level. A high proportion of these threatened species occur in rare ecosystems of the more extreme, drier, lower Plains environments that are predominantly proposed for irrigation. These rare species are patchily and widely distributed across a high proportion of the Basin's remaining less-developed grasslands, and most populations are under pressure from combinations of factors listed in paragraphs 22 and 24.

31. The threat status of New Zealand's flora was most recently revised in 2008 and published in 2009 in the *New Zealand Journal of Botany* (de Lange et al. 2009; see Attachment 8). In determining a species' threat status, each plant species is assessed against criteria to gauge its threat of extinction. 'Threatened' species are those taxa in the Nationally Critical, Nationally Endangered and Nationally Vulnerable categories (Townsend et al. 2008). Other species are considered 'At Risk' of extinction because of declining populations and/or small restricted population sizes ('At Risk' categories are Declining, Naturally Uncommon, and Relict).

32. Of this national list, 20 'Threatened' and 40 'At Risk' plant occur in the Mackenzie Basin floor environments, representing 24% and 23% of the total 'Threatened' and 'At Risk' floras of Canterbury respectively, and 11 and 6% of the national totals for these categories (Table 4). The Basin also supports six 'Data Deficient' plants (11% of the national total and 15% of those in Canterbury); these are plants for which insufficient information exists for assessment and categorisation, but the panel sees reason to believe they also warrant listing (Townsend et al. 2008; de Lange et al. 2009).

33. Canterbury Region has the second-highest number of 'Threatened' plants of any botanical region in New Zealand (de Lange et al. 2009) due mainly to the modification and complete loss in the past of indigenous ecosystems across a high proportion of its lowland and montane land areas.

Table 4. Number of plants in each of the NZ threat classification categories for New Zealand, Canterbury and the Mackenzie Basin

	New Zealand [1]	Canterbury [2]	Mackenzie Basin		
Threat Category	**Number of plants**	**Number of plants**	**Number of plants**	**% of New Zealand**	**% of Canterbury**
Extinct	6	5		0.0	0.0
Nationally Critical	91	42	10	12.0	23.8
Nationally Endangered	45	24	5	11.1	20.8
Nationally Vulnerable	44	19	5	11.4	26.3
Declining	83	50	15	18.1	30.0
Naturally Uncommon	542	119	25	4.6	21.0
Recovering	6	1		0.0	0.0
Relict	20	3		0.0	0.0
Data Deficient	35	26	4	11.4	15.4
All 'Threatened'[3] plants	180	85	20	11.1	23.5
Total 'At Risk'[4] plants	645	172	40	6.2	23.3

[1] from de Lange et al. (2009)

[2] List updated from de Lange et al. (2009) by Department of Conservation Canterbury Conservancy

[3] Nationally Critical, Nationally Endangered and Nationally Vulnerable

[4] Declining, Naturally Uncommon, Recovering and Relict

Resilience of Mackenzie Basin terrestrial ecosystems

34. Tekapo Scientific Reserve is an approximately 1,000 ha area of moraine and inland outwash surfaces that includes ephemeral wetlands, and encompasses ‘Plains’ (47% of its land area), ‘Foothills’ (45%) and ‘Recent soils’ (8%) environments. Prior to becoming a Scientific Reserve it had a history of high rabbit numbers in combination with stock grazing, and in 1992 was almost completely denuded of tussock, with high proportions of bare ground and mouse-ear hawkweed and other weed cover. Following protection in 1992, stock were removed and rabbits controlled to low levels. Over the subsequent 17 years there has been marked native vegetation recovery, most notably on the more extreme and formerly more

degraded outwash plain. Department of Conservation monitoring shows increased tussock cover, recovery of native inter-tussock species diversity, and decreased bare ground and mouse-ear hawkweed (see photographs in Attachment 9). Threatened plant species populations have recovered, including those of *Lepidium solandri* (Category 2; Nationally Endangered), and *Pimelea pulvinaris*, *Carmichaelia vexillata*, *Leucopogon nanum*, and coral broom (*Carmichaelia crassicaulis* subsp. *crassicaulis*) (all Category 4; Declining). Indigenous shrub cover has increased through recruitment. Importantly, land surrounding the reserve has not yet been predominantly developed for intensive agriculture, so (apart from wilding tree control) it is subject to relatively few of the indirect effects of development I describe below.

EFFECTS OF AGRICULTURAL LAND DEVELOPMENT ON TERRESTRIAL ECOSYSTEMS AND SPECIES

35. Dryland herbaceous native plants and invertebrate species of the Mackenzie Basin are adapted to an extreme abiotic environment and are diminutive and are characteristically slow-growing and tolerant of drought and nutrient-poor substrates. Grassland and turf communities in particular are very fine scaled, comprising many tiny plants and insects packed into small areas. The intent and result of agricultural land development in the Basin is to increase productivity and biomass through relieving abiotic stress. This land use change, which involves addition of water and nutrients, destroys the indigenous ecosystems and habitats of terrestrial indigenous species by fundamentally altering the ecological conditions that sustain native fauna and flora. Such habitat destruction – including direct loss of habitat, degradation of habitat quality, and fragmentation of the remaining habitat – is by far the most significant cause of population and species extinction worldwide (Hanski 1998).

Effects of oversowing and topdressing

36. Grasslands of the Mackenzie Basin that are seldom oversown or direct drilled and topdressed with fertiliser retain more indigenous biodiversity.

Oversowing and topdressing introduces larger, faster-growing, palatable exotic pasture grasses and legumes and the nutrients they require to thrive, which alters the habitat and displaces former communities of indigenous plants and animals with introduced ones. Where oversowing (or direct drilling) and topdressing is regularly undertaken, most of the former indigenous species are outcompeted by exotic pasture species and extinguished.

37. Most exotic pasture and crop plants cannot thrive in the Basin environment unless fertiliser inputs are maintained. In the absence of regular inputs, exotic cover may decline and some indigenous species are capable of reinvading. As shown in the Tekapo Scientific Reserve, indigenous species may slowly come to dominate formerly modified communities again, given time and low grazing pressure.

Effects of irrigation

38. Effects of irrigation on the Mackenzie Basin's indigenous ecosystems and species are more substantial and rapid than those of oversowing and topdressing, and less reversible. There are both on-site and off-site effects. (Note that effects of infrastructure (e.g. roads, sheds, canals, pipelines) and ongoing disturbances associated with irrigation will have additional effects are not considered here).

On-site effects

39. The application of irrigation to naturally dry ecosystems typically results in the complete loss of the natural habitat for native species are ill-adapted to regular saturation. Like fertiliser, irrigation reduces environmental stress on the plant community, promoting the growth and competitive advantage of exotic pasture species which displace indigenous species under low-stress conditions. Irrigation is usually accompanied by fertiliser application, oversowing or direct drilling, and cultivation and cropping. In sum, dryland indigenous ecosystems are transformed into productive, low-stress, high-nutrient and wholly exotic pastures where very few native species can survive.

40. Biological survey of the ca 25,000 ha of the Mackenzie Basin directly affected by these applications, to the best of my knowledge, is incomplete. Therefore, on-site effects on flora and fauna cannot yet be comprehensively assessed.

41. From spatial data (described in Attachment 2, paragraph A2.2) I estimate that the present applications directly affect about 10,800 ha of land that may already been substantially converted to an exotic cover type. If these already-developed areas now support little remaining indigenous terrestrial biodiversity, on-site effects may be minor (although ground survey would be required to confirm this). However, increased land use intensity on these areas may still have important off-site effects on terrestrial biodiversity, as described below.

42. On the remaining ca 14,200 ha of land proposed for irrigation, the on-site effects of the applications will include the clearance of known[3] significant indigenous vegetation and significant habitats of indigenous fauna, containing habitat for several nationally Threatened and At Risk species. An example is described in Attachment 10. Applications overlap parts of Recommended Areas for Protection (RAPs) identified in the 1984 Protected Natural Areas Programme survey (Espie et al. 1984), most notably the Tekapo/Pukaki Flats (Simons Hill) and Maryburn Flats RAPs (Classic Properties), and sites of special wildlife interest (SSWIs), especially Clark Creek/Otematapaio River Swamp (Otamatapaio) and the Godley River and Delta (Lilybank). Other sites directly affected by this application are likely to support similarly representative and naturally rare indigenous communities containing threatened indigenous species (Attachment 11, see also Attachment 15).

43. In my opinion, to credibly assess the on-site effects of the applications, new survey of flora and fauna is needed on all proposed irrigation sites, of a standard similar to the example in Attachment 10. Such survey requires

[3] The most recent major source of information is reports from surveys undertaken for the Tenure Review of Crown Pastoral Leases, although these vary in quality, and older reports are less infomative (see Attachment 10). Other information sources include the Department of Conservation's Canterbury significant sites, bioweb and herpetofauna databases, herbaria, and the PNAP report of Espie (1984), none of which represents comprehensive or recent inventory.

specialist expertise (because of the often cryptic and diminutive flora and fauna), and may be time-constrained (because certain threatened spring-annual plants can be observed only briefly each spring).

44. In my opinion, native plant species proportions at many sites affected by the applications mean they are unlikely to be exempt from rules that constrain indigenous vegetation clearance in the operative Mackenzie and Waitaki District Plans.

Off-site effects

45. Many major effects of the application will not be confined to the areas that are directly irrigated. Some off-site may be local; e.g. indigenous plant species can be displaced by exotic pasture species and weeds where cross-boundary water drift reduces stress, as has been seen at Balmoral Reserve in North Canterbury. However, most off-site effects will be less restricted because the Mackenzie Basin's terrestrial ecosystems are interconnected by groundwater and wind, and by animals that use them as breeding and feeding habitats. I describe three broad classes of off-site effects: **increased inputs** (nutrients and seed), **ecosystem fragmentation**, and **disruption of metapopulations**.

46. **Increased inputs** of nutrients to groundwater and/or altered hydrological regimes are likely to degrade and transform downstream indigenous communities of wetlands associated with spring-fed streams and braided rivers.

47. The composition and zonation of ephemeral wetlands and their turfs are sensitive to inputs within their catchments (Johnson & Rogers 2003). They will likely be detrimentally affected by increased nutrient loading (both through enriched groundwater, and perhaps especially through wind-borne fertiliser drift from aerial topdressing and erosion from cultivated and topdressed land) and increased exotic seed inputs (either wind-borne or transported by wild or domestic animals). Areas downwind (south-east) of irrigated, cultivated and topdressed areas will be most severely affected by aerial nutrient and seed inputs (as illustrated by aerial wilding conifer spread).

48. These inputs, and their adverse effects – the displacement of indigenous plants and animals with exotic pasture species and weeds – are likely to increase cumulatively over time.

49. **Ecosystem fragmentation** is the dissection and separation of formerly continuous and intact habitat and/or ecological sequences into smaller remaining patches. Ecological and (longer-term) evolutionary functions such as migration, pollination, dispersal, and speciation may be severed. Moreover, the larger edge-to-area ratio of each patch reduces buffering of its interior against transgressions such as cross-boundary irrigation, and aerial fertiliser and exotic seed drift, which threaten natural processes and are associated with increased weed invasion.

50. Species live and evolve as dynamic 'metapopulations' (Hanski 1998) that are connected in space, and persist in a balance between extinction and colonisation of different habitat patches. Even in a natural landscape, not all suitable habitat patches are occupied by a species at once, and habitat suitability and occupation may vary from year to year or decade to decade. **Metapopulations** are **disrupted** by habitat loss or degradation that reduces the total number of habitat patches that serve as 'sources' for recolonisation and 'sinks' for dispersing seeds or animals, and by fragmentation that severs pathways for recolonisation. These disruptions lower probabilities of species persistence well beyond sites where physical effects can be measured. There can be long delays between metapopulation disruption and declines of species to extinction, or, alternatively, species can become vulnerable to sudden extinction through stochastic events (droughts, floods, fire) because unoccupied and occupied habitat patches are few and environmentally similar (Hanski 1998).

51. In the Mackenzie Basin, the effect of the applications on metapopulations will be gravest and most immediate where habitats of Threatened and At Risk species are affected. Other pressures have already disproportionately reduced these species' metapopulations, and they often occupy relatively few isolated and often environmentally similar patches in small numbers. However, other species’ metapopulations will also be degraded.

52. In my opinion, credible assessment of effects of these applications should consider off-site effects on remaining habitats of terrestrial indigenous species within the catchment.

NATIONAL, SOUTH ISLAND, AND MACKENZIE BASIN TERRESTRIAL BIODIVERSITY LOSS

Past loss of New Zealand's indigenous terrestrial ecosystems

53. Most of New Zealand's coastal, lowland, and montane terrestrial environments have undergone extensive clearance and modification of indigenous ecosystems, and loss has been extreme (>90%) in environments covering nearly a quarter of the total land area (DOC & MfE 2000; Green & Clarkson 2006; Walker et al. 2006). Eastern dryland environments, which make up about 91% of the Mackenzie Basin, have been most extensively developed and modified (Rogers et al. 2005).

54. Past clearance and modification has already committed these environments to loss of biological diversity. For example, New Zealand regions that have undergone most past habitat loss and modification now hold the majority of listed Threatened plant species; Southland (67) and Canterbury (65) stand out as botanical provinces with the greatest numbers (de Lange et al. 2009). Ecological theory predicts and empirical data show that species loss accelerates as habitat loss becomes advanced, and "*…the more fragmented a habitat already is, the greater is the number of extinctions caused by added destruction*" (Tilman et al. 1994). Therefore, species loss is likely to be most exacerbated by further loss of indigenous habitat in regions where considerable loss and modification has occurred in the past.

Recent conversion of South Island grassland ecosystems

55. The area and quality of indigenous ecosystems and habitats for indigenous species (including Threatened and At Risk species) in eastern South Island has been markedly reduced by land development in the last decade. This change has been especially marked in inland hill country and intermontane basin environments like the Mackenzie Basin. For example, the Canterbury Biodiversity Strategy (adopted in February 2008)

acknowledges (p. 29) that these environments are undergoing some of the most rapid changes in land use within the region, and the increasing priority for action to protect them as important indigenous habitats for Canterbury’s biodiversity.

56. The recent loss of indigenous ecosystems is difficult to accurately quantify. Reliable, publicly available data from Statistics New Zealand and MAF show steady increases in stock numbers in Canterbury, Otago and Southland. However, inventory and monitoring of biodiversity on private land is non-existent in most districts, and national land cover databases (LCDBs) are outdated and inaccurate.

57. Comparison of the two national land cover databases LCDB1 (based on 1996/97 satellite imagery) and LCDB2 (based on 2001/02 satellite imagery) shows a net loss of 17,204 ha of nominally 'indigenous' cover classes, plus conversion of 29,338 ha of the mixed Low Producing Grassland class in those five years (Walker et al. 2006). However, neither LCDB1 nor LCDB2 identifies most land cover change in grasslands since 1990, so these estimates mainly represent losses to afforestation (which was assessed in the making of LCDB2) and do not include loss of less-developed grasslands to intensive pasture development (which was not).

58. A PhD study at the University of Waikato co-supervised by Landcare Research's remote sensing experts recently assessed a 4.3 million ha eastern South Island grassland zone to determine how much less-developed grassland has been converted to forestry (planted wilding), exotic pasture or cropland, and mining or urban uses since 1990. The student’s preliminary, unpublished estimates suggest some 80,000 ha of less-developed grasslands were converted in this zone between 1990 and summer 2007/08. Of this, the student estimates that 66% (about 52,500 ha) was converted for pasture or cropland, and almost half of this conversion (c. 25,000 ha) occurred in six years between the summers of 2001/02 and 2007/08.

59. These unpublished estimates suggest the average rate of conversion of less-developed grasslands, shrublands and wetlands in eastern South Island grassland zone for pasture and cropland may have recently

increased from about 2,500 ha per annum between 1990 and 2001, to about 4,200 ha per annum between 2002 and 2008. These rates are consistent with accelerating livestock numbers published by MAF and Statistics New Zealand, and support the statement that New Zealand is undergoing ‘record rates of agricultural intensification’ (Murdoch 2009). In my opinion, this development may represent the most significant wave of direct loss and modification of habitats of indigenous species in New Zealand in modern times, and will likely exacerbate the threat status of many of its species.

Conversion of less-developed grasslands in the Mackenzie Basin

60. Relatively little of the Mackenzie Basin grasslands were fully converted to exotic pastures by intensive agriculture before 1990. Table 5 summarises estimates of the conversion of less-developed grassland communities to land development in the Basin up to 1990, based on interpretation of satellite imagery. These estimates suggest relatively modest percentages (ca 8.3%) of the Basin's grasslands had been converted by 1990. About 40% of this development was in ‘Foothills' environments, about 50% in 'Plains' environments, and the balance in 'Recent soils' environments.

Table 5. Estimated areas of less-developed grasslands converted to forestry, exotic pasture, cropland, mining or urban uses in the Mackenzie Basin in 1990.

Environment (LENZ Level I)	Referred to here as	Land Area in Mackenzie Basin (ha)	Area of grassland converted in 1990
E (Central Dry Foothills)	'Foothills'	134,900	10,000
J (Central Well Drained Recent Soils)	'Recent soils'	4,600	100
K (Central Upland Recent Soils)	'Recent soils'	18,600	2300
N (Eastern South Island Plains)	'Plains'	142,800	12,500
Total	‘Mackenzie Basin’	300,900	24,900 (8.3%)

[1] All estimated areas are rounded to the nearest hundred hectares, so as not to overstate the expected accuracy of the data.

61. However, this situation is changing rapidly. More grassland has been completely converted in the 19 years from 1990 to 2009 than in the previous 150 years of human settlement. Table 6 and Attachment 12 show estimates of the areas of less-developed grasslands within the Basin that have been completely converted for forestry, exotic pasture, cropland, mining or urban land use at present (November 2009), and the area converted from 1990 to present. These estimates suggest that about 12% of the total Basin area has been converted since 1990, and that about 19,600 ha (about 56%) of the post-1990 grassland conversion was in 'Plains' environments, and 14,200 ha (about 40%) was in 'Foothills' environments. Note that our estimates are of complete conversion, and do not include ecosystems that have been highly modified, but still support some indigenous plant species.

Table 6. Estimated areas of less-developed grasslands completely converted to exotic cover for forestry, exotic pasture, cropland, mining or urban uses in the Mackenzie Basin in 1990, at present, and the area converted between 1990 and 2009.

Environment (LENZ Level I)	**Referred to here as**	**Area of grassland converted in 1990 (ha)** [1]	**Area of grassland converted by November 2009 (ha)**	**Area converted from 1990 to 2009 (ha)**
E (Central Dry Foothills)	'Foothills'	10,000	24,100	14,200
J (Central Well Drained Recent Soils)	'Recent soils'	100	200	100
K (Central Upland Recent Soils)	'Recent soils'	2,300	3,700	1,400
N (Eastern South Island Plains)	'Plains'	12,500	32,000	19,600
Total	'Mackenzie Basin'	24,900	60,200	35,300
Percent of Mackenzie Basin		8.3	20.0	11.7

[1] All estimated areas are rounded to the nearest hundred hectares, so as not to overstate the expected accuracy of the data.

62. A map of the areas of less-developed grasslands estimated to have been converted to wholly exotic cover is provided in Figure A12.1 in Attachment 12. It indicates that most of the conversion for intensive land use since

1990 in the Basin has occurred south and west of Twizel, and that the less-developed grasslands that now remain in this part of the Basin are highly fragmented. It also shows that more extensive areas of less-developed ecosystems still remain, particularly in north-eastern parts of the Basin.

63. Estimates in Table 7 indicate the majority of the conversion in the Basin since 1990 has been for exotic pasture through irrigation or cultivation (50.6%), or oversowing and topdressing (41.2%), with just 6.4% being converted for exotic plantation forestry or densely invaded by wilding trees. Note that areas modified but not completely converted by oversowing, topdressing and other pressures are not included in these estimates.

Table 7. Estimated areas of less-developed grasslands converted to different types of land use and land cover in the Mackenzie Basin from 1990 to 2009[1].

Environment (LENZ Level I)	**Construction or Urban**	**Forestry including wilding trees**	**Cultivation or irrigation**	**Conversion by oversowing and topdressing**	**Percent (%) of total conversion**
E (Central Dry Foothills)	100	1,600	5,700	6,600	40.1
J (Central Well Drained Recent Soils)	0	0	100	0	0.2
K (Central Upland Recent Soils)	100	0	1,000	300	3.9
N (Eastern South Island Plains)	500	600	11,000	7,600	55.7
Total conversion	700	2,200	17,800	14,500	
Percent (%) of total conversion	1.9	6.4	50.6	41.2	

[1]All estimated areas are rounded to the nearest hundred hectares, so as not to overstate the expected accuracy of the data.

64. This recent conversion probably represents the most rapid rate of indigenous ecosystem loss and landscape transformation within any single ecological region in New Zealand in modern times. A spatial overlay indicates that parts (>10ha) of at least twenty-nine of the 103 RAPs identified in the Mackenzie Ecological Region Protected Natural Areas Programme survey (Espie et al. 1984), and nine sites of special wildlife

interest (SSWIs) have been converted. Most of this conversion has occurred since 1990.

65. The rate of conversion of remaining indigenous cover is many times the rate of legal protection in most of the Basin's environments. Several LENZ Level IV environments that have been much converted (especially in recent years) are both distinctive of the Basin and very poorly protected. Prominent examples are 'Foothills' environments E4.1a and E4.1b, and 'Plains' environments N6.1a, N6.1b and N7.1a (see Table A12.1 in Attachment 12).

Additional conversion of less-developed grasslands by these applications

66. The present irrigation applications would convert about 14,200 ha of less-developed grassland to exotic pasture (Table 8), excluding associated infrastructure. This represents complete clearance of indigenous vegetation at least a further 4.7% of the of the Mackenzie Basin, and 6% of the less-developed grasslands now remaining. With no other new conversion, it would bring to one quarter the proportion of the Basin's indigenous ecosystems that has been completely converted to exotic cover.

Table 8. Areas (in ha) of less-developed grasslands proposed for additional conversion by irrigation in these applications, relative to areas converted before 1990, and from 1990 to 2009. The final column shows the total area of less-developed grassland that would be converted if all additional irrigation went ahead, and there was no other new conversion (e.g. from oversowing and topdressing, wilding pine spread, spread of urban areas, new canals).

Environment (LENZ Level I)	**Converted up to 1990 (ha)** [1]	**Converted from 1990 to 2009 (ha)**	**Proposed additional conversion for irrigation (ha)** [2]	**Total converted area with proposed irrigation (ha)**
E (Central Dry Foothills)	10,000	14,200	2,200	26,300
J (Central Well Drained Recent Soils)	100	100	0	200
K (Central Upland Recent Soils)	2300	1,400	200	3,900
N (Eastern South Island Plains)	12,500	19,600	11,700	43,900
Total	24,900	35,300	14,200	74,300
Percent (%) of Mackenzie Basin	8.3	11.7	4.7	24.7

[1]All estimated areas are rounded to the nearest hundred hectares, so as not to overstate the expected accuracy of the data.

[2] This column excludes 10,800 ha of the total area of the present applications, which our data show to have been converted before 2009 and therefore may already be substantially developed. Note that no estimates are included of additional areas that would be affected or disturbed by associated infrastructure such as roads, sheds, canals and pipelines.

67. Most (11,700 ha or 83%)new conversion via the present irrigation applications would affect 'Plains' environments. About two thirds (ca 9,490 ha) is in a single Level IV Environment N6.1b (Table A12.1 in Attachment 12), which is mainly confined to the Basin and poorly protected (3.3% in public conservation land). Applications also affect 14% of the distinctive and poorly protected 'Foothills' Environment E4.1b, and a smaller but significant area of the distinctive 'Recent soils' environment K4.1d.

68. Figure 12.1 in Attachment 12 maps the location of present irrigation applications relative to areas that are estimated have already been totally converted to exotic cover within the Basin. Importantly, the new conversion will have the most significant effects on the extent, intactness, and quality of less-developed grasslands in the north and east of the Basin, where they are presently least developed and fragmented, and are the only remaining part of the Basin where relatively continuous sequences of

naturally rare ecosystems still occur. The greatest effects in this regard will be from the Classic Properties, Simons Hill, Simons Pass, Grays Hills Station Limited, Haldon Station (1991) Limited, Hope, High Country Rosehip Orchards, and High Country Rosehip Orchards Ltd applications. Fragmentation and other indirect effects on remaining species and their habitats will also be exacerbated in the south of the Basin by the Five Rivers/Ohau Downs application (which would clear the largest area of less-developed moraine grassland south of Twizel) and the Killermont Station and Southdown Holdings Ltd Killermont applications (which clear much of the largest area of undeveloped outwash surface remaining south of Twizel).

PROTECTION FOR TERRESTRIAL BIODIVERSITY IN THE MACKENZIE BASIN

69. Public conservation land in the Mackenzie Basin includes important examples of naturally rare ecosystems present, including dryland tussock and herbfield communities on inland outwash surfaces (Ben Ohau Conservation Area; Tekapo Scientific Reserve), kettleholes (the Wairepo kettleholes; Tekapo Scientific Reserve), relictual bog pine shrublands (Bendhu Scientific Reserve), red tussock grasslands (Ohau Moraines wetland complex), and shrublands (Pukaki Scientific Reserve, Lake Pukaki Terminal Moraine Scenic Reserve, Simons Hill Conservation Area).

70. However, these protected areas are too small and scattered to sustain representative examples of the region's distinctive biota and ecosystems. Nationally, most Mackenzie Basin environments are very poorly protected (Table A12.1 in Attachment 12). Distinctive 'Plains' environments N6.1a and N6.1b have just 3.3%, and the characteristic 'Foothills' environments E4.1a and E4.1b have just 3.7% and 5.0% of their land area protected. Of the Basin's distinctive environments, only 'Recent soils' environment K4.1d has a reasonable proportion (39%) of its land area protected as public land.

71. In total, 17,000 ha of public conservation land is managed for natural heritage in the Basin (5.6% of the total land area; Table 9). About 8% of

'Foothills' environments and 13% of 'Recent soils' environments are protected. 'Plains' environments, which are targeted for new development, have 2% of their total area protected.

Table 9. Areas of public conservation land protected for natural heritage, and QEII covenants in the Mackenzie Basin at present.

Environment (LENZ Level I)	Referred to here as	Public Conservation land[1] in ha (and % of Basin area)	QEII Covenants (ha) (and % of Basin area)
E (Central Dry Foothills)	'Foothills'	11,130 (8%)	1,960
J (Central Well Drained Recent Soils)	'Recent soils'	280 (6%)	-
K (Central Upland Recent Soils)	'Recent soils'	2,780 (15%)	150
N (Eastern South Island Plains)	'Plains'	2,840 (2%)	130
Total	'Mackenzie Basin'	17,030 (6%)	2,240 (<1%)

[1] These estimates exclude areas such as recreation reserves, local- and government-purpose reserves and marginal strips with little native biodiversity and/or no conservation management. Area estimates are rounded to the nearest 10 ha.

72. These protected land parcels are scattered, and the viability of many is threatened by isolation within an increasingly developed landscape. For example, the 400-ha Quailburn Conservation Area has recently become isolated within a matrix of intensive land use (Figure 1), which will increase exotic seed rain and aerial fertiliser inputs. The area contains ephemeral wetlands (the Wairepo kettleholes) supporting species-rich native turfs of tiny plants dependent on low-nutrient conditions and vulnerable to exotic invasion with eutrophication (Johnson & Rogers 2003).

73. QEII National Trust Covenants cover c. 2230 ha (0.75% of the Basin), of which 87% is in 'Foothills' environments. They add small but notable areas to protected lands in environments E1.4b, and the regionally distinctive E4.1a, and E4.1b. However, not all covenants are managed primarily to protect natural heritage and conserve species; the two largest covenants have been topdressed and oversown with exotic pasture species in recent years. The (expanding) military reserve may also give some protection for indigenous ecosystems against land development. It now covers some 3,200 ha of mainly ‘Foothills’ environments and retains populations of

some threatened species (e.g. the shrub *Leonohebe cupressoides*; Category 2; Nationally Endangered).

Figure 1. Aerial view of the Quailburn Conservation Area and the Wairepo kettleholes adjacent to new intensively developed land uses, in November 2008.

74. Evidence shows neither the CPLA discretionary consent process, nor the Tenure Review process pertaining to Crown Pastoral Leases can be relied on to protect biodiversity in the Basin, especially in environments where indigenous biodiversity is most threatened by development.

75. In principle, discretionary consent is required to cultivate pastoral lease land, and inherent values are considered. However, intensive pasture development on leases is increasing, and consent procedures are not always followed. For example, adjacent to the highway on Maryburn pastoral lease, riparian wetland, and short tussock grassland on moraine supporting the threatened plant *Leptinella conjuncta* (Category 1; Nationally Critical) were recently cultivated without consent.

76. Furthermore, significant inherent biodiversity values identified by experts in the field are not always recommended for protection by the Department of Conservation, or protected by Land Information New Zealand in the

Tenure Review of Crown Pastoral Leases. Biodiversity that is most threatened by development is seldom protected. On 69 leases that underwent Tenure Review from 1992 to 2007, data gathered by the Department of Conservation in 2007 show that the Department recommended protection for just 30% of the area containing identified significant inherent values within National Priority 1 environments (Attachment 13).

SIGNIFICANCE OF REMAINING LESS-DEVELOPED GRASSLANDS OF THE MACKENZIE BASIN

77. Various criteria have been proposed for assessment of significance under Section 6c of the Resource Management Act (RMA). Most criteria are adapted from the Protected Natural Areas Programme (PNAP) (McEwen 1987). They include representativeness, diversity and pattern, rarity and special features, naturalness, size and shape, buffering surrounding landscape and boundaries, and long-term ecological viability. The Government's four National Priorities (MfE 2007; Attachment 1) are consistent with these criteria, especially with representativeness and rarity and special features. The Canterbury Regional Policy Statement's criteria for regional significance (Paragraph 20.4) include natural features endemic or unique to, or characteristic of, Canterbury; that are threatened; or that provide essential habitat linkages or connectivity, and includes the ecological processes that maintain these features. Modern conservation planning principles developed internationally for efficient and effective conservation (e.g. Margules & Pressey 2000) are also consistent with the PNAP conception of representativeness, and identify sites that are both 'irreplaceable' (sites have few or no replacements, including being among the last remaining of a type) and 'vulnerable' (imminently threatened with loss) as highest priorities for protection. Norton & Roper-Lindsay (2004) proposed a more restrictive criteria set for RMA significance assessment.

78. I and others have argued that restrictive (or high-threshold) assessment criteria can promote ongoing and cumulative loss and simplification of the biological diversity that now remains in the landscape (Denyer et al. 2005;

Walker et al. 2008a). Here, I do not endorse any particular set of significance criteria, but instead comment on the remaining less-developed grasslands of the Mackenzie Basin in relation to various criteria as proposed and defined.

Representativeness

79. Under the PNAP definition, high representative value is given to particular communities or ecosystems which: (i) have large overall areas in a district; (ii) have been reduced from their former extent; and/or (iii) are poorly represented in reserves. Representativeness is defined as extending beyond ecological units that are rare or unusual in a local or regional context and includes the typical, characteristic units that normally contribute most to the distinctive character of the ecological districts and regions in which they occur. Subcriterion (ii) is consistent with Government's National Priority 1, and subcriteria (ii) and (iii) are consistent with irreplaceability and vulnerability as defined in the international conservation planning literature, and all three seem consistent with criteria in the Canterbury Regional Policy Statement.

80. In my opinion, the remaining less-developed grasslands of the Mackenzie Basin fully meet these representativeness standards. They were once widespread in the district, have recently been much reduced from their former extent, are very poorly protected nationally and within the Basin, and are imminently threatened with further loss to development. Particularly in the north and east of the Basin, remaining grasslands have not yet been reduced to the '<20% remaining' threshold of National Priority 1 and Norton & Roper-Lindsay's (2004) representativeness criterion. However, this is the last place in New Zealand where representative sequence of linked low-lying ecosystems unique to and characteristic of Canterbury could potentially be maintained across the full range of landforms. The area's potential contribution to a more representative protected area network prompted the Parliamentary Commissioner for the Environment to endorse the creation of a Dryland Conservation Park here (PCE 2008).

Rarity and special features

81. By the PNAP definition, this criterion identifies scarce biological or physical features, whether naturally rare or human induced, in local, regional or national contexts. In my opinion, the Basin's remaining less-developed grasslands fully meet this criterion, being almost entirely comprised of naturally rare ecosystems (National Priority 3) or wetland types that have been significantly reduced nationally (National Priority 2), and with many containing Threatened species (National Priority 4). Many areas are also likely to meet the narrower definition of rarity and distinctiveness proposed by Norton & Roper-Lindsay (2004).

Other criteria

82. The less-developed grasslands of the Mackenzie Basin have a very high degree of natural diversity and pattern, particularly those north and east of Twizel, but also within many remnants in the south and west of the Basin. They include a wide diversity of species and communities, of ecosystems and of physical features (described in Attachments 5 and 6). Environmental and community gradients linking their diverse features are still largely present, especially north and east of Twizel. I am not aware of anywhere else in lowland and montane New Zealand that such a diversity of naturally rare ecosystems is present on a continuous landform sequence.
83. Although modified, these grasslands support a similar suite of communities and species to those found in early European times (paragraph 24), and many also retain a high visual impression of naturalness.
84. With regard to size and shape, remaining grassland areas north and east of Twizel are probably still large enough to support viable metapopulations of species and biota, and buffering from many off-site effects.

Long-term ecological viability

85. The Tekapo Scientific Reserve demonstrates, highly degraded Mackenzie Basin grasslands may be restored with sympathetic management given time.

86. However, the maintenance of the Mackenzie Basin's biodiversity will require protection of the long-term capacity of a landscape to support species populations (Cabeza & Moilanen 2001). This long-term viability will not be achieved by the pattern of land use change seen in recent years; namely the protection of a small number of isolated sites, and development of remaining ecosystems. At least in the northern and eastern portions of the Mackenzie Basin, the scale of the undeveloped landscape remaining, and its limited (albeit increasing) fragmentation provides a last opportunity to protect the interconnected complex of naturally rare ecosystems, and associated wetlands and freshwater habitats upon which the Basin's distinctive indigenous biodiversity depends.

SUMMARY OF KEY POINTS AND CONCLUSIONS

87. The Mackenzie Basin is a biogeographically distinctive and important part of New Zealand, containing its most extensive and intact sequences of low-lying, naturally rare terrestrial rare ecosystems. Although modified in stature and composition, poorly protected, and subject to ongoing decline, remaining less-developed communities are still predominantly native in character. They support several of New Zealand's most endangered plant species, and regionally endemic and threatened invertebrate and freshwater fish faunas, and internationally important populations of threatened migratory wading birds, gulls and terns.

88. Intensive agricultural development is rapidly transforming less-developed grasslands in the Mackenzie Basin from habitat for terrestrial indigenous species (including threatened species) into wholly exotic pasture, as has already occurred over most of Canterbury's lowland, montane and coastal zones. The interrelated adverse effects of this habitat destruction on a landscape's indigenous biodiversity are cumulative and accelerate as the ratio of converted land to unconverted indigenous species habitat increases. The process is well documented in ecological literature, and is the most significant cause of population and species extinction worldwide.

It is likely to greatly exacerbate the threatened status of many of Canterbury's lowland and montane ecosystems and species.

89. Protected land areas are presently inadequate to maintain the Basins' biodiversity. Highly degraded ecosystems appear capable of some recovery with conservation management, but the Basin's protected areas are becoming isolated within an increasingly developed landscape which threatens their viability.

90. In my opinion, many of the remaining less-developed grasslands of the Mackenzie Basin are significant, especially the plant and animal communities of extensive, largely undeveloped landform sequences remaining to the north and east of Twizel. These areas meet all PNAP and Canterbury Regional Policy Statement criteria for significance, are present on land environments that are distinctive and mainly or wholly confined to the Mackenzie Basin, almost entirely comprise naturally rare ecosystems (National Priority 3) and wetlands (National Priority 2), and are the last remaining habitats of some of New Zealand's most endangered plant, bird and freshwater fish species (National Priority 4). Their irreplaceability and extreme vulnerability to ongoing loss makes protection a priority using international criteria.

91. Applications to irrigate a further c. 25,000 ha of the Mackenzie Basin will likely result in the clearance of naturally rare and vulnerable ecosystems within the proposed footprints of irrigated land and associated infrastructure, and in substantial degradation and loss of natural ecosystems and indigenous species populations off-site, including well beyond directly affected areas. These impacts are major and will result in a permanent net loss of significant vegetation and habitats for indigenous fauna that cannot be mitigated or reconstructed.

92. In my opinion, further information is needed to fully assess the on-site and off-site effects of many of the applications on terrestrial biodiversity. In Attachment 15, I provide a list of applications categorised according to my level of concern for potential effects on indigenous terrestrial biodiversity, and annotated with my reasons for these concerns.

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