Biodiversity Collaborative Group

Introductory reading:

State, trends, pressures and values

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1 Document purpose

To assist the collaborative process for developing a National Policy Statement (NPS) on Indigenous Biodiversity, we have prepared this document on biodiversity state, pressure, trends and values in New Zealand. This is not an exhaustive list of all the information, but focusses on providing a concise overview of existing knowledge relating to biodiversity to support the development of an NPS and complementary/ supporting measures. We hope that it will provide a useful context and reference point for the group's work by providing introductory reading to support the development of policy options. Further information on biodiversity management may be provided at a later date.

The majority of sources in this document are external to the Ministry, but *Environment Aotearoa* (Ministry for the Environment & Statistics New Zealand, 2015) the Government state of the environment report, is a key source of information on state, pressures and trends.

As discussions progress, the collaborative group may decide to commission more specific information on key areas. Feedback and further sources of information are welcome and will be made available to all group members to complement the information contained in this report.

1.1 Source and quality of information

Biodiversity information comes mainly from DOC, Landcare Research, Regional Councils and increasingly Territorial Local Authorities, and the wider published literature. The quantity and quality of biodiversity monitoring information available varies between public conservation land and other land tenures, and between regions. Descriptions of recent trends in biodiversity have been constrained by the availability of standardised biodiversity monitoring data and its completeness at a national scale. More recently the DOC National Monitoring and Reporting system (Tier 1) and the LUCAS programme provide for systematic sampling across public conservation land (and forests and scrub on other land tenures), improving trend information for selected components of biodiversity. Coverage is also broadening through the work of some regional councils.

Frequently however, case studies of a particular region or ecosystem type are the only available sources of information. Ecosystem biodiversity is even more complex than species and this contributes to a less clear knowledge of state. Classifications that capture patterns in biodiversity to underpin accurate assessment of state are also still being developed. Many threatened species use different ecosystems and habitats in different stages of their lives e.g. marine mammals and seabirds use the land for breeding, freshwater fish migrate via estuaries into the sea. Also that even though ecosystems are presented separately in reality they form sequences and there is connectivity through the landscape. Thus varied temporal and spatial thinking is needed when developing policy to protect biodiversity.

New Zealand also has a number of national tools (Land Environments of New Zealand, Waters of National Importance, Freshwater Environments of New Zealand) which help prioritise sites of high biodiversity value that would aid the sustainable management of ecosystems if these sites were protected. There has been no co-ordinated use of these tools to improve the representation of ecosystems within New Zealand protected areas.

Standardised and consistently collected regional data on biodiversity has developed through various initiatives such as EMaR - Environmental Monitoring and Reporting. EMaR is a partnership (now between local and central government and aims to improve the collection, collation, publication and reuse of environmental data. The EMaR Biodiversity Working Group includes MfE, DOC and council representatives and has agreed on and developed 18 measures for monitoring terrestrial biodiversity. Relevant measures that have data for all regions are presented below, along with national datasets that can be split by regions (e.g. land cover).

Many of these measures are yet to be implemented by Regional Councils but should eventually lead to a regionally consistent reporting framework that can inform national management of terrestrial biodiversity.

2 Indigenous biodiversity

2.1 What is biodiversity?

Biological diversity is commonly shortened to biodiversity and defined in the Resource Management Act (1991) (RMA) as “the variability among living organisms, and the ecological complexes of which they are a part, including diversity within species, between species, and of ecosystem”. A more comprehensive definition is adopted in the Convention on Biological Diversity (1992)[1], to which New Zealand is a signatory:

> The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. Components include:

- *Genetic Diversity:* The variability in the genetic make up among individuals within a single species. In more technical terms, it is the genetic differences among populations of a single species and those among individuals within a population.
- *Species Diversity*: The variety of species — whether wild or domesticated — within a particular geographical area. A species is a group of organisms which have evolved distinct inheritable features and occupy a unique geographic area. Species are usually unable to interbreed naturally with other species due to such factors as genetic divergence, different behaviour and biological needs, and separate geographic location.
- *Ecological (ecosystem) Diversity*: The variety of ecosystem types (for example, forests, deserts, grasslands, streams, lakes, wetlands and oceans) and their biological communities that interact with one another and their non-living environments.

This more detailed definition has in turn, been adopted in the New Zealand Biodiversity Strategy (Department of Conservation, 2000). This document defines *indigenous biodiversity* as: our native species, their genetic diversity, and the habitats and ecosystems that support them.

2.2 Why is biodiversity important?

Biodiversity provides the life supporting systems that enable all organisms, including humans, to survive. The important resources and services, such as clean air and water, fertile soils, pollution and flood control provided by biodiversity underpins our economic and social sustainability. It also provides products such as timber, fuel, food and medicines. Our farming, forestry and horticulture depend on the resources and services provided by biological systems. Other benefits include recreation, aesthetic, scientific, education and cultural values and a sense of identity.

These benefits that ecosystems provide humankind are known as ecosystem services, represented below:

[1] https://www.cbd.int/

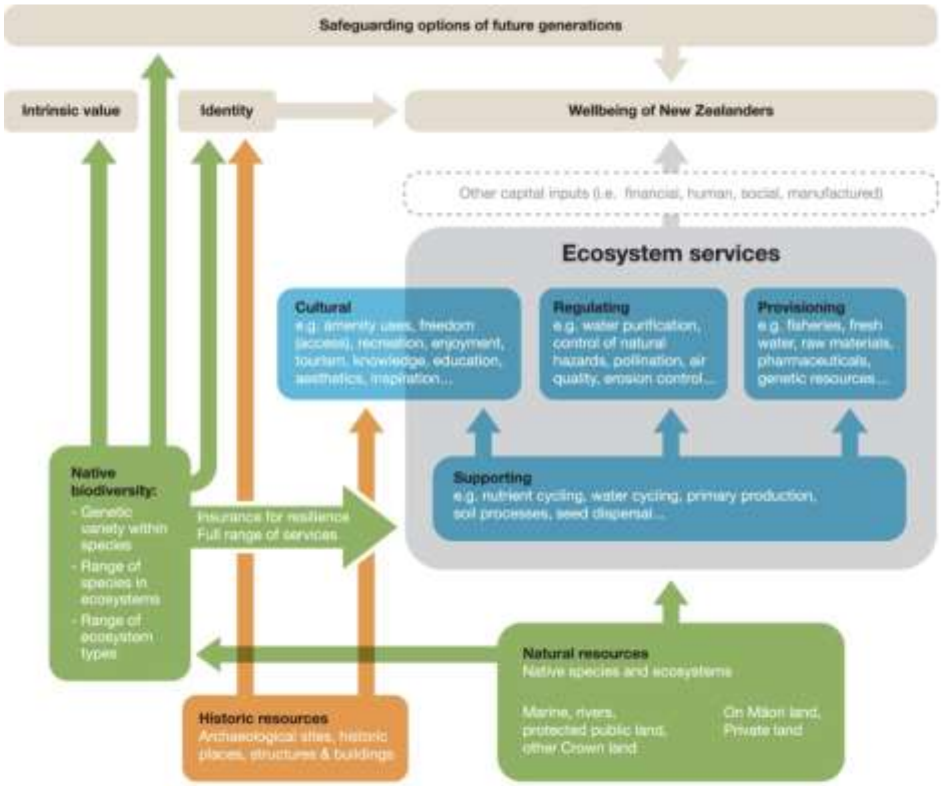

Figure 1: Ecosystem services in New Zealand – annotated from the Department of Conservation http://www.doc.govt.nz/Documents/about-doc/annual-report-2014/large/fig2.jpg

In New Zealand, our biodiversity provides the cultural, regulating, provisioning, and supporting ecosystem services which underpin our prosperity. The specific diverse ecosystems in New Zealand form the basis for our value as a tourism destination, and our national icon in the kiwi. Our fertile soils form the basis of our valuable primary industries, and our diverse forest environments provide the scene for the recreational staple of tramping.

Aside from our anthropocentric interests in biodiversity, its importance lies in its intrinsic value – that is the value inherent to its existence. The concept of intrinsic value recognises that each form of life is respected for its uniqueness. Section 3 of the RMA describes intrinsic value as:

> *Intrinsic values, in relation to ecosystems, means those aspects of ecosystems and their constituent parts which have value in their own right, including–*
>
> *a) Their biological and genetic diversity; and*
>
> b) *The essential characteristics that determine an ecosystem's integrity, form, functioning, and resilience.*

New Zealand's biodiversity derives specific importance from its distinctiveness from the ecosystems present elsewhere in the world. The global community recognises that we have a particular responsibility for biodiversity conservation for this reason.

3 New Zealand's indigenous biodiversity

New Zealand is an internationally recognised world 'hotspot' for biodiversity (Myers et al, 2000). We have exceptionally high numbers of endemic species which are found nowhere else in the world. This high endemism is largely the result of our long isolation from other land masses and diverse geography and climate, allowing unique flora and fauna to develop. Around 90 % of New Zealand's insects and marine molluscs are found nowhere else on earth. This is also true for 80 % of our vascular plants (which includes trees, ferns and flowering plants); 25 % of bird species; all of our 60 reptiles; our four remaining frogs and all our species of bat. Compare this to Britain, which is an island nation of similar size but has only two endemic species.

More than 57 000 native species have been identified so far (Gordon, 2013). About 30 000 of these live on land or in freshwater. There are many species still to be described, many of which are smaller species in 'less appreciated' taxonomic groups such as fungi and invertebrates. This chapter provides an overview of the state and trends for our species and key ecosystems, followed by a discussion of the major drivers and pressures behind biodiversity decline.

3.1 Species

Since humans arrived in New Zealand at least 40 species have become extinct and many more are threatened. Threatened taxa include 81% of the birds that breed here (resident species), 72% of freshwater fish, 88% of reptiles, all our frogs and 39% of plants. Further, many species have largely disappeared from areas where they were once found, contributing to the 'extinction of experience' for our people.

Table 1: Indigenous species that are threatened or at risk of extinction, by taxonomic group

Taxonomic group	Still living (number)	Threatened or at risk (number)	Threatened or at risk (%)
Bats	4	3	75
Birds	203	164	81
Earthworms	171	32	19
Freshwater fish	39	28	72
Freshwater invertebrates	580	148	26
Frogs	4	4	100
Reptiles	57	50	88
Vascular plants	2378	918	39

Source: Department of Conservation; Threat Classification System 2012–14; Hitchmough et al. (2013); de Lange et al. (2013); Robertson et al. (2013); Newman et al. (2013); O'Donnell et al. (2013); Goodman et al. (2014); Grainger et al. (2014); Freeman et al. (2014); Buckley et al. (2015).

The risk of extinction is increasing for some species – the status of about 7% (59 of 799) of our threatened indigenous species worsened between 2005 and 2011, including birds, plants, freshwater fish, and marine mammals (Ministry for the Environment & Statistics New Zealand, 2015; Figure 2). In contrast, prospects are improving for only 1.5% of species (brown teal/pateke, yellowhead/mohua, and the Little Barrier giant wētā/wetapunga).

Species such as freshwater fish which occur primarily beyond protected areas are subject to larger impacts and rates of decline than species within protected or conservation land. Seventy-two % of our 39 indigenous freshwater fish species are classified as at risk or threatened with extinction (Goodman et al, 2014). Many of these fish are diadromous (migrating from/to the sea), are most abundant in the least protected and most impacted lowland waterways of New Zealand and are not legally protected. The risk of extinction worsened for 8 of these species between 2005 and 2011 (Ministry for the Environment & Statistics New Zealand, 2015). Observations of freshwater fish communities between 1970 and 2007 indicate an overall drop in species diversity (Ministry for the Environment & Statistics New Zealand, 2015). Numbers of longfin eel, our largest freshwater fish, are declining (though the rate of decline may have slowed through the 2000's (Haro, et al, 2015).

New Zealand is recognised as the 'seabird capital' of the world (Forest & Bird 2014). Nearly one-quarter of the world's seabird species breed here, and almost 10 % breed only in our marine environment (Taylor, 2000). Yet 90% of indigenous seabird species and subspecies that breed in New Zealand are threatened or at risk of extinction and this risk has increased for eight of the 92 seabird species since 2005 (Ministry for the Environment & Statistics New Zealand, 2015).

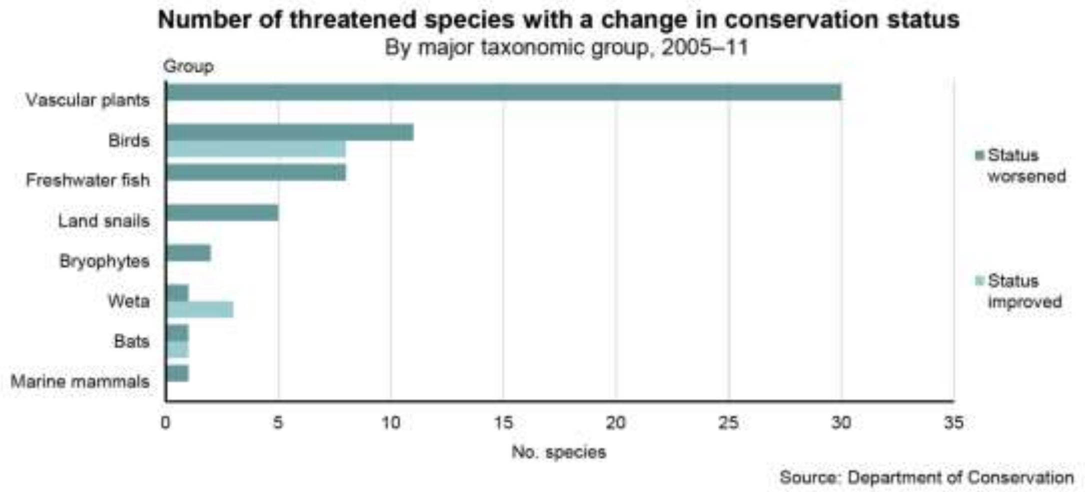

Figure 2. Number of threatened species with changed conservation status between 2005 and 2008-2011

Further changes in status between 2011 and the 2012-2014 listing cycle are shown in figure 3 below. Many of these were vascular plants and birds but also included a range of invertebrate species.

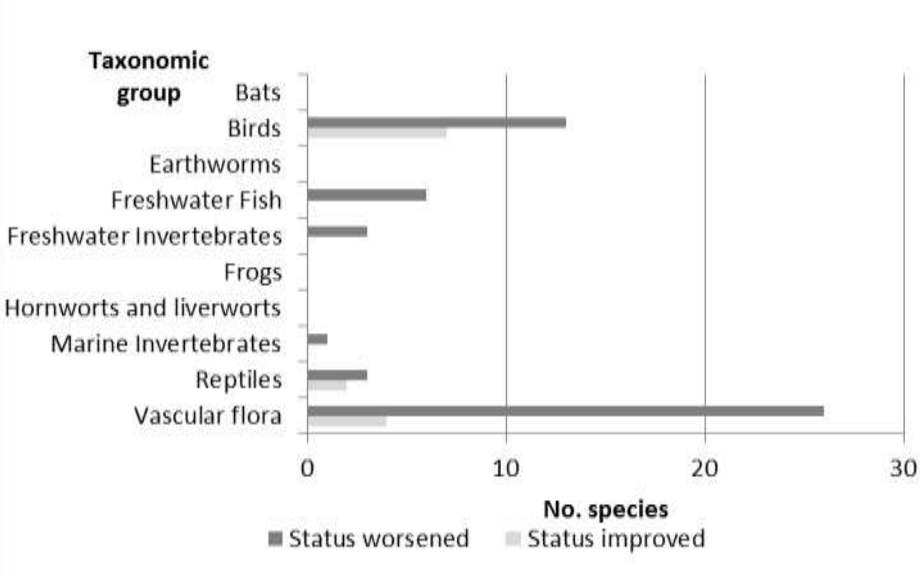

Figure 3. Number of threatened species with changed conservation status, between the 2008-2011 and 2012-2014 listing cycles.

3.2 Ecosystems

3.1.1 Forests

An estimated 80 % of the country was forested before humans arrived in New Zealand (Ministry for the Environment & Statistics New Zealand, 2015). Today, indigenous forest is found mainly at higher altitudes; much of what remains in coastal and lowland areas is in small and isolated fragments (Fig 2). Unsurprisingly then, our most threatened indigenous environments are in coastal and lowland areas, particularly in the east of the South Island and most of the North Island. Patterns of loss vary between regions. For example the West Coast has no originally occurring indigenous vegetation types with less than 25% representation, while the Waikato landscape has five types.

Although the rate of loss of indigenous forests has slowed, it has not stopped. In the 16 years between 1996 and 2012, a further 10,000 ha of indigenous forest has been destroyed (Ministry for the Environment & Statistics New Zealand, 2015). Indigenous forest, broadleaved indigenous hardwoods, scrub, tussock grassland, and other indigenous vegetation decreased in extent between 0.2 and 3.1%. While this only represents a small change in statistical terms, it is ecologically significant because any loss in vegetation cover also leads to a loss in ecosystems and the other plants and animals that inhabit them. The loss of forests and other indigenous vegetation in the lowlands has particularly affected species diversity – an estimated 57% of our threatened plant species grow in these environments (de Lange et al, 2009).

3.1.2 Scrub

New Zealand has extensive areas of lowland and montane scrub (or shrublands) that are successional to forest (Wardle 1991). Seven types have been defined (table 2). In 2012, scrub (including exotic species such as gorse) covered 5.7% of New Zealand's land area. There has been a 3% decrease in scrub cover between 1996 and 2012, the largest decrease of any of the landcover classes (Ministry for the Environment and Statistics New Zealand 2015).

Our knowledge of scrub ecosystems is still developing, both in terms of their biophysical characteristics and their ecosystem services value. Scrub is often composed of a novel mix of native and exotic species, and is scientifically undersampled relative to forests (Allen et al., 2013).

Table 2
Scrub types, distribution (North Island, South Island) and extent (ha). From Allen et al., 2013

*S1: Kānuka shrubland with coprosma and prickly mingimingi	NI, SI	120 986
*S2: Grey scrub with kānuka	NI, SI	75 616
*S3: Mānuka shrubland	NI, SI, Stewart	37 808
S4: Matagouri shrubland	SI	204 000
*S5: Turpentine scrub – *Gaultheria* montane shrubland	SI	60 493
*S6: Gorse shrubland with cabbage trees	NI, SI	15 123
*S7: Grey scrub with cabbage trees	SI	<7562

3.1.3 Grasslands

Grasslands represent a significant part of New Zealand's native vegetation cover, at around 13%. At the time of European settlement grasslands made up 31% of our vegetation. The impacts on grasslands arising from the arrival of Māori are debated, but it is thought that grasslands reached maximum extent immediately prior to European settlement (Mark et al., 2013).

Five ecosystem types are recognised, four tussock, and lowland sward grassland. Montane grasslands are dominated by short and tall tussock genera (*Festuca, Poa, Chionocloa*), but are also home to a range of woody plants (Brake & Peart, 2013). Many specialised invertebrates rely on grasslands – one survey revealed 130-140 species of beetle at two Otago sites (Barratt et al., 2009).

Formal protection of high altitude grasslands has increased since 2000 as a result of the tenure review of high country leases. Low to mid altitude systems are poorly protected and are undergoing rapid land transformation (Mark et al., 2009). Weeks et al. (2013) estimated that about 70,000 hectares of indigenous grassland in the South Island were lost, mainly to high-producing exotic pasture, between 1990 and 2008. Manuka/kanuka (10, 865 ha) and tall tussock grassland (8, 400 ha) suffered the greatest net losses between 2008 and 2012 (LCDB pivot tables).

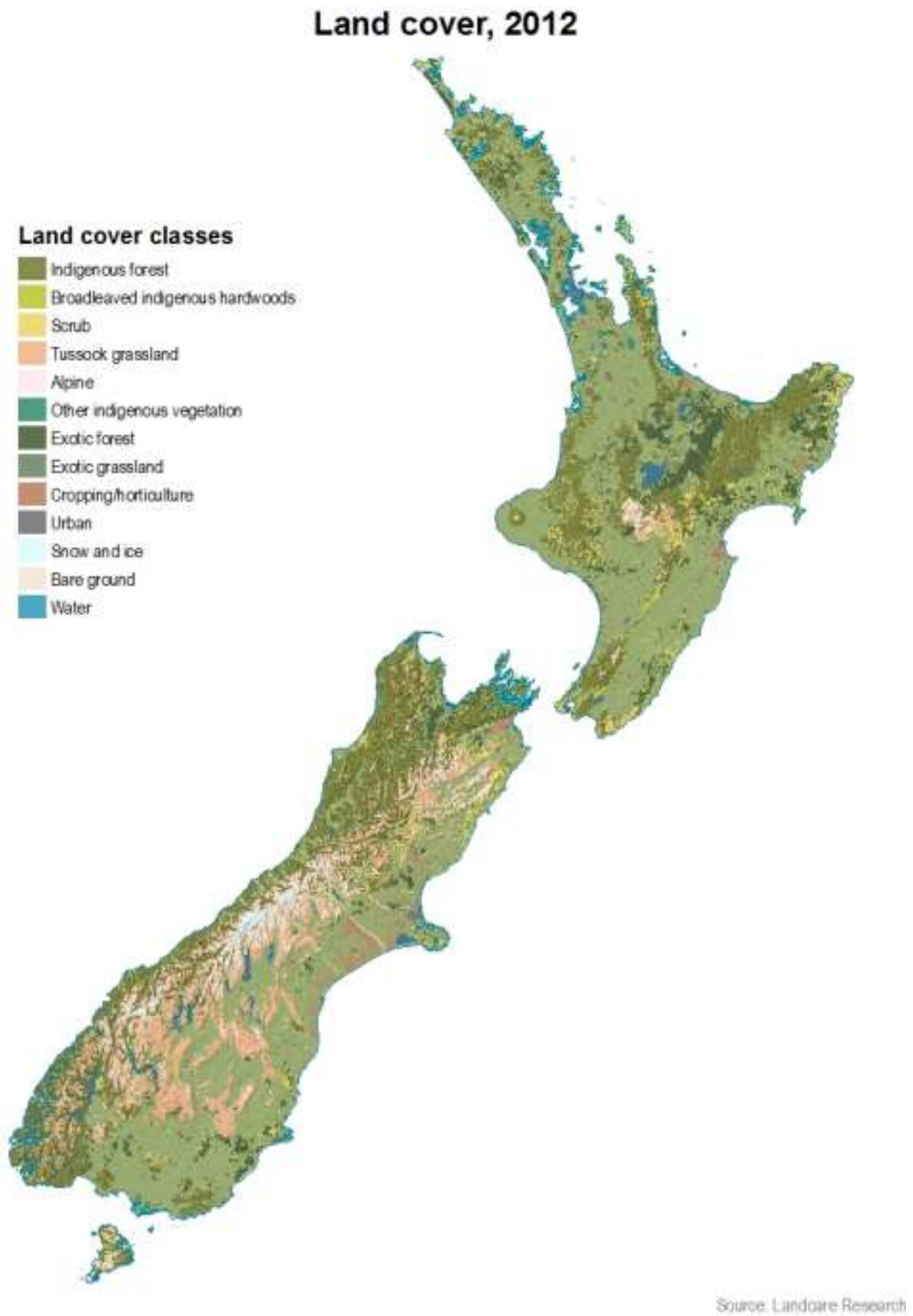

Figure 2. Land cover 2012. Data from the reclassified New Zealand Land Cover Database Version 4.0. Note: land cover classes aggregated to improve legibility

3.1.4 Streams and rivers

New Zealand's rivers and streams are of variable quality – depending significantly on land use in the catchment. Areas dominated by indigenous vegetation have very good water quality, whereas urban and agricultural land use corresponds to poorer health of freshwater ecosystems through reduced water clarity and aquatic insect life, and higher levels of nutrients and *Escherichia coli* (*E.coli)* (Ministry for the Environment & Statistics New Zealand, 2015). Indigenous fish are most abundant in steeper areas generally corresponding to decreased effects from human land use (Brown et al, 2015), and observed communities have declined in overall diversity of species between 1970 and 2007 (Ministry for the Environment & Statistics New Zealand, 2015).

Total nitrogen levels in rivers increased 12% between 1989 and 2013, increasing the prevalence of nuisance slime and algae (periphyton) growth. This growth can reduce oxygen levels in the water, impede river flows, and smother the riverbed and plant life, which fish and other aquatic animals depend on for food and habitat (Ministry for the Environment & Statistics New Zealand, 2015). Land use and population growth account for this increased pressure on rivers and streams. Agricultural land surrounds 46% of New Zealand's rivers, and estimated amounts of nitrogen leached into soil from agriculture have increased by 29% between 1990 and 2012 (Ministry for the Environment & Statistics New Zealand, 2015).

Excessive phosphorus also promotes the growth of nuisance periphyton, and enters rivers through eroded soil settling on riverbeds. Phosphorus levels are higher in exotic forest, urban, and pastoral lowland sites. About 32% of monitored river sites currently have enough dissolved phosphorus to trigger nuisance periphyton growth. Phosphorus levels have increased in large rivers between 1989 and 2013, while levels have generally decreased in a broader sample of rivers between 1994 and 2013(Ministry for the Environment & Statistics New Zealand, 2015).

Freshwater habitat loss and modification are also still occurring, largely in urban and agricultural areas. More than 10km of stream loss is consented per annum in the Auckland region (Brown et al., 2015). Doehring (2009) found that fish species sensitive to poor habitat quality were generally absent from urban waterways and that inland penetration of fish species was reduced in urban-impacted streams.

Conversion to pasture (and most recently the intensification of sheep and beef farming and conversion to dairy), are major drivers of aquatic habitat loss by way of increased water demand, drainage and habitat modification (Allibone et al., 2009; Brown et al., 2015). Many freshwater fish such as the Canterbury mudfish have localised distributions, so are especially at risk from ecosystem degradation or loss. Nationally the allocation of water increased 50% between 1999 and 2006. Irrigation accounts for about three-quarters of consumptive water use (Ministry for the Environment & Statistics New Zealand, 2015).

3.1.5 Wetlands (freshwater and estuarine)

In 2008, wetlands occupied approximately 250,000 hectares (or 1 %) of New Zealand's land area – only about 10 % of their original extent (Ministry for the Environment & Statistics New Zealand, 2015). The West Coast has the greatest extent of freshwater wetlands remaining (84,000 hectares), followed by Southland (47,000 hectares), and Waikato (28,000 hectares). The figures reflect general patterns of agricultural and urban development with the lowest levels found in areas characterised by land favoured for agriculture e.g. the Waikato region (Clarkson et al., 2013).

Wetland losses are continuing to occur. In Taranaki 63 small freshwater wetlands were drained between 1995 and 2013, in Waikato 600 ha of freshwater wetland were drained between 1995 and 2002 (Myers et al., 2013). In Southland, around 10% of wetlands on private land have been lost in the last 7 years[2]. Remaining freshwater wetlands are heavily fragmented, and often in poor condition. Using an index of ecological integrity ranging from 1 (pristine) to 0 (complete loss of biodiversity and ecological function) over 60% of New Zealand's freshwater wetlands measure less than 0.5 (Clarkson et al., 2013). Yet these small remnants can still be important for biodiversity – especially for safeguarding rare and threatened plants (Richardson et al., 2015) - and they form potential 'cores' for restoration.

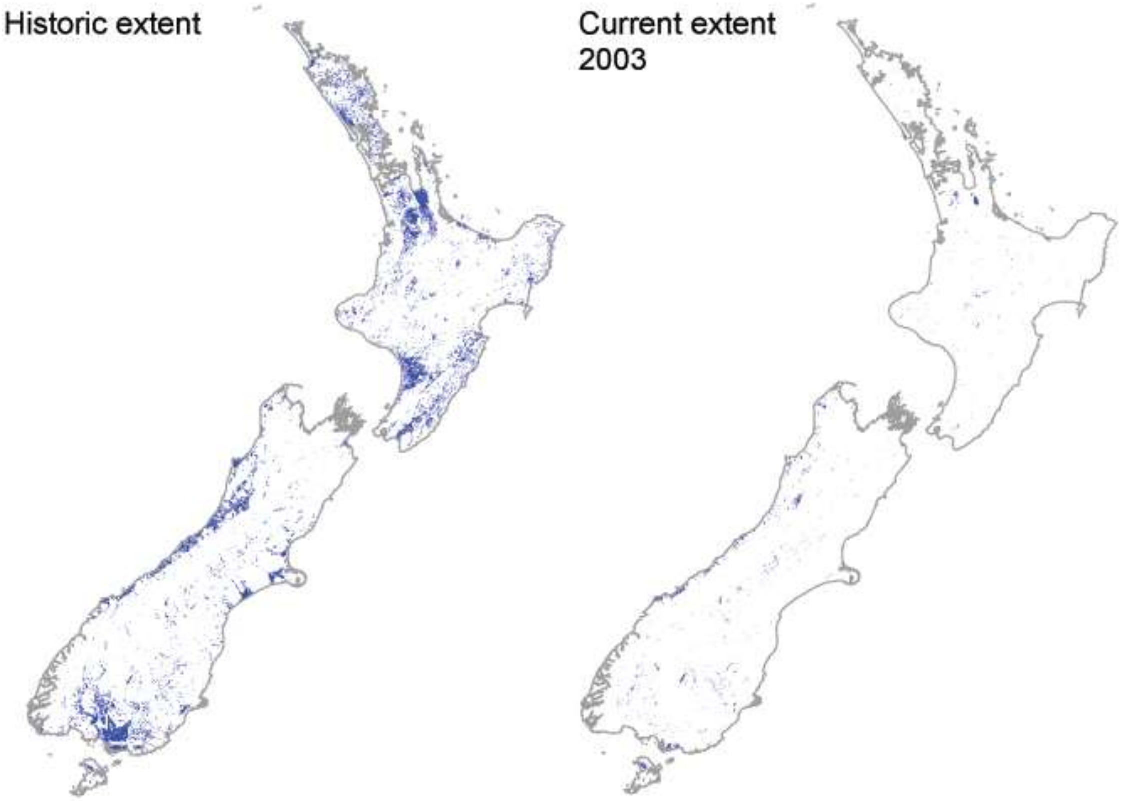

Figure 3: Historical and 2003 extent of wetlands in New Zealand (Ausseil et al., 2011).

3.1.6 Dunelands and other coastal ecosystems

New Zealand's coastal ecosystems are generally of high quality relative to international standards, but they are under particular stress in estuaries in urban areas and at large river mouths. Sedimentation, land development (encroachment and reclamation), point source discharges, and contaminated land runoff have contributed to the decline of coastal ecosystems.

Active sand dunes are dunelands shaped by wind-blown sand. They support unique species of plants and animals, some of which face extinction (e.g. the New Zealand iris and some snail, moth, and butterfly species). Active sand dunes are affected by weeds that stabilise the dunes, changing their

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[2] i.e. non-public conservation land
http://www.es.govt.nz/Document%20Library/Research%20and%20reports/Various%20reports/Science%20reports/Ecosystem%20health/Wetland%20Inventory%20Project%202015-16%20PART%201.pdf

MfE is also procuring data on contemporary wetland loss natural character and reducing their suitability as habitat for some indigenous species New Zealand's native sand binders (pīngao) are now extremely rare (Dahm, et al, 2011). Coastal development and rising sea levels also put pressure on sand dunes. Following these effects of human activities, dunes are more susceptible to wind erosion (Esler, 1978). They now cover less than 20% of the area they covered in the 1950s, and their loss has continued to the most recent measurement in 2008 (Ministry for the Environment and Statistics New Zealand, 2015).

3.1.7 Naturally uncommon ecosystems

Some ecosystems have never been common throughout the country. In New Zealand 71 kinds of naturally uncommon ecosystems are recognised (Table 3). These are generally small (ranging from < 1 ha to 1,000 ha) and non-forested, but with distinct environmental conditions that support unique communities of plants and animals, many of which are threatened. Loss of many of these ecosystems is continuing. Active sand dunes now cover less than 20 % of the area they covered in the 1950s, and their loss continued to the most recent measurement in 2008 (Ministry for the Environment & Statistics New Zealand, 2015).

Almost two-thirds (45) of the rare ecosystems are also classified as threatened under the IUCN red-list criteria (Holdaway, et al., 2012). Of these, 18 (40 %) are critically endangered (Ministry for the Environment & Statistics New Zealand, 2015). The Department of Conservation and Landcare Research are mapping distributions of naturally uncommon ecosystems.

Table 3: New Zealand's naturally uncommon ecosystems

Critically endangered	**Endangered**	**Vulnerable**
Shell barrier beaches (chenier plains) Coastal turfs Old tephra plains (frost flats) Inland sand dunes Outwash gravels Inland saline areas Leached terraces Fumeroles Geothermal stream sides Geothermal heated ground Geothermal hydrothermally altered ground Seabird guano deposits Seabird burrowed soil Marine mammal influenced sites Cave entrances Ephemeral wetlands Gumlands Damp sand plains	Active sand dunes Dune deflation hollows Stony beach ridges Shingle beaches Stable sand dunes Coastal cliffs on calcareous rock Ultramafic sea cliffs Volcanic dunes Sandstone erosion pavements Frost hollows Volcanic boulder fields Sinkholes Dune slacks Domed bogs (Sporadanthus) Lagoons Braided riverbeds Seepages and flushes	Coastal cliffs on mafic rock Screes of calcareous rock Young tephra plains and hill slopes Boulder fields of calcareous rock Cliffs, scarps & tors of mafic rocks Cliffs, scarps & tors of calcareous rocks Moraines Lake margins Blanket mires Estuaries

3.2 Pressures on biodiversity

While halting further loss of indigenous forest cover may be seen as a simple challenge, controlled by the Resource Management Act 1991, it is in fact fraught with economic, social and political barriers (Allen et al., 2013).

Understanding the broad bio-physical, socio-cultural and institutional drivers of pressures and trends on biodiversity is important for considering future impacts and for thinking about the operating environment of any national policy statement. Drivers of biodiversity change operate at a range of scales from the global (e.g. international commodity prices), the local (territorial policy) to the individual (preferences). Not all drivers have negative consequences. For example, a few indigenous species adapt to climate conditions or land use changes. But as a general rule, development usually results in the homogenisation of native biodiversity (Norton et al., 2013).

Large scale risks to biodiversity may lag considerably behind contemporary pressures (Kerr and Olssen, 2012). Thus the negative impact of human activities on current biodiversity may not be fully apparent for several decades. Long lag times also blur cause-effect relationships, mixing responses to historic drivers (e.g. land use change) with more recent phenomena such as climate change (Dullinger, et al., 2013). Pressures interact, rather than occur in isolation of one another. So there are synergistic effects and they are cumulative in nature, meaning that additional activities may have disproportionate effects (Brown et al., 2015).

3.2.1 Growth, development and land conversion

This section concentrates on the main human drivers of biodiversity loss.

Urbanisation

Population projections suggest our population (4.51 million in 2014) is likely to grow to around 5 million by 2025. New Zealand is highly urbanised - some 86% of us live in urban areas - and like other countries, this trend is continuing. Urban expansion affects the productivity of land, accessibility to nature and the ability to support biodiversity. Land use intensification, urbanisation and associated infrastructure networks is a key driver of biodiversity loss (Wallace, 2016) through habitat degradation, fragmentation or loss. Between 1996 and 2012, New Zealand's area of urban settlement increased 10 %.

Rural land use change

Many factors influence decisions to change rural land use and the rate of that change. Global market conditions, climate change, other markets and incentives, land tenure types, regulation and individual preferences all affect land use. Collectively these factors make up the economy - however there is not a simple relationship between economic drivers and biodiversity outcomes. Economic factors can impact positively or negatively on biodiversity e.g. good financial returns on farms provides more disposable income which could be spent on beneficial activities such as conservation or impact mitigation, or used to intensify production (Norton et al., 2013).

In recent years demand for milk solids has driven an increase in dairy production with consequential agricultural intensification. Production has trended upwards for the past 3 decades, with a record 1.89 thousand million kilograms of milk solids produced in 2015. Production dropped slightly in 2016 (Livestock Improvement Corporation and Dairy NZ, 2016).

The area of pastoral farming in New Zealand has remained relatively stable between 1996 and 2012 however intensification has occurred (Ministry for the Environment & Statistics New Zealand, 2015). An increasing number of indigenous grassland properties in the South Island are being converted from extensive grazing to intensive agricultural activities or exotic forestry (Mark et al., 2013).

Exotic forestry increased 11.5 % (208,146 ha) between 1996 and 2012, but the last 4 years of that period showed a decrease (26,037 ha between 2008 and 2012). Horticulture has increased in area by 9.6%, around the same proportion as our urban areas (Ministry for the Environment & Statistics New Zealand, 2015). Crops, orchards and vineyards now account for 1.8% of our land area, and urban settlements 0.8%.

Infrastructure projects

Creating and maintaining infrastructure has consequences for biodiversity, especially aquatic and riparian life. Large water projects such as dams and river control works affect fish communities - sites above dams have been shown to have lower species richness and a higher percentage of exotic species (Jellyman & Harding, 2012). Many of our native fish are diadromous, migrating between salt and freshwater at different life stages, so are particularly vulnerable to barriers like culverts and weirs.

Irrigation and flood control schemes are important for our wellbeing but can affect biodiversity by reducing the habitat created by side channels and floodplains, as well as the wetted extent of rivers themselves. Processes such as sedimentation, clearance of instream debris and gravel abstraction also affect habitat quality and impact on juvenile survival, competitive interactions, and migration (Young et al., 2004).

Lakes are seldom completely drained but their margins can be impacted by fluctuations in level due to power generation and consumptive water uses. The area of ponds and lakes in New Zealand may be increasing due to artificial impoundments, but these environments are often more favourable to exotic species.

Nutrients & sediment

Increasing nutrient loads are one of the most pervasive pressures on our freshwater ecosystems (Parliamentary Commissioner for the Environment, 2012). The nutrients of most concern are nitrogen and phosphorus; an excess of these nutrients leads to excessive growth of slime and algae (periphyton), which can reduce oxygen in the water and smother riverbed habitats. High levels of nitrogen are also harmful to fish, but this is less of a concern currently with <1 % of monitored river sites having nitrate-nitrogen levels high enough to affect the growth of multiple fish species. However many of New Zealand's streams are affected by deposition of fine sediment, reducing the number of benthic fish that can occupy any reach of a waterway (Joy & Death, 2013).

Estuarine eutrophication used to be highly localised, involving sewerage or abattoir waste. Now, nutrients and non-point discharges are an increasing concern (Heggie & Savage, 2009; Thrush, et al., 2013). Sedimentation and the accumulation of pollutants is also a problem especially in areas with limited flushing capacity. Levels of turbidity caused by sediment are higher in estuaries than in other coastal environments (Ministry for the Environment & Statistics New Zealand, 2015), and these ongoing large-scale environmental changes within estuaries are affecting the functioning of fish nurseries (Lowe, 2013). Pollutants such as heavy metals can also bind to sediments, inhibiting microbial activity (Dell'Anno, et al., 2003) - an example of the synergistic effects of disturbance.

3.2.2 Pest plants and animals

There is a recognised lag time between the introduction of an invasive species and the time when it affects indigenous ecosystems. In Europe, the number of alien species established in the wild is an indicator of socioeconomic activity from the 1900s, even though most species only arrived during the second half of the twentieth century (Essl et al., 2011). As such, the consequences of New Zealand's 'invasion debt' have yet to be fully realised, especially with regard to plants.

About 2,500 exotic plant species have established in the wild. Some plant species put pressure on specific ecosystems e.g. marram grass is the main threat to the remaining active dune systems (Hilton, 2006), and wilding pines pose a serious threat to many areas of tussock grassland especially in Canterbury and Otago (Mark et al., 2013; Ministry for the Environment & Statistics New Zealand, 2015). Indigenous grasslands are more vulnerable to weed invasion than most ecosystems but wetland, open river and coastal ecosystems are also vulnerable (Ministry for the Environment & Statistics New Zealand, 2015).

Mammalian pests (especially possums, rats and stoats) are present in at least 94% of the country and pose the greatest threat to our terrestrial fauna, causing declines or extinctions of many birds, insects and lizards and localised extinctions of plants. Ungulates such as feral goats, deer, and Himalayan tahr have a more limited distribution but when concentrated in large numbers they can have significant effects on forest and alpine ecosystems (Ministry for the Environment & Statistics New Zealand, 2015). Other pests with expanding range and potentially significant impacts include wallabies and plague skinks. Exotic invertebrates have so far had only a relatively minor impact on NZ's ecosystems, although the naturalised insect fauna continues to grow (Brockerhoff et al., 2010). European wasps adversely affect beech forest ecosystems and Argentine ants our offshore islands.

In aquatic ecosystems freshwater pests (9 fish, 11 invertebrates and 41 plant species) have had a significant impact on our rivers, streams, and lakes through predation, competition, and by altering freshwater habitats (Ministry for the Environment & Statistics New Zealand, 2015). They are widespread, for example didymo is now in over 150 South Island rivers (Ministry for the Environment & Statistics New Zealand, 2015), and introduced plants are a common and serious problem in New Zealand's lakes (Schallenberg et al., 2013). de Winton et al. (2012) surveyed 195 lakes nationally, and demonstrated that invasive weeds are a pressure on native aquatic plant biodiversity and lake ecological condition, distinct from other pressures such as eutrophication.

Trout have caused widespread reductions in the distribution and abundance of native galaxiid fishes, a family dominated by threated species (McIntosh et al., 2009). Some impacts are now historical, but in others (southern South Island) they continue to threaten some rare native galaxiids (Brown et al., 2015). There are also numbers of less studied taxa such as cladocerans or "water fleas" - crustaceans that may be spreading through New Zealand and having as yet unidentified impacts (Duggan 2010).

3.2.3 Direct human impacts

Direct human impacts like recreation, tourism, off-road vehicles and tramping threaten 12 out of 18 of our critically endangered terrestrial ecosystems. Off-road vehicles are a particular problem on beaches and sand dunes; disturbing nesting seabirds and damaging vegetation. Shell barrier beaches are damaged by direct human impacts like drainage, pastoral development, stock damage, and shell extraction in some areas (Wiser et al., 2013). We are also seeing a trend for increasing trade and tourism. In 2015 New Zealand received over 3 million visitors. International passengers have increased by 93% in the ten years between 1993 and 2003. Trade volumes have increased by 76% in that time. The pressure on the border increases the chances of pests and disease entering New Zealand and unintentional impacts of visitors use on natural areas (Biosecurity Council, 2003).

Changes in technology and knowledge could impact both positively and negatively for biodiversity. Technology has enabled more sustainable management practices, for example more accurate application of fertiliser and herbicides with GPS guidance; irrigation efficiency - but this has also enabled agriculture to extend to new areas that might otherwise have been marginal or difficult to crop. Changes in technology might also impact on land use. For example the increased use of wind farms to generate energy might also impact on grasslands as many exposed locations suitable for wind farm development coincide with tussock grasslands (Mark et al., 2013).

3.2.4 Climate change

Of the environmental trends that affect biodiversity, climate change may be the most influential. By mid-century, climate change is projected to become a major driver of land cover change (IPCC 2014) resulting from changes in the suitability of land to different types of production. For example climate-related crop failure may affect prices, which in turn influences land use decisions. Projections show that in New Zealand, drought events are likely to increase in both frequency and severity in the eastern lowlands and this would also likely lead to increased damming and abstraction for irrigation, which modifies freshwater habitats (Young et al., 2004). Climate induced droughts and severe winters in some regions may lead to a change in traditional land-uses or increased irrigation.

Management responses to climate change also affect biodiversity. Climate change mitigation policies influence land-use decisions, which could have negative impacts on habitat/species (Jantz, 2015). In New Zealand, a potential example could be the carbon credit schemes (designed to manage emissions) incentivise conversion to exotic forestry which in turn, can compete with ecosystems such as indigenous grasslands, while being beneficial to some species. Rising sea level is also an issue where maladaptation can cause loss of valuable intertidal and wetland areas.

The forecasted effects on New Zealand's biodiversity are varied but include:

- degradation of the rich biota of the alpine zone through increasing shrubby growth and loss of herbs, especially if combined with increased establishment of invasive species
- death of cold water-adapted freshwater fish and invertebrates which are vulnerable to warming
- increased spring flooding may increase egg/chick mortality for braided-river birds
- Tuatara populations are at risk as warming increases the ratio of males to females

- estuarine habitats will be affected by changing rainfall or sediment discharges, as well as temperature, acidification, sea level and connectivity to the ocean (IPCC, 2014).

For some restricted native species, suitable habitat may increase with warming (e.g., native frogs) although their dispersal ability will limit range expansion. Warmer weather can also favour establishment of exotic species as well as the spread of pests and diseases. The few studies available suggest that ongoing impacts of invasive species and habitat loss will be more important for biodiversity in the short term, but that climate change will significantly outweigh existing stresses in the medium to long term (IPCC, 2014).

4 How is biodiversity valued in New Zealand?

Environmental surveys show that New Zealanders regard the current state of biodiversity in New Zealand as bad or very bad (Hughey et al., 2013). The current policy and regulatory framework in New Zealand is criticised for being disjointed, under-resourced, poorly enforced and consequently, as compromising biodiversity outcomes including the recovery of threatened and at risk species (Wallace 2016). Wallace notes that there is no clear and universal mandate to protect and plan for threatened species or ecosystems across all environments along with inconsistencies in how species are managed under different Acts.

4.1 Socio-cultural influences and attitudes to conservation

Social values have an important influence on what happens to native biodiversity. Personal motivations (influenced by values, behaviour and circumstances) will drive the outcomes of biodiversity change on the ground. Yet understanding these motivations and their underlying contributors is limited in research and often carries a high degree of uncertainty. Others have found significant differences between ethnicities in views on water quality, causes of damage to water, and water management (Hughey et al., 2014). There is an increasing acknowledgement that New Zealand's Clean Green image, while drawing tourists to New Zealand, could also be impacted should the clean green perception be challenged.

4.2 Economic influences

Perhaps the most understood are the motivations for land use change. At the level of individual land use choices, personal drivers have been shown to have the strongest influence over decisions to change land uses (Kerr and Olssen, 2012) but are made in a context in which broader economic incentives and drivers will too, play a part. New Zealand research has shown that where one land-use is clearly more profitable, the land use decision is less sensitive to farmer behaviour; conversely when the profitability differential between land-use options is smaller, divergent land-use decisions result (Shilling et al., 2012). Institutional drivers play an influential role in biodiversity outcomes. Farming subsidies can incentivise land use conversion to agriculture or between different agricultural types and carbon incentives can encourage changes in land use and land cover. Other incentives such as valuing the carbon sequestered by coastal wetlands (which is four times the amount of forestry) mean that these values are hidden from the market.

4.3 Māori and biodiversity

4.3.1 The Māori worldview - te ao Māori

The Māori worldview considers everything living and non-living to be interconnected. Whakapapa describe these connections and tell the story of how people, the landscape, plants and animals came into being. People, plants and animals are all descendants of Ranginui (the sky father) and Papatuanuku (the earth mother) and their children, which means humans are therefore, intrinsically linked with biodiversity.

The concepts of mauri (life force), mana (authority/power), tapu (sacred and restricted customs) and wairua (spirit) are important to consider in relation to both people and nature. The tangata whenua (people of the land) have a role as kaitiaki (guardians) to preserve the mauri, wāhi tapu (sacred sites) and natural taonga (treasures) in their area. Kaitiakianga includes active stewardship or guardianship of the land, with Māori traditionally having their own system of resource management to sustain people and natural resources for the future.

The relationship between the health of the ecosystem and the wellbeing of the people can be demonstrated by the following phrase: Ko ahau te taiao, ko te taiao, ko ahau – The ecosystem defines my quality of life (Ngāti Wai and Ngāti Whatua) (Harmsworth & Awatere, 2013).

4.3.2 Mātauranga Māori

Mātauranga Māori describes a body of knowledge held by Māori and could be defined as the ancestral knowledge of Māori, although it is not limited to historical knowledge, but rather continues to develop as the world and Māori culture evolve and change. Mātauranga Māori represents the tradition or continuum of Māori knowledge weaving forward and back through whakapapa.

Mātauranga Māori is fundamental in the way many Māori form a perspective and approach to environmental management, planning, design, policy development implementation, and in resolving complex resource management issues. In the environmental area, the contemporary Māori world-view is still strongly based on traditional cultural beliefs, knowledge, concepts, and values.

Mātauranga Māori has links to western concepts of sustainable management, sustainable development, integration, ecosystems, interconnection of ecosystems, holism and intergenerational equity. While these scientific paradigms all capture aspects of Māturanga Māori it is important to note there is a direct incompatibility between the encompassing holistic nature of Mātauranga Māori and the western scientific norm.

4.3.3 Māori land ownership, uses and values

Māori land has deep spiritual significance for Māori. It is 'imbued with cultural and spiritual values over and above its value as an economic resource' and is integral to the expression of mana (authority over a region) (Stephenson, 2001).

Māori land is not just land that happens to be owned by Māori people. While much land is owned by Māori in fee simple, the term 'Māori land' refers to a particular status of land that is distinctly different from all other land ownership in New Zealand. This is due to its form of tenure (multiple, undivided ownership) and its own legislation - Te Ture Whenua Māori (Māori Land) Act 1993.

Māori land also has unique characteristics in terms of ownership. Most Māori land has multiple owners to the extent that shareholders can number into the thousands for a single land block (Te Puni Kōkiri, 2011). This poses unique challenges in making land and resource use decisions.

Only approximately 6 per cent or 1.5 million hectares of New Zealand's land area remains in Māori ownership (Harmsworth & Awatere 2013). But, significantly, almost 50 per cent of the total indigenous vegetation remaining on private land is held in Māori title (Stephenson, 2001). Land returned more recently through the Waitangi Tribunal means that Māori have not had the same length of time to develop their land than other landowners. Consequently, Māori-owned lands that are yet to be developed for productive purposes may be disproportionately affected by planning rules seeking indigenous vegetation protection (Wilson & Memon, 2005).

Several factors have contributed to this situation including the sale, acquisition or confiscation of much of the fertile lands. The remaining Māori land was less productive and so less economically viable to develop. There are also institutional factors which have influenced the use of Māori land such as the lack of access to capital due to communal ownership (Kingi, 2008).

Economic uses of Māori land are concentrated in the primary industries. By GDP standards, the Māori economy asset base, although increasing in size and value, remains below average (Te Puni Kōkiri, 2015). Land-based assets can be hindered in development because of restricted access, limited potential and in some circumstances, difficult management/ownership structures) (Te Puni Kōkiri, 2015).

Māori have aspirations to maintain their association with their lands and to provide opportunity for owners to utilise undeveloped land (e.g. for hunting and fishing, papa kainga). Utilising land to exercise values such as kaitiakitanga and manaakitanga is also valued by Māori (Te Puni Kōkiri, 2011).

It is significant that public land now managed for conservation purposes was originally appropriated from Māori by the Crown. Conservation agendas which promote further habitat protection on Māori land, often land adjoining existing protected areas, are affected by this historical legacy of land alienation (Matunga, 2000; Coombes & Hill, 2005). Habitat protection on Māori land, therefore raises issues of equity given the ecological value of remaining habitat has increased due to the cumulative effect of previous clearances (Davis & Cocklin, 2001). Efforts at biodiversity protection can create tension between conservation agendas and Māori aspirations for self-governance.

Common methods of environmental protection on private land may not be acceptable to Māori. For example, conservation covenants which are created in perpetuity are difficult to initiate in the context of multiple owners, and foreclose options for future generations which are important to retain for Māori. The Ngā Whenua Rāhui contestable fund is administered by the Department of Conservation and was developed as a response to this issue. The fund provides for habitat protection on Māori land through renewable 25 year Kawenata (conservation covenants) and support for landholders to undertake monitoring and management activities such as pest control (Department of Conservation 2017).

Understanding Māori perspectives on biodiversity and the relationship of biodiversity with Māori land is important because there are unique circumstances and cultural needs which should be considered in the design of conservation mechanisms. The comparatively high biodiversity value of Māori lands and drive to increase primary production also poses challenges for sustainable development alongside biodiversity management.

4.3.4 Treaty of Waitangi - Te Tiriti o Waitangi and biodiversity

The Treaty of Waitangi (English version) guarantees Māori "respective families and individuals thereof the full exclusive and undisturbed possession of their Lands and Estates Forests Fisheries and other properties which they may collectively or individually possess so long as it is their wish and desire to retain the same in their possession…"[3] Investigations over the last century however, have revealed that in many instances the Crown's actions in purchasing Māori land were flawed. Since 1985, the Waitangi Tribunal has conducted hearings into many matters relating to Māori land and the economic and social impacts of land dealings from 1840 onwards. The Tribunal's account of historical events form the basis of the grievances of Māori addressed through the Treaty negotiations processes.

The current Treaty settlement process has resulted in a number of settlements which range from the large Waikato-Tainui, Ngāi Tahu and Central North Island collective settlements, to smaller settlements such as Hauai, Te Uri o Hau and Ngāti Tūrangitukua.

The nature and amount of redress provided in each settlement package largely depends on the severity of the breaches of the Treaty and their extent, as reflected in the amount of land alienated and how this was achieved (for instance, through confiscation or by purchase). The settlements to date reflect a combination of a variety of redress options. Some early settlements consist solely of financial and commercial redress. Since 1997, most settlement packages have been made up of a Crown Apology, cultural redress and financial and commercial redress.

How the Treaty of Waitangi should be interpreted and given effect to in modern governance arrangements is an important consideration in relation to biodiversity management. Customary use of natural resources by Māori is a significant aspect of sustaining Mātauranga Māori. Wai 262 was a claim lodged in 1991 by Dell Wihongi, Haana Murray and others, on behalf of Te Rarawa, Ngati Kuri, Ngati Wai, Ngati Porou, Ngati Kahmlgunu and Ngati Koata to rights in respect of mātauranga Māori and indigenous flora and fauna, including intellectual property rights about those flora and fauna. The Waitangi tribunal found that: Iwi and hapū are obliged to act as kaitiaki towards taonga in the

[3] Treaty of Waitangi- Te Tiriti o Waitangi 1840

environment such as land, natural features, waterways, wāhi tapu, pa sites and flora and fauna within their rohe (tribal areas). It also found that current (resource management) laws and policies and conservation and wildlife laws do not support kaitiaki relationships to the degree required by the Treaty.

Treaty settlements are also changing the relationship of Māori in governance as well as the prospects for Māori owned lands as resourcing becomes available. While the Crown is responsible for upholding the Treaty, considering the rights and interests of Māori in the context of changing circumstances for iwi/hapū will be important for designing appropriate biodiversity measures.

5 Further reading

Biodiversity state

Allen R, Bellingham P, Holdaway R and S Wiser, 2013. New Zealand's indigenous forests and shrublands. In Dymond JR ed. Ecosystem services in New Zealand – conditions and trends. Manaaki Whenua Press, Lincoln, New Zealand.
https://www.landcareresearch.co.nz/__data/assets/pdf_file/0017/77030/1_2_Allen.pdf
A comprehensive and balanced overview of the characteristics of New Zealand's forests, their values and management.

Ausseil A, Gerbeaux P, Chadderton W and Leathwick J, 2008. Wetland ecosystems of national important for biodiversity: Criteria, methods and candidate list of national important inland wetlands. Landcare Research
http://www.epa.govt.nz/Publications/GWRC_5_Marks_Appendix%209.pdf

Ausseil A, Dymond J and Weeks E, 2011. Provision of Natural Habitat for Biodiversity: Quantifying Recent Trends in New Zealand. In: Biodiversity Loss in a Changing Planet. O Grillo and G Venora (Eds), Intech 2011
http://www.intechopen.com/books/biodiversity-loss-in-a-changing-planet/provision-of-natural-habitat-for-biodiversity-quantifying-recent-trends-in-new-zealand
Especially useful for its comparison of the current extent of freshwater wetlands with their historic extent (fig 4 p 209). In the North Island only 5% of historic wetlands remain; 16% in the South Island, mostly on the West coast. Remaining wetland sites are highly fragmented, most (74%) are less than 10 ha in size and account for only 6% of national wetland area. Swamps and pakihi/gumland are the most common New Zealand wetland types. Swamps have undergone the most extensive loss, with only 6% of their original extent remaining.

Burns B, Floyd C, Smale M and Arnold G, 2011. Effects of forest fragment management on vegetation condition and maintenance of canopy composition in a New Zealand pastoral landscape. Austral Ecology 36:2
http://onlinelibrary.wiley.com/doi/10.1111/j.1442-9993.2010.02130.x/abstract

Cieraad E, Walker S, Price R and Barringer J, 2015. An updated assessment of indigenous cover remaining and legal protection in New Zealand's land environments New Zealand Journal of Ecology (2015) 39:2
http://newzealandecology.org/nzje/3235.pdf
The authors present a revision of the 'Threatened Environments Classification' combining analysis of the national landcover database based on satellite imagery (2012), an updated national spatial database of protected areas (2012), and an abiotic classification of New Zealand's land environments. Environments with historically high levels of indigenous vegetation and protection appear to be better protected currently, while a number of lowland and montane environments have less indigenous vegetation and protection than was previously estimated. In conjunction with field surveys, the threatened environment classification can help prioritise formal protection against clearance and/or incompatible land uses, or ecological restoration.

Clapcott J, Collier K, Death R and Young R, 2011. Quantifying relationships between land-use gradients and structural and functional indicators of stream ecological integrity. Freshwater Biology 57:1
https://www.researchgate.net/publication/240311154_Quantifying_Relationships_between_Land-Use_Gradients_and_Structural_and_Functional_Indicators_of_Stream_Ecological_Integrity

Clapcott J, Goodwin E, Young R and Kelly D, 2014. A multimetric approach for predicting the ecological integrity of New Zealand streams. Knowledge and Management of Aquatic Ecosystems 415(3):10
https://www.researchgate.net/publication/272169366_A_multi-metric_approach_for_predicting_the_ecological_integrity_of_New_Zealand_streams

Clarkson B, Wehi P and Brabyn L, 2007. Bringing back nature into cities: Urban land environments, indigenous cover and urban restoration. Centre for Biodiversity and Ecology Research Report, University of Waikato
http://researchcommons.waikato.ac.nz/handle/10289/3786

This study analyses patterns of urban biodiversity in NZ using data from two national databases in relation to the 20 largest cities. Thirteen of 20 major land environments in NZ are represented in cities, and nearly three-quarters of all acutely threatened land environments are represented within 20 km of city cores. Indigenous land cover is low, with less than 2% on average remaining, and fragmentation is high. However in the peri-urban zone, indigenous cover increases to more than 10%, and the size of indigenous remnants and number of landcover types also increases.

Clarkson B, Briggs C and Fitzgerald N, 2011. Current and historic wetlands of Southland Region: Stage 2 Landcare Research
http://envirolink.govt.nz/assets/Envirolink-reports/903-ESRC231-Current-and-historic-wetlands-of-Southland-Region-Stage-2.pdf
The authors were contracted to classify and digitally map current and historic wetlands in Southland, excluding Fiordland National Park and Stewart Island. Some 272 284 ha of wetlands were classed and mapped, representing 10% of the original extent. This 90% loss indicates that virtually all remaining wetlands could be considered significant, especially marshes and swamps.

de Lange P, Norton D, Courtney S, Heenan P, Barkla J, Cameron E, Hitchmough R and Townsend A, 2009. Threatened and uncommon plants of New Zealand. New Zealand Journal of Botany 47:1
http://www.tandfonline.com/action/showCitFormats?doi=10.1080%2F00288250909509794
While assessing the conservation status of indigenous NZ vascular plant flora, de Lange et al estimate the proportion of threatened plant species that grow in different altitudinal zones. An estimated 57 % of our threatened plant species grow in coastal and lowland areas.

Department of Conservation n.d. New Zealand Threat Classification System (NZTCS)
http://www.doc.govt.nz/nztcs

de Winton M, Clayton J and Edwards T, 2012. Incorporating invasive weeds into a plant indicator method (LakeSPI) to assess lake ecological condition. Hydrobiologia 691: 47
http://link.springer.com/article/10.1007/s10750-012-1009-0
The authors apply the 'LakeSPI' indicators to 195 New Zealand lakes and found that weed invasion is not merely a 'passenger' of habitat degradation, but represents an additional pressure. The results suggest weed invasion should be incorporated into macrophyte assessment schemes for a more complete differentiation of lake ecological condition.

Duncan R and Yound J, 2000. Determinants of plant extinction and rarity 145 years after European settlement of Auckland, New Zealand. Ecology, 81:11
http://esajournals.onlinelibrary.wiley.com/hub/issue/10.1002/ecy.2000.81.issue-11/

Dymond J, Shepherd J, Newsome P and Belliss S, 2017. Estimating change in areas of indigenous vegetation cover in New Zealand from the New Zealand Land Cover Database (LCDB). New Zealand Journal of Ecology 41:1.
http://newzealandecology.org/nzje/3287.pdf

Haro A, Dekker W and Bentley N, 2015. 2013 Independent review of the information available for monitoring trends and assessing the status of New Zealand freshwater eels. New Zealand Fisheries Science Review 2015/2.
http://fs.fish.govt.nz/Doc/23945/FSR_2015_02_2013_Eel_Review.pdf.ashx

Heenan P, 2015. 'Hotspots' of endemism (biodiversity found only in NZ). Landcare 2015
http://www.landcareresearch.co.nz/publications/innovation-stories/2015-stories/endemism-hotspots
In a 'proof-of-concept' project, Heenan (Landcare) assessed whether free *Biodiverse* software and digitised herbarium records could be used to identify important areas of endemism for conservation prioritisation, planning and management and environmental reporting. He georeferenced spatial data for New Zealand indigenous vascular flora, along with a DNA phylogeny showing relationships between genera. The results are a more accurate and detailed description of where plant endemism occurs. On mainland New Zealand, species-level endemism occurs mostly in the South Island whereas genus-level endemism is predominantly found in the northern half of the North Island. Neo-endemism prevails in the South Island mountains, the

result of recent and rapid species radiations in some plant lineages. In the northern North Island, palaeo-endemism prevails due to accumulated older plant lineages. Forty % of the areas that are hotspots for endemic species occur within the conservation estate; along with 29% of hotspots for endemic genera estate

McArthur N, Harvey A and Flux I, 2015. State and trends in the diversity, abundance and distribution of birds in Wellington City. Greater Wellington Regional Council.
http://www.gw.govt.nz/assets/Our-Environment/Environmental-monitoring/Environmental-Reporting/Wellington-City-bird-monitoring-report-2015.pdf
Five-minute bird counts have been carried out in Wellington City's parks and reserves network between 2011 and 2014. The abundance of most native forest bird species has varied little in that time. Many of the species recently re-introduced to Zealandia or other predator-free sites near the city continue to have fairly localised distributions. Nonetheless, some natural re-colonisation events have occurred in recent years, including whiteheads and red-crowned parakeets in Trelissick Park.

Mark A, Michel P, Dickinson K and McLennan B, 2009. The conservation (protected area) status of New Zealand's indigenous grasslands: an update. New Zealand Journal of Botany. 47:1
http://www.tandfonline.com/doi/abs/10.1080/00288250909509793

Mark A and McLennan B 2005. The conservation status of New Zealand's indigenous grasslands. New Zealand Journal of Botany (43)1.
http://10.36.136.24:8080/ProgressMessages/0028825X.2005.9512953?proxy=10.36.136.24&action=complete&index=323&id=419268734&filename=0028825X.2005.9512953

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http://www.mfe.govt.nz/sites/default/files/media/Environmental%20reporting/our-marine-environment.pdf

Parlato E, Armstrong D and Innes J, 2015. Traits influencing range contraction in New Zealand's endemic forest birds. Oecologia 179:2
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http://newzealandecology.org/nzje/2941.pdf

Richardson S, Clayton R, Rance B, Broadbent H, McGlone M and Wilmshurst J, 2015. Small wetlands are critical for safeguarding rare and threatened plant species. Applied Vegetation Science 18.
http://www.landcareresearch.co.nz/about/news/blog/small-wetlands-are-critical-for-safeguarding-rare-and-threatened-plant-species

Singers N and Rogers G, 2014. A classification of New Zealand's terrestrial ecosystem. Department of Conservation.
http://www.doc.govt.nz/Documents/science-and-technical/sfc325entire.pdf

Weeks E, Walker S, Dymond J, Shepherd J and Clarkson B, 2013. Patterns of past and recent conversion of indigenous grasslands in the South Island, New Zealand. New Zealand Journal of Ecology, 37:1
http://newzealandecology.org/nzje/3068.pdf
The study uses recent satellite imagery to quantify the extent, type, and rate of conversion of remaining eastern South Island grasslands in recent years. Although large areas of inland indigenous grassland remain, grassland loss has been ongoing, being reduced by 3% (70 200 ha) between 1990 and 2008. Almost two-thirds of post-1990 conversion has occurred in threatened environments, primarily in the Waitaki, Mackenzie and Central Otago districts. In the Mackenzie and Waitaki districts the rate of conversion in 2001–2008 was approximately twice that in 1990–2001.

Weeks E, Death R, Foote K, Anderson-Lederer R, Joy M and Boyce P, 2016. The demise of New Zealand's freshwater flora and fauna: a forgotten treasure. Pacific Conservation Biology 22:2

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Wiser S, Buxton R, Clarkson B, Hoare R, Holdaway R, Richardson S, Smale M, West C and Williams P, 2013. New Zealand's naturally uncommon ecosystems. In Dymond JR ed. Ecosystem services in New Zealand – conditions and trends. Manaaki Whenua Press, Lincoln, New Zealand.
http://www.landcareresearch.co.nz/publications/researchpubs/uncommon-ecosystems-book-section.pdf
This article provides an overview of naturally uncommon ecosystems, listing 72 such ecosystems across the country. The authors apply the IUCN's draft Ecosystem Red List criteria, classifying 18 ecosystems as critically endangered, 17 as endangered, and 10 as vulnerable. Many of these ecosystems occur in azonal environments that lack trees, despite often lying below the regional treeline. They may be small (e.g. 100 m2 to a few hundreds of hectares) but geographically widespread, or larger (e.g. 10 000s of hectares) but geographically restricted. Further information is provided for the 18 critically endangered ecosystems.

Pressures & drivers

Beggs J, 2001. The ecological consequences of social wasps (Vespula spp) invading an ecosystem that has an abundant carbohydrate resource. Biological Conservation 99: 17-28.
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Britton R, and Fenton T, 2007. Identification and Analysis of Drivers of Significant Land Use Change Environment Waikato
https://www.waikatoregion.govt.nz/services/publications/technical-reports/tr/tr200740
A technical report produced by Environment Waikato. Dated, but helpful document which documents a study carried out in Waikato to analyse the drivers of significant land use change. It includes an analysis of the impact of various land use changes on biodiversity (Table 1). The work concludes that a key drier of land use change are economic drivers (price of land) but that personal drivers have the strongest influence over decisions to change land uses and the rate at which changes occur.

Didham R, Denmead L and Deakin E, 2012. Riches to Rags: The Ecological Consequences of Land Use Intensification in New Zealand. In Lindenmayer D, Cunningham S and Young A, eds. Land Use Intensification: Effects on Agriculture, Biodiversity and Ecological Processes, CSIRO Publishing, pp. 73-83.
https://www.researchgate.net/publication/271431966_Riches_to_rags_the_ecological_consequences_of_land-use_intensification_in_New_Zealand

Foote K, Joy M and Death R, 2015. New Zealand Dairy Farming: Milking our environment for all its worth. Environmental Management 56:709
Primary production is NZ's main export earner. Dairy products contributed 25% of export revenue in 2012, rising form 13% in 1990. Dairy exports increased in value by 460% over this time, from $2 to 11.6 billion (Statistics NZ). In 2010, the dairy sector directly accounted for 2.8% of GDP, or $5 billion (Shilling et al)From 1990 to 2012, the number of dairy herd decreased by 19% while the average herd assize expanded by 147%. During this period, milk solid production increased by 195% from 0.572 to 1.685 million tonnes (LIC and Dairy NZ 2012)

Forest Owners Association, 2014. Facts and Figures New Zealand Plantation Forestry Industry
http://www.nzfoa.org.nz/images/stories/pdfs/factsandfigures_2014_web.pdf
Includes data on ownership, location and species type as well as deforestation figures.

Green W and Clarkson B, 2005. Turning the Tide? A review of the first five years of the New Zealand Biodiversity Strategy. The Synthesis Report.
http://www.doc.govt.nz/documents/conservation/nzbs-report.pdf
At a global level, habitat loss, invasive alien species and over-exploitation are recognised as the key drivers increasing numbers of threatened species and the decline in ecosystem capacity to deliver goods and services. In New Zealand, there is good circumstantial evidence that the rate of biodiversity loss is due in a large part to economic drivers for agricultural intensification and the high rate of conversion of agricultural land to lifestyle blocks. Biosecurity issues are likely to be more significant in the future given growing volumes of trade, more trading partners and increasing tourist numbers.

Kerr S and Olssen A, 2012. Gradual land-use change: Results from a Dynamic Econometric Model. Motu Economic and Public Policy Research Trust
http://motu-www.motu.org.nz/wpapers/12_06.pdf
Models land-use change using a dynamic econometric model and commodity prices. Finds that land use responses can be slow and that any policy-induced land-use change is likely to be slow or costly. Looks at land use change across four major uses (dairy, sheep and beef, forestry, scrub) from 1974 to 2005. Results show that it takes at least six years before 75 % of long-run equilibrium adjustment occurs in response to an increase in the own-commodity price by one standard deviation.

Landcare Research, 2008. Future Scenarios - Biodiversity Edition
http://www.landcareresearch.co.nz/science/living/sustainable-futures/future-scenarios/biodiversity-edition
Landcare Research has been developing four contrasting future possibilities for NZ since 2004, to contribute to a future choices debate. None of these possibilities are predictions, or favourites, but each is plausible and has recognizable roots in today's experiences.
A specific set of scenarios have been developed for biodiversity. The Four Futures differ economically in the extent of their global imports and tourism connections, readiness and ability to use new technologies, and reliance on commodity exports.
While these scenarios are not statistical forecasts, they are helpful to project thinking about what issues biodiversity might face in the future, and the possible environments in which regulation would operate.

Ledgard G, 2013. Land use change in the Southland Region Technical Report June 2013. Environment Southland
http://www.es.govt.nz/Document%20Library/Research%20and%20reports/Science%20summary%20reports/land_use_change_in_the_southland_region.pdf
Cites economic reasons as the main driver of land use change in the region. Details history of land use change in Southland and connections to broader economic trends and incentives.

Livestock Improvement Corporation Limited and DairyNZ Limited, 2015. New Zealand Dairy Statistics 2014-15.
https://www.dairynz.co.nz/media/3136117/new-zealand-dairy-statistics-2014-15.pdf
Dairy production saw a 3.6% increase in milksolid processing in 2014/15. Dairy companies processed 21.3billion litres of mild containing 1.89 billion kilograms of milksolids. Total milksolids processed increased by 3.6%from the 1.83 billion kilograms processed in the previous season. This was a record level of mild production and 56 per cent higher than 2004/05. Report includes tables and graphs of production and population figures over the last 30 years. Also has maps of the regional distribution of dairy cows across the country.

Mark A, Barratt B and Weeks E, 2013. Ecosystem services in New Zealand's indigenous tussock grasslands: conditions and trends. In Dymond JR ed. Ecosystem services in New Zealand – conditions and trends. Manaaki Whenua Press, Lincoln, New Zealand.
https://www.landcareresearch.co.nz/__data/assets/pdf_file/0007/77029/1_1_Mark.pdf
The Ngakawau Ecological District in the North Westland Ecological Region includes two unique upland plateau wetlands dominated by locally endemic tussocks. These are associated with the Brunner Coal Measures, so they are either already being mined for high quality coal or are threatened with mining. Open-cast mining continues to devastate much of the plateau tussock wetland of the Stockton Plateau. Wind farms may also impact on grasslands. Given the relatively exposed locations of most upland tussock grasslands, pressure may continue for wind farm development in these areas.

Ministry for Business, Innovation and Employment, 2017. Regional Economic Activity Report
http://webrear.mbie.govt.nz/summary/new-zealand
Presents economic data on New Zealand's 16 regions. It highlights trends, challenges and opportunities for each region including education, employment, and natural resources data.

Ministry for Primary Industries, 2016. Biosecurity 2025 Direction Statement for New Zealand's biosecurity system. Ministry for Primary Industries 2016
http://mpi.govt.nz/protection-and-response/biosecurity/biosecurity-2025/

Over the past 10 years trade volumes have increased by 76% and international passengers by 93%; a high level of growth should continue. The pressure on the boarder increases the chances of known pests and diseases entering New Zealand. Additionally, new threats will emerge across all sectors.

Moller H, MacLeod C, Haggerty J, Rosin C, Blackwell G, Perley C, Meadows S, Weller F and Gradwohl M, 2008. Intensification of New Zealand agriculture: Implications for biodiversity. New Zealand Journal of Agricultural Research 51:3
http://www.tandfonline.com/doi/abs/10.1080/00288230809510453
Dated, but helpful for describing links between agricultural intensification and freshwater biodiversity loss. Agricultural intensification potentially threatens the environment, biodiversity and the sustainability of agricultural production. Clear evidence that agricultural intensification has degraded aquatic biodiversity, but lack of research and monitoring of robust indicators of terrestrial biodiversity in NZ production landscapes. We can only infer a generalised likelihood that intensification has reduced biodiversity and agro-ecosystem resilience, and posit that ongoing intensification continues to threaten biodiversity, sustainability and resilience. Stogner evidence links impacts of agricultural intensification to declining aquatic biodiversity, but little equivalent information for terrestrial biodiversity exists. Calls for better indicators, monitoring and research

Norton D, Reid N and Young L 2013. Ultimate drivers of native biodiversity change in agricultural systems F1000Reserach 2013, 2:214
https://f1000research.com/articles/2-214/v1
Identifies six ultimate drivers that underlie what native biodiversity occurs in modern agricultural landscapes; (1) historical legacies; (2) environmental change; (3) economy; (4) social values and awareness; (5) technology and knowledge; and (6) policy and regulation. While historical legacies and environmental change affect native biodiversity directly, all six indirectly affect biodiversity by influencing the decisions that land managers make about the way they use their land and water resources.

Secretariat of the Convention on Biological Diversity, 2014. Global Biodiversity Outlook 4 Montréal.
https://www.cbd.int/gbo4/
The direct drivers of biodiversity loss act together to create multiple pressures on biodiversity and ecosystems. Indirect drivers primarily act on biodiversity by influencing the quantity of resources used by human societies. So for example population increase, combined with higher per capita consumption, will tend to increase demand for energy, water and food - each of which will contribute to direct pressures such as habitat conversion, over-exploitation of resources, nutrient pollution and climate change. Increased world trade has been a key indirect driver of the introduction of invasive alien species.
Indirect drivers can have positive as well as negative impacts on biodiversity. For example, cultural and religious factors shape society's attitudes towards nature and influence the level of funds available for conservation. The loss of traditional knowledge can be particularly detrimental in this regard… Cultural changes such as the loss of indigenous languages can therefore act as indirect drivers of biodiversity loss by affecting local practices of conservation and sustainable use.
Scientific and technological change can provide new opportunities for meeting society's demands while minimizing the use of natural resources - but can also lead to new pressures on biodiversity and ecosystems.

Simcock R, Wright W, Brown M and Bishop C, 2015. Effectiveness of protecting urban vegetation: assessing vegetation cover changes with urban expansion and intensification. Technical Document for Protecting the Urban Forest. Landcare Research Manaaki Whenua.
https://www.landcareresearch.co.nz/__data/assets/pdf_file/0018/101448/Policy_Brief_13_Protecting_urban_vegetation.pdf
Shows a net increase in indigenous vegetation in North Shore City ~2001-2009 although the authors discuss in detail differences that might be observed in macro LCDB changes and fine scale changes in vegetation structure.

Statistics New Zealand, 2015. Agricultural Production Statistics: June 2015 (final). Statistics New Zealand.
http://www.stats.govt.nz/browse_for_stats/industry_sectors/agriculture-horticulture-forestry/AgriculturalProduction_final_HOTPJun15final.aspx

As 30 June 2015, the number of dairy cattle was nearly 6.4 million, down 300,000 from 2014. Sheep 29.5 million, down 300,000 from 2014. Deer and beef both decreased. During the year ended 31 March 2015: 25.5 million cubic meters of exotic timber were harvested, down 3 % from 2014.

Statistics New Zealand, 2014. National Population Projections: 2014(base)-2068.
http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/NationalPopulationProjections_HOTP2014.aspx

Thorrold B, 2010. The future landscape of New Zealand agriculture. Proceedings of the New Zealand Grassland Association 72
https://www.grassland.org.nz/publications/nzgrassland_publication_2563.pdf
Changing economic opportunities and government policy around water and nutrient loss will continue to shift the balance of forces driving land use change. Land use change can be explained by differences in the profitability and capital values of different land uses, influenced by resource limits including slope, soil types and irrigation availability. Drivers of the future will not be the same in detail as the drivers of the past. Change does not happen instantaneously; existing land owners go through a long process of deciding to sell or convert [land use]. Carbon costs, nutrient loss limits and visual impacts are three possible constraints that might shift the balance of land use in the Canterbury and Southland regions. Of these, nutrient loss seems the most likely to impact on land sue patterns in the more intensively farmed areas.

Timar L, 2011. Rural Land Use and Land Tenure in New Zealand, Motu Economic and Public Policy Research Trust
http://motu-www.motu.org.nz/wpapers/11_13.pdf
Uses a discrete choice model to model land use choice between dairying, beef and sheep, scrub and plantation forestry and considers the impact of Maori tenure on land use choice. Shows that Maori freehold land is underdeveloped relative to general land, even after taking into account differences in land quality and location. *Some limitations to the analysis but does point to the equity implications of policy interventions*.

Tourism New Zealand, 2015. International visitor experience 2015. Tourism New Zealand
http://www.tourismnewzealand.com/markets-stats/research/infographics/visitor-experience/
In 2015 NZ received over 3 million visitors. International tourism contributes $121.8 billion to New Zeeland and is our second largest export accounting for 17.4% of total exports.

Wallace P, 2016. Unnatural divides: species protection in a fragmented legal landscape. Policy Quarterly 12:1
http://igps.victoria.ac.nz/publications/PQ/2016/PQ12-1-Wallace.pdf
Habitat fragmentation caused by agricultural intensification, urbanisation and associated infrastructure networks are the key drivers of biodiversity loss. Downward trends for NZ birds are thought to be related to changes in land use, particularly conversion from sheep farming to dairy farming, changes in oceanic productivity, possibly linked to global warming, and fisheries bycatch and predation

Climate change

Christie J, 2014. Adapting to a changing climate. A proposed framework for the conservation of terrestrial native biodiversity in New Zealand. Department of Conservation 2014.
http://www.doc.govt.nz/Documents/science-and-technical/sap257.pdf

IPCC, 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Summaries, Frequently Asked Questions, and Cross-Chapter Boxes. A Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Field C, Barros V, Dokken D, Mach K, Mastrandrea M, Bilir T, Chatterjee M, Ebi K, Estrada Y, Genova R, Girma B, Kissel E, Levy A, MacCracken S, Mastrandrea P and White L (Eds). World Meteorological Organization, Geneva, Switzerland, 190 pp.
https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-IntegrationBrochure_FINAL.pdf

Contemporary drivers of land use and cover change include rising demand for food, fibre and bioenergy and changes in lifestyle and technologies…by mid-century climate change is projected to become a major driver of land cover change.
The underlying driver of land use change is the rate at which per capita consumption is growing, particularly in emerging economies…Agricultural commodity prices have risen and may stay high through 2020 owing to (1) demand growth outpacing supply growth, exacerbated by climate-related crop failure (2) decline in the rate of improvement in agricultural productivity; (3) shortage of arable land not already under cultivation, especially in the temperate zone (4) growing pressure on as-yet uncultivated ecosystems concentrated in tropical latitudes…and (5) declining area under cultivation in temperate zones, mainly in developed countries.
Report on terrestrial and inland waters has a table which summaries the drivers and outcomes of land use and cover change under different scenarios.
Changing land use is expected to affect freshwater systems strongly in the future. For example, increasing urbanisation may increase flood hazards and decrease groundwater recharge. Of particular importance for freshwater systems is future agricultural land sue, especially irrigation, which severely impacts freshwater availability for humans and ecosystems.
Owing mainly to population and economic growth but also to climate change, irrigation may significantly increase in the future. The share of irrigation from groundwater is expected to increase owing to increased variability of surface water supply caused by climate change.

Jantz S, Barker B, Brooks T, Chini L, Huang Q, Moore R, Noel J & Hurtt G, 2015. Future habitat loss and extinctions driven by land-use change in biodiversity hotspots under four scenarios of climate-change mitigation. Conservation Biology, 29: 1122–1131
https://www.researchgate.net/profile/Samuel_Jantz/publication/279733780_Future_habitat_loss_and_extinctions_driven_by_land-use_change_in_biodiversity_hotspots_under_four_scenarios_of_climate-change_mitigation/links/55ddab8808aeaa26af0e97aa/Future-habitat-loss-and-extinctions-driven-by-land-use-change-in-biodiversity-hotspots-under-four-scenarios-of-climate-change-mitigation.pdf
In the future, global biodiversity will be affected by both climate change and land-use change, the latter of which is currently the primary driver of species extinctions. How societies address climate change will critically affect biodiversity because climate-change mitigation policies will influence land-use decisions, which could have negative impacts on habitat for a substantial number of species.
Future land-use changes are projected to reduce natural vegetative cover by 26-58% in the hotspots. As a consequence, the number of additional species extinctions, relative to those already incurred between 1500 and 2005, due to land-use change by 2100 across all hotspots ranged from about 220 to 21000 (0.2% to 16%), depending on the climate-change mitigation scenario and biological factors such as the slope of the species–area relationship and the contribution of wood harvest to extinctions. These estimates of potential future extinctions were driven by land-use change only and likely would have been higher if the direct effects of climate change had been considered.
Future extinctions could potentially be reduced by incorporating habitat preservation into scenario development to reduce projected future land-use changes in hotspots or by lessening the impact of future land-use activities on biodiversity within hotspots.

McGlone M & Walker S, 2011. Potential effects of climate change on New Zealand's terrestrial biodiversity and policy recommendations for mitigation, adaptation and research. Science for Conservation 312. Department of Conservation, Wellington
http://www.doc.govt.nz/Documents/science-and-technical/sfc312entire.pdf
Some mitigation and adaptation activities in New Zealand could produce benefits for terrestrial biodiversity e.g. well-planned and resourced afforestation projects and control of herbivores). However, many (perhaps the majority) pose additional threats to biodiversity.
It seems likely that damage to NZ's terrestrial biodiversity from its mitigation and adaptation activities will be greater than damage from climate change itself over the next 50 years.

Ministry for the Environment, 2016. Climate change impacts in New Zealand.
http://www.mfe.govt.nz/climate-change/how-climate-change-affects-nz/climate-change-impacts
Warmer weather would favour conditions for increased competition from exotic species as well as the spread of disease and pests, affecting both fauna and flora

- Warmer temperatures will reduce some critical habitats, increasing the risk of localised extinction
- Increased summer drought will cause stress to dry lowland forests

- Earlier springs and longer frost-free seasons could affect the timing of bird egg-laying, as well as the emergence, first flowering and health of leafing or flowering plants

Robertson H, Bowie S, Death R, & Collins D. (Eds) 2016: Freshwater conservation under a changing climate. Proceedings of a workshop hosted by the Department of Conservation, 10–11 December 2013, Wellington. Department of Conservation, Christchurch.
http://www.doc.govt.nz/Documents/conservation/climate-change-proceedings.pdf
Climate change driver of pressure on freshwater and estuarine ecosystems: Climate change would also likely lead to increased damming and abstraction for irrigation, which modifies freshwater habitat (and leads to the pressure above), which affects flora and fauna. Expand the text as there are other key messages especially for estuaries.

Royal Society, 2007. Biodiversity-Climate Interactions: adaptation, mitigation and human livelihoods. Summary of an international meeting held at the Royal Society 12-13 June 2007.
https://royalsociety.org/~/media/Royal_Society_Content/policy/publications/2007/7991-Summary.pdf
Summary of an international meeting held at the Royal Society 2007, Dated, but clear summary of the likely impacts on ecosystems. Shows that climate change is already disrupting some species interactions and ecological relationships and that one consequence of this will be the alteration of predator-prey and host-pathogen relationships, many of which may impact on human health and productive sectors (e.g. Agriculture, forestry and fisheries), with likely economic consequences.

Stroombergen A, 2010. The International Effects of Climate Change on Agricultural Commodity Prices, and the Wider Effects on New Zealand. Motu Working Paper 10-14, Motu Economic and Public Policy Research, December 2010
http://motu.nz/our-work/environment-and-resources/emission-mitigation/agricultural-greenhouse-gas-emissions/the-international-effects-of-climate-change-on-agricultural-commodity-prices-and-the-wider-effects-on-new-zealand/
This research takes a closer look at the effects of climate change on New Zealand agriculture and on the wider economy, including indirect international effects such as changes in the prices of goods exported from and imported to New Zealand, as well as carbon prices and policies. Results suggest that New Zealand agricultural production is likely to benefit from the sorts of changes in agricultural commodity prices that are expected to occur under global warming, especially if there is no carbon fertilisation effect.
Floods and other extreme events aside, it seems that the effects on NZ from changes in agricultural commodity prices caused by global warming could easily outweigh the direct effects (e.g. soil moisture) of global warming on agricultural output.

Wang Y, Poletti S, Zakeri G, Kim J & Sharp B, n.d. Land Use Change between agriculture and forestry under the NZ ETS
http://www.nzae.org.nz/wp-content/uploads/2015/01/Land_use_change_between_forestry_and_agriculture_under_the_NZ_ETS-_SMALL.pdf
Paper analyses land use change between forestry and agricultural sectors under different carbon tax scenarios. Models land switch. Findings suggest that more land would be transferred to forest use at a higher carbon price. Sheep-beef farming projected to take up the largest land use type when a carbon price equals zero. And if there was an increase of carbon price, (0-100) forestry sector would manage the largest proportion of land.

How is biodiversity valued in New Zealand?

Brown P. 2015. Survey of Rural Decision Makers. Landcare Research NZ Ltd.
www.landcareresearch.co.nz/srdm2015
More than 3,000 people from across New Zealand responded, including more than 2300 commercial farm owners and farm managers. The survey covers the entire spectrum of primary industry, including dairy, sheep and beef, deer, other livestock, arable, forestry, horticulture, wine-growing, and lifestyle farmers.
Raw survey results of respondent's answers to a variety of farm management questions including pest control, environmental expectations, land use change challenges and opportunities.

The results show that the majority of respondents agree or strongly agree that private land owners should protect habitat for native plants and animals on private land and that DOC should protect habitat for native plants and animals on public land. The survey results also suggest changes rural landowners do not consider land use change (from one productive agricultural/horticultural use to another) as impacting on the environment with 47.5% seeing the effect of land use changes over the last 10 years on the environment as resulting in no change, and 49.4% seeing the change as beneficial for the environment.
There is also an expectation (by farming community, faming families and broader New Zealand) that farms will be managed in an environmentally friendly way.

Coombes B & Hill S, 2005. "Na whenua, na Tuhoe. Ko D.o.C. te partner"—Prospects for Comanagement of Te Urewera National Park. Society & Natural Resources 18:2
http://www.tandfonline.com/doi/abs/10.1080/08941920590894516
Comanagement is an attempt to produce better and fairer institutions of environmental management. It is applied to protected areas to reduce their social impacts, incorporate Indigenous peoples into decision making, and generate policies that reflect local ecology and culture. Yet comanagement has not always reduced the conflicts between Indigenous peoples and park managers. Through evaluation of the prospects for comanagement of Te Urewera National Park in New Zealand, we conclude that there is a need to identify the demand of Indigenous peoples for comanagement. Historical legacies of land alienation affect present relationships between Māori (the Indigenous population of New Zealand) and conservation authorities, and it is unrealistic to assume that the former will embrace comanagement when it is offered as a token resolution of land grievances. Case studies also confirm a need to acknowledge diversity within Indigenous communities and to address its impact the equity of comanagement.

Davis P & Cocklin C, 2001. Protecting habitats on private land: Perspectives from Northland, New Zealand. Science for Conservation 181. 69p
http://www.doc.govt.nz/Documents/science-and-technical/SfC181.pdf
The issue of protecting habitats on private Māori land needs specific consideration for several reasons. The Treaty of Waitangi guarantees Māori 'the full exclusive and undistributed possession of…their forests'. Some Māori consider, therefore, that decisions to protect, conserve or utilise indigenous forestry resources on Māori land should remain entirely and exclusively with the owners or iwi involved.
About 50% of the indigenous forests remaining on private land are on Māori-owned land – a disproportionately high figure given that Māori own only 7% of the land under general or Māori title. Policies affecting habitats on private land are, therefore, likely to have a disproportionate impact on Māori. Several factors contributed to this situation. The social and political marginalisation which Māori experiences as their Treaty partners became numerically, economically and politically stronger, resulted in the sale, acquisition and confiscation of much of their most fertile land. The remaining Māori land was less productive and so less economic to develop. Also, access to capital for development purposes was restricted due to the communal ownership of the majority of Māori land.

Department of Conservation, 2000. New Zealand Biodiversity Strategy, 2000-2020
http://www.doc.govt.nz/nature/biodiversity/nz-biodiversity-strategy-and-action-plan/new-zealand-biodiversity-strategy-2000-2020/
Theme 7 of the strategy sets a desired outcome for 2020 on recognition of the relationship and knowledge of Māori with biodiversity, and includes a number of actions in relations to this.
The traditional relationship of close interaction with New Zealand's indigenous biodiversity developed over centuries and remains an important part of the lives of many Māori. As well as being traditional users of biological resources, Māori have interests in agriculture, forestry, fisheries, aquaculture and ecotourism, all of which revolve around biodiversity. Māori are involved in all aspects of biodiversity management, including conservation and customary and commercial use. They are kaitiaki for the biodiversity of tribal areas and holders of traditional tribal knowledge.
The key environmental laws of the past decade recognise, to varying degrees, Māori interests in New Zealand's indigenous biodiversity, as protected in Article Two of the Treaty of Waitangi. However, Māori continue to assert ownership over indigenous biological resources, including genetic resources, claiming that their ownership of such resources was guaranteed by Article Two. The customary use of indigenous biodiversity is vital for sustaining relationships with traditional areas and maintaining cultural integrity, knowledge and values.

Hughey K, Kerr G & Cullen R, 2014. Ethnicity and views about the New Zealand environment Conference contribution
https://hdl.handle.net/10182/6513
Limited research has been completed on the relationship between ethnicity and views within a country on the environment, pressures on the environment and its management. Some recent New Zealand research has found no significant difference in environmental world views between different ethnic groupings. We report selected results from a decade of biennial, nationwide surveys of adults in New Zealand. By socio-demographic measures, respondents are broadly representative of New Zealand adults. In each biennial survey we have found significant differences between ethnicities in views on water quality, causes of damage to water, and water management.

Manaki Whenua Landcare Research, n.d. Māori values and native forest, published online.
http://www.landcareresearch.co.nz/__data/assets/pdf_file/0017/43910/maori_values_native_forest.pdf
A succinct description of Māori values and the status of native forest (Ngahere), describing why native forests are culturally important. Ngahere traditionally represent the Māori supermarket, the spiritual domain, the schoolhouse and the medicine cabinet as well as many other uses. Remnant forests are important biophysically, but also sustain many cultural activities and practices. Some remnant forests may be the only natural forest within some tribal rohe.

McGowan R, 2011. The impacts of the loss of biodiversity on the continuation of rongoā Māori (traditional Māori medicine), The New Zealand Journal of Natural Medicine, published online in 2011.
http://www.naturalmedicine.net.nz/rongoa/the-impacts-of-the-loss-of-biodiversity-on-the-continuation-of-rongoa-maori-traditional-maori-medicine/
Of growing concern to practitioners of rongoā Māori is the difficulty in accessing the plants they need. This has serious consequences; rongoā may no longer be available; mātauranga (traditional knowledge) concerning certain rākau (plants and trees) is being lost: the plants are not available to keep that mātauranga alive. As a result more and more knowledge is being lost with the passing of each of the old healers. While much work has been done to protect intellectual property surrounding rongoā (for example Wai 262) there has been much less attention paid to the fading plant resource.
Plants traditionally used for rongoa are becoming increasingly hard to find in many parts of the country. The areas most deplete in indigenous species are also the most populous, so where there is likely to be the greatest call for rongoa. When the healers can't find the plants they need they stop using them, and can't pass on their knowledge about those plants in the way that they themselves learnt. In time more and more Mātauranga is being lost. The article includes an assessment of what is driving loss (e.g. pests, pollutants) and some practical responses to addressing this.

Ministry of Justice, New Zealand- Māori land online Map Search
http://www.maorilandonline.govt.nz/gis/map/search.htm
This website, originally launched in 2004, provides a snapshot of current ownership, trustee, memorial and block information for land that falls within the jurisdiction of the Māori Land Court under Te Ture Whenua Māori Act 1993 and other legislation – this is primarily Māori Customary and Māori Freehold Land, but also includes, General Land Owned by Māori, Crown Land Reserved for Māori and some treaty settlement reserves, mahingā kai and fishing rights areas.

Moran S, 2001. Provision of New Zealand's native biodiversity: where to from here? Dissertation published in 2001 by Lincoln University
https://hdl.handle.net/10182/3020
Many of New Zealand's native species are threatened or endangered. The Department of Conservation is the major provider of native biodiversity, and its approach focuses on the preservation and protection of native species. The Department faces a limited budget and has to make difficult decisions about the allocation of base resources and management services. There is evidence to suggest, however, that the Department may not always produce the most effective outcomes from its investments because it attempts to preserve all of New Zealand's native biodiversity. Conversely, the private sector may only invest in native biodiversity from which it can appropriate a value and consequently a return that satisfies the needs of the investor.
This research paper considers whether private sector initiatives could be used as an alternative to the public sector's provision of native biodiversity in New Zealand. It is argued that the private sector could complement, but not substitute, the provision of native biodiversity by the public sector. The methodology for this research

is separated into five steps. First, the paper examines the present state of native biodiversity in New Zealand. Second, is an investigation of the possible causes of the decline and loss of native biodiversity. Third, private sector initiatives to obtain investment from the private sector for the provision of native biodiversity are used to illustrate how economic approaches can increase the value of native biodiversity. The final step is to apply economic approaches to the provision of native biodiversity in New Zealand for a case study of the Kiwi.
An important aspect of this research is how the provision of native biodiversity relates to the possible causes of the decline and loss of native biodiversity. Rational selection is identified as the key cause of the decline and loss of native biodiversity and it is based on economic choices that determine the human environmental portfolio. If economic choices can lead to disinvestment in a native species then addressing the economic reasons for those choices may lead to investment in native species: Finally, the potential implications of this research for the future direction for provision of native biodiversity in New Zealand are discussed in the conclusion. The suggested direction includes potential changes to legislation, to the approach of native biodiversity provision, public attitudes, and potential role changes for the Department of Conservation.

Seabrook-Davidson Mark N. H. Brunton Dianne H. (2014) Public attitude towards conservation in New Zealand and awareness of threatened species. Pacific Conservation Biology 20, 286-295.
http://www.publish.csiro.au/pc/PC140286
The paper examines public attitudes towards government spending on conservation and awareness of threatened species. Conservation ranked fourth in public priorities for government spending, behind health, education and law, which is higher than it ranks among priorities of average annual government spending. This, combined with good awareness of key threatened species, indicates public support for expenditure on nature conservation.

Te Puni Kōkiri, 2009. Te Ripoata Ohanga Māori mō Te Waiariki: Report on the Māori Asset Base in the Waiariki Economy – An Economic Growth Strategy for a Sustainable Future, Te Puni Kokiri 2009
http://www.tpk.govt.nz/en/a-matou-mohiotanga/business-and-economics/te-ripoata-ohanga-maori-mo-te-waiariki
The Māori asset base in the Waiariki rohe (western bay of Plenty, Tauranga City, Rotorua District, Whakatane District, Kawerau District and Opotiki District) is concentrated in primary industries and is driven by land ownership. It has an estimated value of between $5.69 and 8.94 billion. The area owned by Māori entities, including the Central North Island Iwi Collective is 685,000 hectares. This is 31.5% of the Bay of Plenty region and shows the significant role Māori play in the economy of this rohe. Land administered by Māori land incorporations and ahu whenua trusts totals more than 500,000 ha and is administered by approximately 1,290 entities. The majority of these have diversified operations, with most having some form of forestry interest. The report identifies future trends and opportunities for growth and diversification of the asset base and illustrates the important role of the Māori economy in land use decisions.

Te Puni Kōkiri, 2011. Owner Aspirations Regarding the Utilisation of Māori Land, Te Puni Kokiri April 2011
http://www.tpk.govt.nz/en/a-matou-mohiotanga/land/owners-aspirations-regarding-the-utilisation-of-ma
Identifies a wide range of aspirations including:

- To retain land handed down from Tipuna thereby maintaining owners' association with it
- To utilise land within the context of exercising values associated with land as taonga tuku iho such as kaitiakitanga and manaakitanga
- To provide the opportunity for owners to directly utilise undeveloped land (e.g. for hunting and fishing, papakainga, cultural observance)

Also identifies a number of influences that have limited the ability for Māori to utilise their land. These include barriers on the use of land, governance arrangements and information gaps.

Te Puni Kōkiri, 2013. He Tiro Whānui e pā ana ki te Tiaki Taiao 2012: 2012 Kaitiaki Survey report, Te Puni Kokiri 2013
https://www.tpk.govt.nz/en/a-matou-mohiotanga/land/2012-kaitiaki-survey-report
The Kaitiaki Survey was conducted with individuals and organisations that do environmental work and engage in Resource Management Act processes on behalf of iwi or hapū. The survey is a first step in establishing baseline information about how iwi and hapū are involved in natural resource management.
The report shows that most groups have between 2-5 people working for them and spend about 40 hours a week on environmental work, much of this carried out in a voluntary or unpaid basis. Capacity and capability for iwi/hapū and councils identified as a key issue affecting engagement.

Te Puni Kōkiri, 2015. Māori Economy Report 2013, Te Puni Kokiri April 2015
http://www.tpk.govt.nz/en/a-matou-mohiotanga/business-and-economics/maori-economy-report-2013
A helpful summary of the Māori economy including the sector concentration of Māori enterprises, their location, asset values and value added. GDP from Māori economy producers totalled $11 billion in2013. This contribution is still dominated by the primary sector. The study confirms a further expansion of the size of the Māori economy asset base. The asset base is improving in size and value, but productivity (as broadly measured by GDP) of these assets remain below average. The nature of many of the land-based assets (restricted access, limited potential, and/or difficult management/ownership structures) tends to make this below-average outcome inevitable. However broadening of asset interest across a range of sectors lessens this inevitability.

Waitangi Tribunal, 2011. Ko Aotearoa Tēnei: A Report into Claims Concerning New Zealand Law and Policy Affecting Māori Culture and Identity. Te Taumata Tuarua volumes 1 and 2- Indigenous Flora and Fauna and Cultural Intellectual Property Claim (WAI262 Tribunal Report 2011).
https://www.waitangitribunal.govt.nz/
Wai 262 is a claim to rights in respect of mātauranga Māori or Māori knowledge, and indigenous flora and fauna. The claimants say these rights are guaranteed under the Treaty of Waitangi. The claim raises issues in respect of intellectual property rights that have not been addressed before. The tribunal found that: Iwi and hapū are obliged to act as kaitiaki (cultural guardians) towards taonga (treasured things) in the environment such as land, natural features, waterways, wāhi tapu, pa sites and flora and fauna within their tribal areas. Current [resource management] laws and policies do not support those kaitiaki relationships to the degree required by the Treaty. Similarly, the tribunal found that despite considerable effort by DOC, current conservation and wildlife laws do not support kaitiaki relationships to the degree required by the Treaty. See the summaries of Resource Management and Conservation findings which describe the relationship of Māori and the environment.

Wilson G, and Memon P, 2010. The contested environmental governance of Māori-owned native forests in South Island, Aotearoa/New Zealand Land Use Policy, 27(4):1197-1209) 2010
http://www.sciencedirect.com/science/article/pii/S0264837710000360
In this study we set out to critically examine the environmental governance of native forests owned and managed by the Māori in New Zealand, with a specific focus on 'SILNA' lands given to the South island Māori as compensation lands for lost ancestral tribal lands. We will interrogate reasons for different forestry pathways in terms of how the process of European colonisation unfolded politically and spatially, the response of the Māori SILNA forest owners to pressures linked to land allocation and land rights issues over time, and the repercussions of these responses for biodiversity preservation in indigenous forest management systems. In order to unravel the complex environmental governance processes at play in the New Zealand context, we will pay particular attention to 'exogenous' (i.e. propelling forces outside Māori communities) and 'endogenous' regulation mechanisms (i.e. regulation of native forest management within SILNA forest blocks). New Zealand is a particularly appropriate setting as Māori governance, forest management and land rights issues have come to the fore over the past decades. Our findings suggest that Māori SILNA forest owners have used the full spectrum of forest management pathways, ranging from outright clear felling and associated biodiversity depletion to forest preservation. The study highlights the complex interplay between endogenous environmental governance processes (actor embeddedness with their land and the role played by trusts and committees in particular) and exogenous drivers, in particular through the influence of international logging companies, and the policy environment which has sent mixed, and at times confusing, messages to Māori SILNA native forest owners.

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