Biodiversity in Aotearoa

an overview of state, trends and pressures

2020

Department of Conservation
Te Papa Atawhai

New Zealand Government

Front cover: Homer grasshopper (*Sigaus homerensis*) occurs in a few small, isolated gullies in Northern Fiordland which are prone to avalanche and rock fall. Predation and the effects of climate change pose the most significant threats for this species. It has a conservation status of 'Threatened – Nationally Critical'.
Photo: Simon Morris

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Kei ngaro ngā taonga o te ao tūroa, pērā i te ngaro o te moa.

Lest the treasures of the natural world be lost as the moa was lost.

Biodiversity in Aotearoa – an overview of state, trends and pressures is a companion report to *Te Mana o te Taiao – Aotearoa New Zealand Biodiversity Strategy* 2020[1] which sets the strategic direction for the protection, restoration and sustainable use of biodiversity in Aotearoa New Zealand until 2050.

Purpose | Te aronga

The purpose of *Biodiversity in Aotearoa – an overview of state, trends and pressures* is to objectively present the data and information that currently describes the extent of the biodiversity crisis in Aotearoa New Zealand. In doing so it sets the scene and supports *Te Mana o te Taiao*[1] by providing the evidence base for the action needed to respond to this crisis.

The report has been written for everyone who has an interest in Aotearoa New Zealand's indigenous biodiversity.

Content of the report | Te kiko o te pūrongo

Aotearoa New Zealand's flora, fauna and ecosystems are described across three domains – land, freshwater and marine. For each domain, an overview is provided of the state of and trends in important ecosystems and species groups, along with details of the pressures affecting them. Any limitations around the extent of available knowledge are recognised and described. Sections within the report were authored by subject experts and are based on a wide range of published material and publicly available data.

Oral and written accounts of mātauranga Māori are included in some sections of this report, noting that the recognition and integration of mātauranga Māori by mainstream conservation management is still limited, not only in this report, but in conservation work more widely. Acknowledging the interconnection between the three domains is fundamental from a te ao Māori perspective.

Biodiversity in Aotearoa focuses on the five direct pressures responsible for the decline of Aotearoa New Zealand's species and ecosystems. These are: introduced invasive species, changes in land and sea use, direct exploitation and harvesting (including water extraction), pollution and the increasing threat of climate change. These five pressures, all related to human actions or activities, are identified as having the largest impacts on biodiversity globally.

Since humans arrived in Aotearoa New Zealand, the same five overarching pressures have triggered a wave of extinctions and continue to exert momentous change on indigenous biodiversity. The pressures often interact in complex ways and their impact is cumulative over time.

Key messages – land domain | Ngā kōrero matua – Whaitua whenua

Active tectonic geology and complex landscapes in Aotearoa New Zealand shape unique and varied biotic communities. The major decline in many indigenous land-based species, and in some case their extinction, is largely the result of the substantial reduction in the extent and quality of natural habitats, the impact of introduced predators and herbivores and the legacy of past impacts (including harvesting). Indigenous vegetation continues to disappear with land-use change and intensification. While rates of loss have slowed in recent times, less than half of Aotearoa New Zealand's land area now

[1] www.doc.govt.nz/anzbs-strategy

remains in indigenous vegetation cover. Of the nearly 11,000 terrestrial species assessed using the New Zealand Threat Classification System (NZTCS), 811 (7%) are ranked as 'Threatened' and 2416 (22%) as 'At Risk'. Between 2012 and 2017, population declines were recorded for 61 vascular plant species. Some threatened plants are key structural species for ecosystems, so their declines can have significant ramifications for their associated ecosystems. However, positive changes have been recorded for other species. For example, the conservation status of 23 land bird species improved between 2008 and 2019 as a result of population increases resulting mainly from conservation management.

Key messages – freshwater domain | Ngā kōrero matua – Whaitua wai māori

The variability in Aotearoa New Zealand's climate, geology and landforms give rise to great diversity in freshwater ecosystems. There are more than 425,000 km of mapped rivers and streams, 50,000 lakes, geothermal and cold-water springs, karst systems and 200 identified aquifers. Wetland ecosystems have declined in extent by about 90% since people arrived. All freshwater habitats and species have suffered increased sedimentation, eutrophication and other physical damage as a result of increased agricultural activities and urbanisation. Of the 976 freshwater species assessed in the NZTCS, 136 (14%) are ranked as 'Threatened' and a further 176 (17%) as 'At Risk'. Nearly a quarter (218) of freshwater species assessed are 'Data Deficient', indicating that there is insufficient information to assign them a conservation status.

Key messages – marine domain | Ngā kōrero matua – Whaitua wai māori

Aotearoa New Zealand has 15 times more sea than land area. The marine habitat spans about 30° of latitude. Marine habitats are diverse, ranging from sheltered inlets, fiords, estuaries, seagrass beds, rimurapa/kelp forests, shellfish beds, hydrothermal vents, extensive sandy coasts through to rocky coasts and reefs and the open ocean. The large extent of the country's marine environment and its remoteness make it significant globally for marine biodiversity. Of the 12,820 marine species described for the area, over half are endemic. Of the 1552 marine species assessed using the NZTCS, 55 (4%) are 'Threatened' and a further 504 (32%) are 'At Risk', while nearly half are 'Data Deficient'. The pressures on marine biodiversity are varied and include climate change, impacts from harvesting and the effects of pollution.

The way forward | Te ara whakamua

Whānau, hapū and iwi have strong connections to their whenua, awa and moana and, as kaitiaki, they have strong interests in and responsibilities for the management and wellbeing of the natural world. The people of Aotearoa New Zealand are connected to nature, because it supports life and human activity. All aspects of our wellbeing – physical, cultural, social and economic – are dependent on nature and the services that it provides.

Biodiversity in Aotearoa – an overview of state, trends and pressures concludes that biodiversity in Aotearoa New Zealand, along with the rest of the world, is in a general state of crisis. It is evident that the extent of the crisis varies across and within the different elements of biodiversity. In recent years, it has been demonstrated that if intensive intervention management is applied to populations and ecosystems, it is possible to turn the tide of decline for at least some elements of biodiversity. *Te Mana o te Taiao* sets a strategic direction for the protection, restoration and sustainable use of biodiversity in Aotearoa New Zealand for the next 30 years. Through implementation of *Te Mana o te Taiao* we can support the manifestation of kaitiakitanga so that Papatūānuku thrives.

Foreword | Kupu whakataki

Biodiversity in Aotearoa – an overview of state, trends and pressures provides an important overview of the extent of our biodiversity crisis across the land, freshwater and marine domains. It outlines the current state and recent trends in biodiversity across Aotearoa and identifies the pressures that are causing change. This report sets the scene for the revised *Te Mana o te Taiao – Aotearoa New Zealand Biodiversity Strategy* 2020. It outlines how we, as a nation, need to tackle the challenges in order to retain the natural heritage and taonga of these islands – the full range of unique indigenous biodiversity that is so intrinsically tied to our lands and seas and who we are as peoples.

This document includes some te ao Māori perspectives as well as Western viewpoints and incorporates mātauranga Māori examples. It summarises the global backdrop of the crisis in order to place Aotearoa New Zealand's unique biodiversity within a contemporary context.

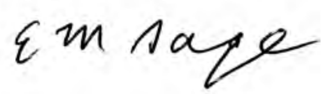
The information in this report utilises data collection and analysis by many agencies, organisations and researchers over the years, as well as significant insights and thinking shared from a mātauranga Māori perspective, and I am grateful for their work. However, we need to recognise that the combined knowledge and data gathering systems which we use to gauge state and trends for indigenous species and ecosystems are not yet comprehensive or integrated across worldviews, and significant system shifts are required to change that.

Photo: Rick Zwaan

I would also like to acknowledge the amazing work that has happened and is happening in conservation in recent decades. From central government agencies to councils, philanthropic organisations, from iwi to whānau, from landowners to volunteers, from practitioners to researchers, from retirees to school children, thousands of New Zealanders actively participate in conservation every day. Without those efforts our current state would be even more perilous, and we would not be able to tell some of the remarkable recovery stories that we have witnessed.

We hope that you will use this report alongside *Te Mana o te Taiao* to recognise the need to act now and that they will inspire you to take an active interest and role in protecting our precious native animals, plants and ecosystems – our unique heritage and taonga tuku iho.

Hon Eugenie Sage



Minister of Conservation

Introduction | Kupu arataki

When the first waka of people arrived from Hawaiki around 740 years ago they understood that the plants and animals, waters, and soils of Aotearoa would be key to their survival. Thus arose the ethic that is now known as kaitiakitanga – the understanding that there is a reciprocal relationship between nurturing the health of the natural environment and people.

Source of arrival date: Wilmshurst et al. (2008).

Aotearoa New Zealand comprises a thread of islands that are little more than dots within a vast ocean. The surging of the Earth's crust over millions of years left them here, stranded in time and space. Aboard these lifeboats from the wreck of Gondwana were plants and animals that are today found nowhere else on Earth.

Yet today, those plants and animals – Aotearoa New Zealand's biodiversity, or variety of life – are in crisis, reflecting the situation throughout the rest of the world. The consequences of human population growth and accompanying resource needs have left plants and animals displaced, often battling to survive; and indigenous ecosystems eliminated or depleted to make way for other land uses.

There remains an opportunity to reverse this, however. In May 2019, a global assessment by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) found that:

[It] is not too late to make a difference, but only if we start now at every level from local to global. Through transformative change, nature can still be conserved, restored and used sustainably – this is also key to meeting most other global goals.

Tuatara (*Sphenodon punctatus*) is the only living representative of the order Sphenodontia, which is over 250 million years old. They are sometimes referred to as 'living fossils'. Tuatara are of great cultural significance to Māori and are viewed as the kaitiaki (guardians) of knowledge by some iwi. Tuatara have a conservation status of 'At Risk – Relict'.
Photo: Dave Hansford

As part of Aotearoa New Zealand's commitment to help stem the loss of biodiversity worldwide, a New Zealand Biodiversity Strategy was published in 2000 (DOC and MfE 2000) under the Convention on Biological Diversity.[2] This strategy expired in 2020 and *Te Mana o te Taiao – Aotearoa New Zealand Biodiversity Strategy* (hereafter *Te Mana o te Taiao – ANZBS*) will set a strategic direction for the protection, restoration and sustainable use of biodiversity until 2050.

The purpose of *Biodiversity in Aotearoa – an overview of state, trends and pressures* (hereafter *Biodiversity in Aotearoa*) is to provide the data, information and evidence that objectively describes the extent of the biodiversity crisis in Aotearoa New Zealand. In doing so it sets the scene and supports *Te Mana o te Taiao – ANZBS* by providing the evidence base for what action is needed to respond to this crisis. They are companion documents. Both reports are written for all New Zealanders who have an interest in biodiversity.

The report begins by identifying the importance of biodiversity, and then outlines the state, trends, and pressures on global biodiversity as context for the situation in Aotearoa New Zealand. The unique character of New Zealand's biodiversity is described, along with how it is understood and measured. The principle pressures on biodiversity in Aotearoa New Zealand are discussed, including the increasing threat posed by climate change and the way pressures regularly act in combination and accumulate. New Zealand's flora, fauna and ecosystems are described across three domains – land, freshwater and marine. For each domain, an overview of the state and trends is provided for the important ecosystems and species groups, along with the pressures that impact them and the caveats around the extent of available knowledge. Oral and written accounts of mātauranga Māori are included in some sections of this report, noting that the recognition and integration of mātauranga Māori within mainstream conservation management is still limited, not only in this report, but in biodiversity work in general. Case studies are presented throughout the report to highlight some specific positive actions being undertaken to address pressures.

Biodiversity in Aotearoa is a snapshot in time, providing a high-level stocktake of what is presently recorded. It draws on key national datasets and published accounts of scientific research. The report has some overlap with the Environmental Reporting series[3] but expands on those elements that focus on indigenous biodiversity.

Biodiversity in Aotearoa is an overview and does not provide an in-depth analysis of all elements of biodiversity in Aotearoa New Zealand. Nor does it include the extensive knowledge which is held by whānau, hapū and iwi about taonga species and the whenua, awa and moana to which they associate, though some examples of mātauranga Māori are included. It does not catalogue efforts to respond to the crisis in Aotearoa, with the exception of case studies. The recommendations for responses to the pressures are addressed in *Te Mana o te Taiao – ANZBS*. This report does not attempt to analyse indirect pressures and social drivers (including legislation, policy, economic imperatives, compliance and enforcement) which influence direct pressures.

The report acknowledges that there are some limitations to presenting information within a framework of domains, as it is very common for an animal or plant to move between land, freshwater and marine environments in order to fulfil all stages of its lifecycle. Recognising the interconnection between all domains is fundamental from a te ao Māori perspective. The report also accepts that while there is significant knowledge available, there are also substantial gaps in many aspects relating to state, trends and pressures. It is apparent also from this report that the extent of the crisis varies across and within the different elements of biodiversity and that there are some heartening success stories where management intervention has turned the tide for some species.

[2] See Convention on Biological Diversity box in Global response | Te urupare ā-ao and **www.cbd.int**

[3] **https://www.mfe.govt.nz/more/environmental-reporting**

Key definitions (see Glossary)

Biodiversity, or biological diversity, means the variability among living organisms from all sources including land, marine and freshwater ecosystems and the ecological complexes of which they are part; this includes diversity within species (including genetic diversity), between species and of ecosystems (definition based on Convention on Biological Diversity).

State is what is known about the current situation for a specific group of animals, plants, or ecosystems.

Trend refers the general direction of change based on the best data and knowledge available – which in many cases wouldn't necessarily account as a 'trend' in the strictest statistical sense due to lack of datapoints over time.

Pressures mean any factors that act as direct drivers of biodiversity loss. Indirect drivers of biodiversity loss, such as increase in human population growth and consumption are out of scope for this report.

Species means a group of living organisms consisting of similar individuals capable of exchanging genes or breeding. In this document the term is used to include subspecies and varieties

Indigenous species are those that occur naturally in Aotearoa New Zealand.

Endemic species are indigenous species which breed only within a specified region or locality and are unique to that area. New Zealand's endemic species include birds that breed only in this country, but which may disperse to other countries in the non-breeding season or as sub-adults.

Domain includes the animals, vegetation and structures associated with the physical environment. The physical environment comprises:

- soil, underlying rock and what is on the land surface (land domain)
- fresh water in all its physical forms, but excluding atmospheric water (freshwater domain)
- estuaries, the sea, the seabed and soil associated up to the mean high-water mark. In Aotearoa this extends from the seashore to the outer limits of New Zealand's Exclusive Economic Zone, including the continental shelf (marine domain).

Ecosystem means a community of plants, animals, and microorganisms in a particular place or area, interacting with the non-living components of their environment (like air, water, and mineral soil). Ecosystems can be defined at a range of scales. For the purposes of this document a scale is applied that is useful for the classification of ecosystems for conservation purposes. For ecosystems in the Land domain, for example, this is equivalent to the 152 ecosystems defined for Aotearoa in Singers & Rogers, 2014.

Species and ecosystem conservation in this country has its roots in both Māori and European history. Māori culture and language evolved in the ecosystems and landscapes of Aotearoa and are inextricably woven with them. Mātauranga Māori is a trove of intimate knowledge that has been gathered over centuries, and also refers to the Māori way of knowing. It is the collective understanding of generations of people who lived as an integral part of the diverse natural systems in Aotearoa from which they are descended (Waitangi Tribunal 2011). Māori ancestors arrived at a land with abundant natural resources and were fully dependent on its flora and fauna for their survival. Over the generations, intimate knowledge evolved about how to live within ecosystems in ways that enable mutual wellbeing (Waitangi Tribunal 2011). These many centuries of experiential learning provide both caution and inspiration for the future of the natural world. The warnings of the need to care for our ecosystems based on the understanding that people exist within them are captured in a well-known whakataukī – *Kei ngaro, pērā i te ngaro o te moa* (*lest they be lost as the moa was lost*).

The story of Richard Henry (see *case study*) provides an inspirational example of one person's attempt to save a species.

Whānau, hapū and iwi have strong connections to their whenua, awa and moana, and as kaitiaki, they have a strong interest in the management and wellbeing of the natural world. It is through exercising rangatiratanga and kaitiakitanga that these relationships, responsibilities and practices, including mātauranga Māori, can be sustained. Giving effect to the principles of the Treaty of Waitangi to strengthen Treaty partnerships and increase respectful and mutually beneficial engagement for biodiversity holds much potential for the future wellbeing of the country's ecosystems, species and people.

People in Aotearoa are connected to nature, and people's wellbeing is dependent on healthy, thriving biodiversity. Biodiversity in Aotearoa provides the evidence for *Te Mana o te Taiao – ANZBS* of the future work required of all New Zealanders in order to support the manifestation of kaitiakitanga and maintain the spirit of Henry's efforts in continuing to protect our taonga – including those precious relicts of Gondwana.

Richard Henry – a pioneer for conservation

Richard Henry is in large part to thank for successful conservation efforts in New Zealand, especially for kākāpō. In the late 1800s, Henry campaigned for bird protection and pioneered revolutionary methods for their rescue, long before the majority of people came to understand the severe impacts that introduced mammalian predators have on native birds.

In 1891, Māuikatau/Resolution Island in Fiordland's Dusky Sound was made a reserve and in 1894 Henry was appointed curator and caretaker. He saw the impact introduced stoats were having on flightless ground birds in Fiordland, and over a number of years, with the aid of his muzzled fox terrier 'Lassie' (the first conservation dog in New Zealand) he performed a world-first effort of tracking, catching and moving about 750 kākāpō, kiwi and other birds onto Māuikatau/Resolution and other nearby islands. Unfortunately, stoats later swam to the islands and proceeded to wipe out the translocated birds. In 1908 a discouraged Henry moved away and became caretaker of Kāpiti Island.

Kākāpō (*Strigops habroptilus*) are one of many species that have recovered from the brink of extinction, in large part due to translocation methods pioneered by early conservationist Richard Henry. Pictured is the late Don Merton QSM, a New Zealand conservationist best known for his involvement in saving the black robin from extinction. He is holding kākāpō 'Richard Henry', who was named in honour of the pioneering conservationist. The conservation status of kākāpō is 'Threatened – Nationally Critical'. *Photo: Don Merton*

Despite Henry's initial efforts being thwarted by the arrival of predators, the translocation methods that he pioneered, and his detailed and accurate field observations, were later used to rescue the same species and others from the brink of extinction. In 1975, three of the last remaining male Fiordland kākāpō were captured and translocated to Te Pāteka/Maud Island in the Marlborough Sounds. Only one of these males, which happened to have been named Richard Henry in memory of the early conservationist, survived to pass on his genes to the current population. Today, thanks to intensive efforts building on Henry's work, the kākāpō population has recovered from just 51 individuals in 1995 to 211 in 2020.

Source: Ormerod (1993).[4]

[4] https://www.doc.govt.nz/our-work/kakapo-recovery

The global biodiversity crisis | Te mōrearea rerenga rauropi ā-ao

The 2019 ***Global assessment report on biodiversity and ecosystem services***[5] is the most recent and comprehensive assessment of the state of the world's natural environment. Prepared by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), it assesses changes over the last 50 years. The information in this chapter has been drawn from the IPBES summary report (Díaz et al. 2019) unless otherwise specified.

This chapter discusses the importance of biodiversity (including ecosystem services, which are vital to human survival). The key state and trends of biodiversity, along with the pressures that are influencing them, are described. A summary of the direct conservation responses is included. It does not cover the recommended policy responses and actions to conserve biodiversity.

Red slender loris (*Loris tardigradus*) is an endangered mammal found only in Sri Lanka. Like many other species globally, the future of the red slender loris is seriously threatened by habitat loss due to factors such as urbanisation and forestry. The red slender loris is classified as 'Vulnerable' by the International Union for the Conservation of Nature (IUCN). *Photo: James Reardon, JamesReardon.org*

[5] **https://ipbes.net/global-assessment**

Why is biodiversity important? | He aha i hira ai te rerenga rauropi?

Nature has intrinsic value, that is, a value in its own right. Functioning natural systems also provide many benefits to the organisms that inhabit them, including people (Fig. 1). The benefits ecosystems bring to human wellbeing and the wellbeing of other species and ecosystems are known as 'ecosystem services' and fall into four main categories:

- Supporting (e.g. nutrient cycling, soil formation, primary production)
- Provisioning (e.g. food, fresh water, wood, fibre, fuel)
- Regulating (e.g. climate regulation, flood and disease regulation, water purification)
- Cultural (aesthetic, spiritual, educational, recreational) (Millennium Ecosystem Assessment 2005).

High levels of biodiversity have a positive impact on ecosystem functions and resilience (e.g. Worm et al. 2006; Oliver et al. 2015) which means that ecosystem services are more likely to be maintained despite disturbance and change. On the other hand, a loss of biodiversity has a negative impact on ecosystem stability and recovery and can result in resource collapse (Worm et al. 2006). Consequently, the loss of species and ecosystems, and the services they provide, threatens people's existence, as the economy, along with individual livelihoods, health and food security all rely on nature. Globally, perceptions and language around the value of biodiversity tend to change through time and also vary between cultures and economic sectors. However, some principles remain consistent and uncontested. For instance, it is widely accepted, (including in Aotearoa) that people's wellbeing depends on the health of the natural environment around them. This aligns with the Māori worldview that people are not separate from nature.

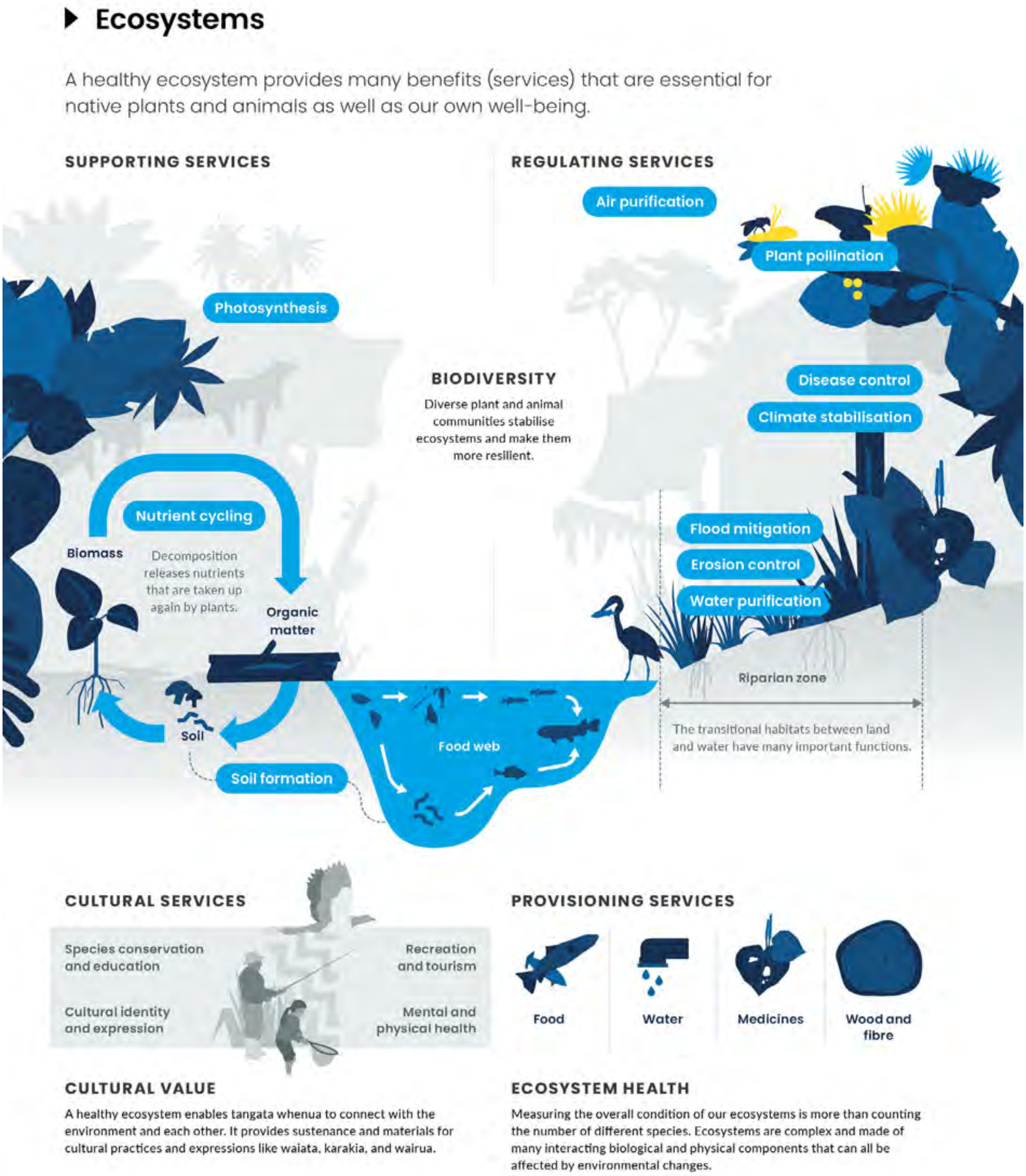


*Figure 1. Ecosystem services. Source: Ministry for the Environment, Statistics NZ, and data providers. Licensed by the Ministry for the Environment and Statistics NZ for reuse (***CC BY 4.0**[6]*).*[7]

[6] https://creativecommons.org/licenses/by/4.0/deed.ast
[7] https://www.mfe.govt.nz/publications/environmental-reporting/environment-aotearoa-2019

State and trends of global biodiversity | Te āhuatanga me ngā ia o te rerenga rauropi ā-ao

Three-quarters of the world's land surface and 66% of its oceans have been significantly altered by humans. The extent and condition of the world's ecosystems have declined by an average of 47% compared with the natural baseline, and some are faring worse than others. For example, 87% of the world's wetlands are estimated to have been lost between 1700 and 2000 and the remainder are disappearing at a rapid rate (Davidson 2014). Furthermore, terrestrial biodiversity hotspots (regions with exceptional concentrations of species richness and endemism which are under threat) are suffering greater reductions in extent and condition and faster declines than other regions on land. For example, tropical forests, which are the most biologically diverse ecosystems on land, were reduced by 32 million ha between 2010 and 2015.

Around 1 million animal and plant species are now facing extinction. This includes 41% of amphibians, 38% of marine mammals and 33% of reef-forming corals, which are the three worst-hit groups (IUCN 2018).[8] Current extinction rates are much higher than the average extinction rates in the absence of humans, and in the best-studied taxonomic groups the rate has been accelerating in the last 40 years.

The size of vertebrate populations decreased by an average of 58% between 1970 and 2012 (WWF 2016), and at least 680 vertebrate species have become extinct since 1500. Almost 600 seed plants (flowering plants, conifers and other seed-producing plants) have become extinct in the last 250 years, predominantly from biodiversity hotspots and tropical islands (Humphreys et al. 2019), a pattern that mirrors the decline in animal species. Freshwater ecosystems are the most threatened of all global habitats: monitored freshwater species populations have declined by an average of 83% between 1970 and 2014 (WWF 2018).

The pollinators on which many wild and cultivated plants rely are also affected, with a rapid decline in insect pollinators having occurred in some places and around 16% of vertebrate pollinators, such as birds, bats and monkeys, being threatened with extinction (Potts et al. 2016). People are also failing to safeguard the genetic diversity of cultivated plants and farmed and domesticated animals (and their wild relatives).

[8] The International Union for Conservation of Nature's (IUCN) Red List of Threatened Species is the world's most comprehensive source on the global conservation status of animal, fungi and plant species.

What are the pressures causing these losses? | He aha ngā pēhanga hei pūtake o ēnei ngarotanga?

Most **direct drivers** of biodiversity loss stem from a range of underlying **indirect drivers** related to human behaviour and values, such as rapid human population growth, and unsustainable production and consumption. This report focuses on **direct drivers** and, for consistency, uses the term '**pressure**' throughout the document to describe these[9]. Indirect drivers acting at a global scale are described in a general sense in order to understand their influence on the five overarching pressures that are recognised as having the largest impact on biodiversity (Fig. 2):

- Changes in land and sea use
- Direct exploitation
- Climate change
- Pollution
- Introduced invasive species (especially in island nations such as Aotearoa).

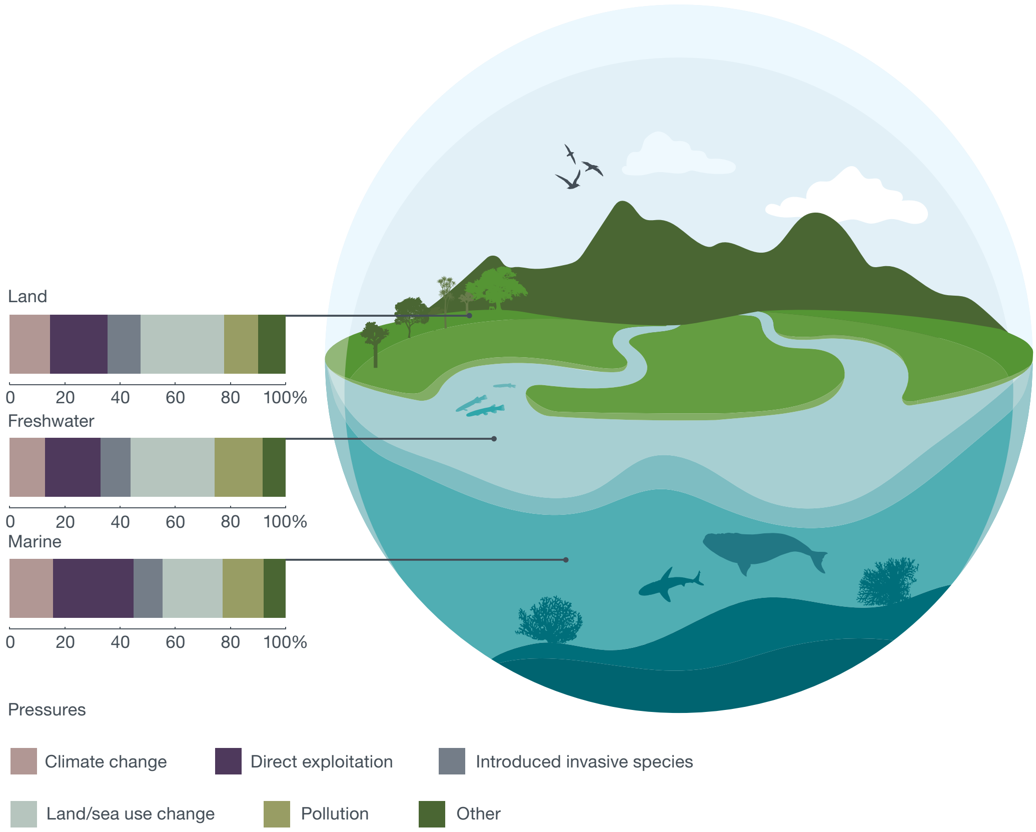


Figure 2. The five overarching pressures that impact on biodiversity globally, and their relative impacts on biodiversity across domains. The sixth category 'Other' refers to all other pressures not accounted for under the five main pressures. Source: The IPBES summary report (Díaz et al. 2019), adapted with permission.

[9] For further reading on indirect drivers of biodiversity loss, see draft Chapter 2.1 Status and trends – Drivers of change in the Global assessment report on biodiversity and ecosystem services. Available at: **https://ipbes.net/global-assessment**

Land-use and sea-use change is mainly caused by agriculture and forestry on the land, and aquaculture and coastal development in the marine environment. Urbanisation is also an increasing threat, with the size of urban areas having more than doubled since 1992. These changes are driven by population growth and, in the case of agriculture, the growing demand for grain-fed meat. Large-scale commercial agriculture is the main cause of deforestation globally (FAO 2016). Land-use change has had the largest relative negative impact on biodiversity for terrestrial and freshwater ecosystems, mainly through habitat loss and degradation (Collen et al. 2014). Marine habitats have been negatively affected by sea-use changes such as increased coastal development, aquaculture and bottom trawling.

Direct exploitation means the extraction of living and non-living resources from nature for agriculture, forestry, fishing, hunting, construction and industry. Direct exploitation of organisms has the largest relative impact in the marine domain, where commercial fishing covers at least 55% of oceans. Global capture fisheries production (the combined total harvest of fish from both freshwater and marine domains) in 2018 reached a record 96.4 million tonnes, with 78.7% of landings coming from biologically sustainable stocks (FAO 2020). The increase in 2018 was mostly driven by marine capture fisheries, with production increasing from 81.2 million tonnes in 2017 to 84.4 million tonnes in 2018.

Climate change impacts are expected to increase the number of species under threat. Climate change has caused shifts in species' distributions, changes in cyclic and seasonal behaviour, and altered population dynamics. In addition, it has caused further disruptions from the genetic to the ecosystem level in marine, terrestrial and freshwater ecosystems. Climate change can also exacerbate the impact of other pressures. For example, the number and intensity of extreme weather events, floods, droughts and fires has increased globally in the last 50 years. In marine ecosystems, climate change is leading to increases in sea surface temperatures, ocean acidification and ultraviolet radiation, all of which are considered responsible for the majority of the cumulative marine impacts that were observed between 2008 and 2013 (Halpern et al. 2015). Highly productive coastal ecosystems (such as seagrass meadows and coral reefs) are showing sharp declines, threatening the livelihoods, health and wellbeing of human coastal communities. Half of the world's coral cover has vanished since 1870 and impacts such as ocean acidification are driving further and faster losses. In terrestrial ecosystems, it is estimated that almost half of all terrestrial mammals and almost a quarter of threatened birds may have been negatively impacted by climate change in at least part of their distribution. In freshwater ecosystems, climate change effects have been documented for 23 of the 31 ecological processes that underpin freshwater ecosystem functioning (Scheffers et al. 2016). It is estimated that climate change potentially threatens approximately 50% of global freshwater fish species (Darwall & Freyhof 2015).

Pollution, including untreated waste, oil spills, and toxic pollutants, has a major negative effect on the environment across land, freshwater and marine domains, and it is still increasing in some areas. For example, the volume of oceanic waste plastic has increased tenfold since 1980, impacting at least 267 marine species which, in turn, can affect human health through food chains.

Introduced invasive plant, animal and microbial species can have devastating effects on native animals, plants and ecosystems. This is especially the case in areas where a large proportion of species are endemic and on islands, which are more often invaded by non-indigenous species than continents (Vitousek et al. 1997). Since 1980 there has been a 40% increase in records of introduced species globally, and the rate of introductions of new invasive species is not showing any sign of slowing down.

Although the magnitude and consequences of these pressures differ from place to place, their overall effects are worsening. Furthermore, the interplay between these pressures multiplies into cumulative impacts across terrestrial, freshwater and marine environments.

Global response | Te urupare ā-ao

These trends would be even worse in the absence of active conservation effort. Investment in mammal and bird conservation by 109 countries between 1996 and 2008 is thought to have eased the extinction risk by a median value of 29% per country. Great advances and successes in the eradication of introduced invasive species, particularly on islands, have benefitted at least 107 species of highly threatened birds, mammals and reptiles. However, on balance the global response to biodiversity loss has been inadequate.

The ability to predict the extinction risk of species relies on good data, yet a large proportion of assessed species are classified as 'Data Deficient',[10] meaning there is 'inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status' (IUCN 2014). Consequently, only an inkling of the true composition of ecosystems and communities is presently available.

It has been estimated that 86% of terrestrial and freshwater species and 91% of marine species have not yet been officially described by taxonomists (Mora et al. 2011). Generally, much more is known about groups of animals and plants that are 'charismatic' and visible, such as mammals, birds and flowering plants, than about insects, fungi, microbial species and parasites. This depth of knowledge is no measure of a group's importance, however. Many poorly-understood groups are ecologically and environmentally crucial as well as being important for human wellbeing and holding enormous potential for industry, agriculture and medicine (Taxonomy Decadal Plan Working Group 2018).

Some aspects of biodiversity, such as genetic diversity, also receive less research effort, and there are much greater data gaps in the freshwater and marine domains compared with the terrestrial domain.

While the amount of information available is generally increasing, decision makers are not fully utilising that knowledge. At least a quarter of the world's lands are managed by indigenous peoples and local communities, nearly three-quarters of whom report deterioration in important systems based on their own measures of ecosystem integrity. However, these people are struggling to have a legitimate presence in conservation efforts, in part because there are few useful indicators that would help to integrate traditional knowledge and science – and this, in turn, is exacerbating the decline in that traditional knowledge.

Global biodiversity action is coordinated through the Convention on Biological Diversity (CBD) (see *case study*).

[10] Although describing a similar concept, the term 'Data Deficient' is defined differently by the International Union for the Conservation of Nature (IUCN) and the New Zealand Threat Classification System (NZTCS). For the NZTCS definition, see **Species Conservation Status** section.

Convention on Biological Diversity

Under the auspices of the United Nations Convention on Biological Diversity, a global movement for nature is underway to safeguard biodiversity. More than 195 countries, including New Zealand, have signed up to the Convention on Biological Diversity (CBD), and representatives of these countries, along with experts, activists and non-government stakeholders from around the world, are negotiating a set of global biodiversity targets for the next decade. The new post-2020 biodiversity targets are due to be adopted at the next CBD Conference of Parties in October 2020, in China.

These new global biodiversity targets will become the world's plan to halt the alarming declines in the state of nature, as outlined in the *Global Assessment on Biodiversity* prepared by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). The new targets will build on the Convention's current Aichi Biodiversity Targets, which expire in 2020, and will set out an ambitious plan to galvanise urgent and transformative action by Governments and wider society, including indigenous peoples, local communities, civil society and businesses, to achieve the outcomes the Convention sets out in its vision, mission, goals and targets.

The new global targets will be implemented primarily through national-level activities, with supporting action at subnational, regional and global levels. The targets will provide a global, outcome-oriented framework for the development of national and, as appropriate, regional, goals and targets, and will inform the updating of national biodiversity strategies and action plans to achieve national targets, as well as facilitating regular monitoring and review of progress at the global level.

The first New Zealand Biodiversity Strategy (NZBS) was published in 2000 (DOC and MfE 2000) as part of New Zealand's commitment to help stem the loss of biodiversity worldwide under the Convention of Biological Diversity. This is being replaced with *Te Mana o te Taiao – Aotearoa New Zealand Biodiversity Strateg*y 2020 that outlines priorities and actions until 2050.

New Zealand's marine environment is vast, diverse and unique. The Convention on Biological Diversity is one of a number of international agreements to which New Zealand is a party and has an important role in helping to protect this biodiversity. This includes vulnerable species, threatened species and also those areas of particular importance for biodiversity and ecosystem services, such as these giant kelp (*Macrocystis pyrifera*) forests off Rakiura/Stewart Island. *Photo: Vincent Zintzen*

The importance of Aotearoa New Zealand's biodiversity | Te hiranga o te rerenga rauropi o Aotearoa

In Māori traditions, te ao mārama, the world of light and life, was created when Ranginui, the sky father, and Papatūānuku, the earth mother, were separated by their children, bringing light to the world of darkness. Their children then became atua, deities of the natural world, such as Tāne, atua of the forests and Tangaroa, atua of the ocean. The atua went on to have children of their own, establishing an interconnected family of landscapes, flora, fauna and people. Everything in creation is believed to have sprung from that union of Ranginui and Papatūānuku.

Source: Royal (2005).

This chapter summarises the unique characteristics of the flora and fauna in Aotearoa, along with the complex of environmental drivers that have helped to shape them.

Over and above its intrinsic value, the indigenous biodiversity of Aotearoa is fundamental to Māori culture, as nature and people are entwined through whakapapa (genealogy), te reo (the Māori language), tikanga (custom), toi (the arts), kai (food), rongoā (medicines) and taha wairua (spirituality). This relationship is reciprocal: the people are kaitiaki (guardians) of the natural world, and the natural world is kaitiaki of the people. Consequently, the loss of biodiversity and the growing distance between the people and what biodiversity remains are undermining relationships, responsibilities and practices (Waitangi Tribunal 2011). Biodiversity in Aotearoa also helps to define the 'kiwi' character and contributes to society's sense of national identity. The tourism industry relies on indigenous biodiversity for its international branding.

Surville Cliffs jasmine (*Parsonsia praeruptis*) was once common on the Surville Cliffs (North Cape, Northland), but due to pressures such as browsing by possums, it now has a conservation status of 'Threatened – Nationally Critical'. *Photo: Andrew Townsend*

For 80 million years, the species and ecosystems of Aotearoa have been evolving in geographic isolation. There are several consequences to this isolation and these subject New Zealand to a lot of interest and recognition on the world stage. For example, a large proportion of New Zealand's wildlife is endemic, i.e. found nowhere else in the world (see Fig. 3). This endemism occurs not just at species level, but also at genus, family and order levels. In the marine domain, Aotearoa has the highest number of endemic seabirds globally (Croxall et al. 2012). Some species are only found in very small areas, such as on a single island or mountain, and others are restricted to highly specific habitats, such as geothermal wetlands.

However, most of the country's plants and many of its insects and birds evolved from the same ancestors as Australian species, arriving here within the last 2–7 million years through dispersal by wind, active flight and the tides. The biota in Aotearoa is a mix of recently evolved species and those that are truly ancient (Gibbs 2016).

Another important aspect of Aotearoa New Zealand's biodiversity is that until the arrival of humans, animal and plant species evolved largely in the absence of the terrestrial mammals that are common in most other parts of the world. Aside from bats, which most likely originated from Australia, Aotearoa was a land of birds, some of which evolved quasi-mammalian features or behaviours to exploit the niches which elsewhere would be occupied by mammals.

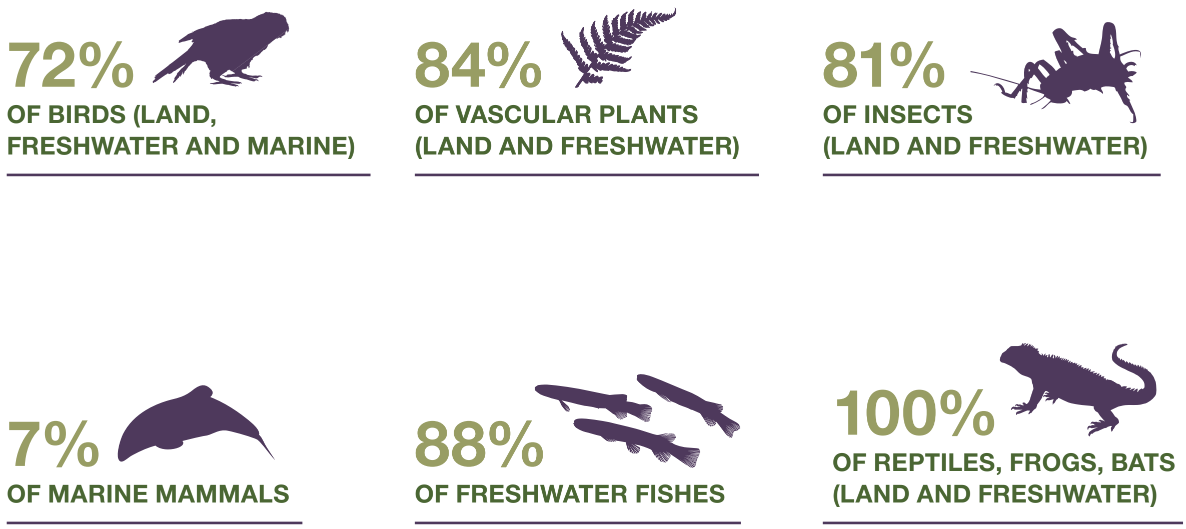


Figure 3. Proportion of New Zealand's indigenous species found nowhere else on Earth. Data does not include extinct species. Sources: Macfarlane et al. (2010); Gordon (2013); NZTCS (2019).

A diverse and complex environment | He taiao kanorau, matatini hoki

The complex landscape and seascape of Aotearoa has shaped its unique biodiversity. Changes in the physical environment have occurred over millions of years at a range of scales. Beneath the country, the Australian and Pacific tectonic plates are colliding. As a result of this collision, the Pacific Plate is subducting under the Australian Plate below the North Island, producing a zone of active volcanism. Under the South Island, the two plates are pushing past each other, producing one of the World's great faults – the Alpine Fault – and the rapidly uplifting Southern Alps/Kā Tiritiri o te Moana. South of the South Island the Australian Plate is subducting under the Pacific Plate. This active tectonic geology makes for a very diverse range of ecosystems that host correspondingly varied plant and animal communities. Braided rivers, alpine screes and lakes formed from earthquake slips are all examples of how tectonic activity has shaped some of our most characteristic ecosystems.

New Zealand's climate is mostly temperate, moderated by the oceans that surround it, so that both winters and summers are milder than on the continents. Our weather, on the other hand, is idiosyncratic. In the South Island the persistent westerly winds meet the Southern Alps/Kā Tiritiri o te Moana and create a rain shadow which sees a sharp gradient between the wetter western areas and the dry zones of the eastern lowlands.

The country's marine environment (territorial sea and exclusive economic zone, EEZ) covers a massive 4.2 million km^2, 15 times larger than its land area and one of the largest EEZs in the world. The marine domain stretches from the subtropical waters off the Kermadec Islands/Rangitāhua to the chill subantarctic waters surrounding Campbell Island/Motu Ihupuku.

Looking northeast over Sedgemere Flat towards Mount Tapuae-o-Uenuku, Molesworth. This is an example of a glaciated, intermontane valley basin that has formed in a tectonic environment along the Awatere Fault (shadow through the left of the picture). The land on the left (northwest) side of the fault has been displaced right-laterally (away from view) and also uplifted, impeding drainage into the Wairau River, causing wetlands and lakes to form on its southeastern side. *Photo: Andrew Townsend*

Understanding and measuring Aotearoa New Zealand's biodiversity | Te mārama me te ine i te rerenga rauropi o Aotearoa

This chapter outlines the variety of data, information and knowledge that are used to describe, assess, monitor and manage biodiversity in Aotearoa. For each of the land, freshwater and marine domains described in this document, findings have been summarised from biodiversity assessments ranging in scale from detailed genetic analyses to imagery of vegetation captured by orbiting satellites. Key data sets and resources used in those assessments which indicate current trajectories or predicted trends in knowledge are summarised in the following sections. There is also an assessment of where there are gaps in knowledge and a lack of tools or systems available to capture information and enhance our understand of biodiversity in Aotearoa. A *case study* describing the way that currently available datasets and tools guide DOC's conservation priorities is provided. Further discussion on data and knowledge gaps for specific taxa groups and ecosystems can be found in the land, freshwater and marine domain chapters.

There are notable differences in the completeness of knowledge available between species groups and domains. To put this into context, the Parliamentary Commissioner for the Environment (PCE) in *Focusing Aotearoa New Zealand's environmental reporting system* (2019) found that environmental monitoring, particularly for biodiversity, contains major gaps and, where undertaken, is often fragmented. The PCE also reported that a lack of consistency and barriers to accessing results make it difficult to construct a coherent national picture from disparate sources. This is due in part to the difficulty in detecting and quantifying biodiversity. A host of organisms and a wide range of ecological, functional and physiological processes must be investigated, from those detected at a microscopic level through to landscape-scale trends, and over timeframes from seasonal to decadal. This in part explains the limited coverage of biodiversity in most environmental assessments to date.

The information that is available to help assess biodiversity can be separated into three broad categories – species, ecosystems and spatial datasets. Within these categories there are a range of tools, methods and datasets, including some important examples that are outlined in the following sections and subsections.

Scientists searching for the liverwort *Frullania wairua* (conservation status 'Threatened – Nationally Critical') on twigs that have fallen from the canopy of one of only two known rātā moehau (*Metrosideros bartlettii*) host trees (also 'Threatened – Nationally Critical'). *Photo: Andrew Townsend*

Species | Ngā momo

Māori and Western ways of understanding the connections between and within species differ. Whakapapa (genealogy) is fundamental to Māori knowledge, and genetics to Western knowledge. For Māori, whakapapa underpins all interconnections, and is important for conveying knowledge. The whakapapa of the various families and species of flora and fauna highlights the links between them and relates to the order in which the emergence of species occurred (Marsden 2003). However, mainstream conservation management does not yet integrate the concept and understandings of whakapapa in a cohesive way.

The three main groups of species data that are currently used in addition to whakapapa to help people understand species and prioritise them for conservation management are outlined in the following sections. These are taxonomy (the science of classifying organisms), conservation genetics and species conservation status.

Powerful new genetic techniques have greatly helped in improving our understanding of biodiversity. Evolutionary genetics underpin taxonomy, while conservation genetics are pivotal in the study of depleted populations. Species conversation status helps to understand the risk that the country's indigenous biota face and therefore allows for the prioritisation of effort to manage populations and avoid extinctions.

In addition to the three main groups of species data, the study of a species' ecology (autecology) also assists with an understanding of a species' conservation status and management requirements. When species data indicate a need for management intervention to conserve a species, autecology is essential for developing an appropriate management regime. However, studies of individual species' ecology are lacking (e.g. for the New Zealand flora only 15 studies have been published in the New Zealand Biological Flora series, the most recent being Nepia & Clarkson (2018)).

The orange-fronted parakeet/kākāriki karaka (*Cyanoramphus malherbi*) provides an excellent example of the importance of taxonomy for conservation. During the 1990s, the orange-fronted parakeet/kākāriki karaka was considered to be a colour morph of the yellow-crowned parakeet/kākāriki kōwhai (*Cyanoramphus auriceps*) which is not considered threatened. However, more recent genetic analysis revealed that these were two separate species, and the orange-fronted parakeet/kākāriki karaka now has a conservation status of 'Threatened – Nationally Critical', in part because appropriate conservation action was not taken earlier. *Photo: Sabine Bernert*

Taxonomy | Te pūnaha whakarōpū

To conserve a species, the entities being worked with and the relationships between them need to be known. Evolutionary genetics underpin modern taxonomy which, in turn, underpins conservation. However, more traditional taxonomy based on morphology (form, shape or structure) is also crucial. If species are to be conserved, the entities being worked with and the relationships between them need to be known.

Comprehensive taxonomic data are generally only available for well-known large vertebrates, such as birds, and commercially important species, such as some marine fishes. In some groups of organisms (e.g. land snails), new species are being discovered faster than taxonomic research can be completed. In marine systems, the cumulative rate of discovery of new species is still increasing, highlighting the ongoing need for taxonomic expertise (Lundquist et al. 2014). Lack of progress in taxonomic research poses significant risks to threat classification and consequent decisions to invest in species conservation (Gerbeaux et al. 2016).

There are instances where conservation opportunities have been missed or misdirected because the taxonomy was lacking. For example, the kākāriki karaka/orange-fronted parakeet is listed as 'Threatened – Nationally Critical' in part because during the 1990s it was not considered distinct from kākāriki kōwhai/yellow-crowned parakeet which is not threatened (Kearvell et al. 2003), so no conservation action was applied to it. Conversely, tuatara from Ngāwhatu-kai-ponu/The Brothers Islands in the Cook Strait previously monopolised species recovery effort because they were mistakenly assumed to belong to a separate species (Daugherty et al. 1990). Taxonomic certainty helps to remove such doubts and ensure species recovery efforts are well targeted.

Gaps in taxonomic knowledge are, at best, being addressed slowly and inconsistently across life forms. The number of taxonomists working in New Zealand Crown Research Institutes and museums has fallen since 1995 (Taxonomy Decadal Plan Working Group 2018) and the employed workforce has an aging demographic. Seventy-seven percent of publicly funded taxonomists spend less than 25% of their time on taxonomic research, and 60% spend less than 10% (Taxonomy Decadal Plan Working Group 2018). Resourcing for key biological collections is commonly inadequate and uncoordinated. This exposes New Zealand to the risk of failing to recognise and protect unique endemic species.

Conservation genetics | Te mātai iranga whāomoomo

Conservation genetics is pivotal to informing management of depleted populations. When a species loses its genetic diversity, its recovery becomes harder because it often has some or all of the following: reduced vigour, increased reproductive failure, increased susceptibility to disease and a weakened resilience to change (Jamieson 2015). An example of this can be seen in the genetically bottlenecked Stewart Island/Rakiura population of kākāpō, in which approximately two-thirds of eggs fail to hatch (Briskie & Mackintosh 2004).

Across the terrestrial and freshwater domains, the population structure and genetic diversity of many species of vertebrates (including bats, reptiles, frogs, freshwater fish, and some groups of invertebrates, fungi, algae and plants) have been documented. However, many groups of plants, invertebrates and others – especially in the marine domain – are unstudied (Nelson et al. 2015a).

Although large gaps remain, knowledge of the genetics of the New Zealand biota is growing rapidly. Environmental DNA (eDNA) allows inventories of species to be made by sampling and extracting genetic material directly from soils, sediment and water and is efficient, non-invasive and easy to standardise. There have been new discoveries in the presence and distribution of vascular and non-vascular plants, and even vertebrates, using this technique (Holdaway et al. 2017).

Species conservation status | Te tūnga whāomoomo o ngā momo

This report utilises New Zealand Threat Classification System (NZTCS) data extensively to report on the conservation status of species. All data were derived from the NZTCS database on 25 November 2019 (NZTCS 2019). They do not account for changes to the NZTCS database since then.

Understanding a species' extinction risk is critical for decision making and conservation management. In Aotearoa, the NZTCS, administered by DOC, is used to determine the extinction risk of species by assigning each one with a conservation status (Fig. 4). The current version of the NZTCS was developed in 2008 to provide a national system that complements the global Red List[11] provided by the International Union for Conservation of Nature and Natural Resources (IUCN), but which is more sensitive to New Zealand's specific needs and conditions (Gerbeaux et al. 2016).

Assessments are published online in NZTCS reports[12] and in the NZTCS database[13]. Reports are prepared for groups of species based on their taxonomic relationships (e.g. birds, reptiles) or shared environments (e.g. freshwater invertebrates, marine mammals). The NZTCS assesses the risk of extinction for native species that occur or have occurred in the wild in Aotearoa. Statistics and graphical representations in this document that refer to NZTCS data include extant (living) and resident native species. They exclude extinct, exotic or non-resident native 'Coloniser', 'Migrant'. 'Vagrant' species.

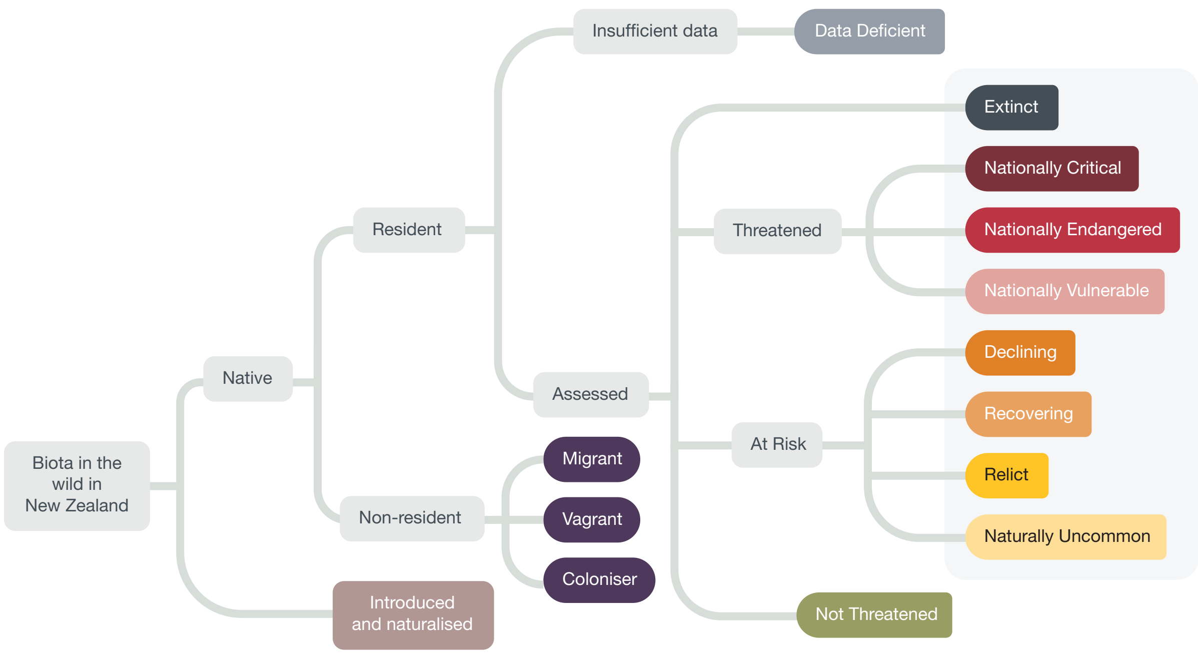


Figure 4. The New Zealand Threat Classification System (NZTCS). The NZTCS comprises four major categories for extant (living) resident native species: 'Data Deficient', 'Threatened', 'At Risk' and 'Not Threatened'. There is a separate category for 'Extinct' species. The 'Threatened' and 'At Risk' categories are divided into conservation statuses to indicate the level of threat that has been assessed for a species. Source: NZTCS (2019).

[11] https://www.iucnredlist.org/
[12] https://www.doc.govt.nz/about-us/science-publications/conservation-publications/nz-threat-classification-system/
[13] https://nztcs.org.nz

Resident native species fall into one of three broad conservation status categories – 'Threatened', 'At Risk' or 'Not Threatened' (Fig. 4).

- 'Threatened' species whose populations are in decline face imminent extinction if current trends are not arrested. 'Threatened' species that have stable populations are highly susceptible to stochastic (unpredictable) events that could lead to extinction. The 'Threatened' category comprises three conservation statuses that reflect the severity of risk: 'Nationally Critical', the most severe level of threat, followed by 'Nationally Endangered' and 'Nationally Vulnerable'.
- 'At Risk' species are buffered from extinction by the size and state of their populations but are likely to become 'Threatened' should pressures on their populations worsen. There are four 'At Risk' conservation statuses: 'Declining', 'Recovering', 'Relict' and 'Naturally Uncommon'.
- Species that meet none of the criteria to be 'At Risk' or 'Threatened' are 'Not Threatened'.

NZTCS includes as 'resident native', migratory species that breed in Aotearoa (long-tailed cuckoo/koekoeā and shining cuckoo/pipiwharauroa) and migratory species that have more than 25% of their global population spending more than 50% of their life in Aotearoa (eastern bar-tailed godwit and lesser knot).

In addition, there is a fourth major category – 'Data Deficient' – meaning there is insufficient information to assess their risk of extinction. Some 'Data Deficient' species are so poorly known and have not been observed for such a long time that they may be extinct.

See Appendix 1 for the full list of taxonomic groups and numbers assessed for 'Threatened' and 'Data Deficient' categories under the NZTCS.

NZTCS assessments utilise panels of experts to assess extinction risk of resident, native species based on estimates of population sizes and trends (trend referring to the general direction of population change based on the best data and knowledge available the expert panel at the time). Information used in the assessments draws from databases held by Manaaki Whenua – Landcare Research, the National Institute of Water and Atmospheric Research (NIWA) and others, and is supported by observational monitoring data, mātauranga Māori, citizen science initiatives and expert anecdotes. Assessments are reviewed approximately every 5 years. NZTCS statistics in this report draw attention to the relatively small proportion of species that have a change in conservation status between assessments because of population trend (Fig. 5). However, in reality a much greater number of species have declining population trends, but that does not result in a change of conservation status at assessment time because the decline is not pronounced enough to reach the threshold required. This includes species that are classified 'At Risk – Declining'.

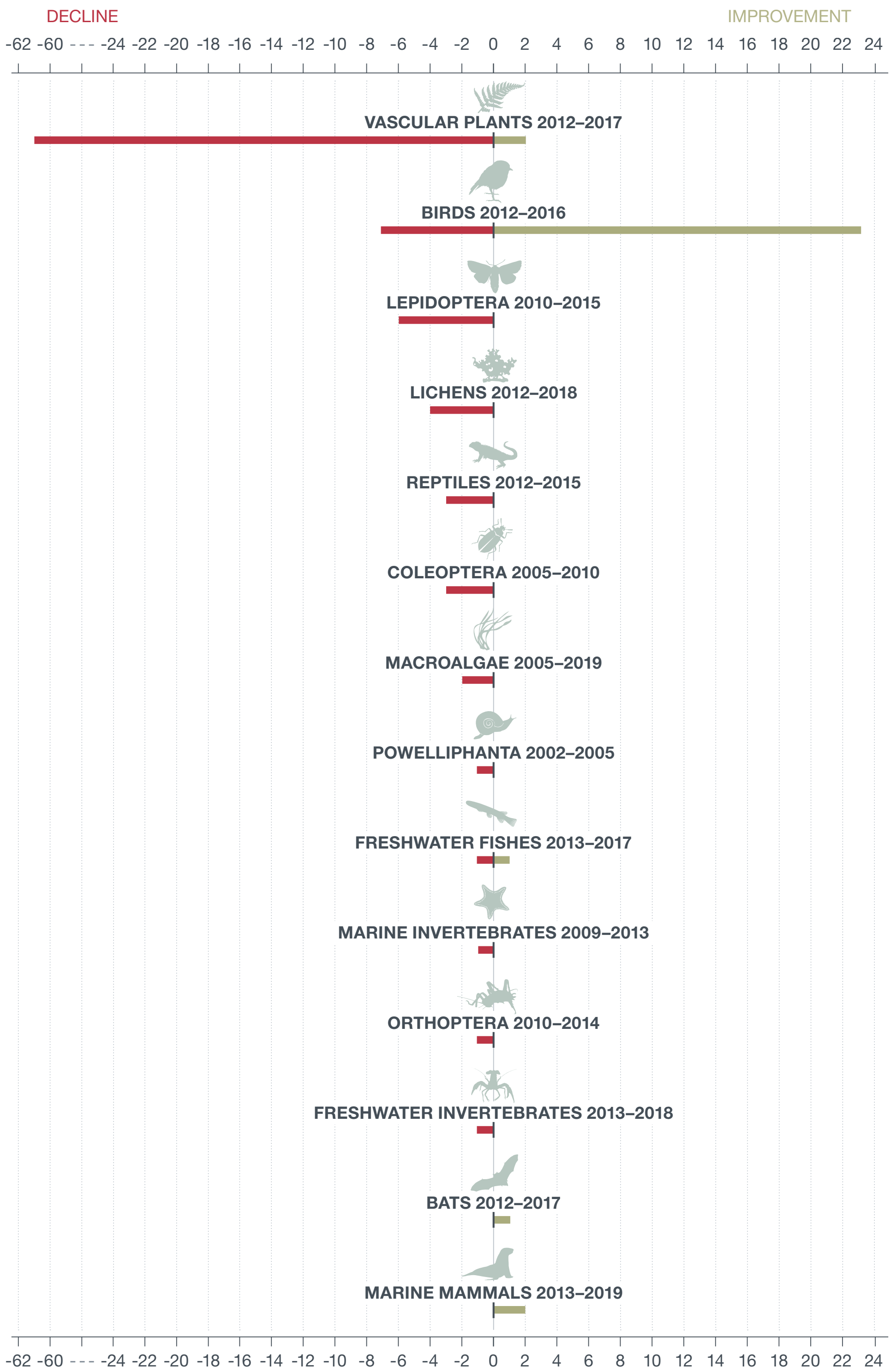


Figure 5. The number of species for which declines (red lines) or increases (green lines) in populations have resulted in a change of conservation status between the last two NZTCS assessment years. Population trends of the species being assessed are measured over three generations or 10 years, whichever is longer. Those species that have changed status because their assessments were more accurate due to improved knowledge are not included in this figure. Source: NZTCS (2019).

There are caveats around the use of the NZTCS in this report. Species in the NZTCS database are assigned to one of three environmental domains – land, freshwater, and marine. Many species may occupy two or all three domains during their life cycles, so their assignment to a particular domain is arbitrary and open to debate. This is especially so for highly mobile species and species that occupy ecotones (transition zones between two ecosystems).

The lack of population state and trend data can make it difficult to accurately assess the conservation status of species – 5000 of the c. 14,000 species listed are 'Data Deficient'. Furthermore, 1600 species that have a conservation status are qualified as 'Data Poor' because confidence in the accuracy of their assessments is low. Lack of information prevents effective management to protect most 'Data Deficient' and 'Data Poor' species. In addition, approximately 10% of listed species in the NZTCS are considered 'Taxonomically Unresolved' and the true figure is likely to be even greater as new species are discovered and because of historical reluctance to list taxonomically uncertain species. Until the taxonomic status of these species is resolved, the validity of their threat classification is uncertain.

The groups for which comprehensive assessments are available are:

- terrestrial and freshwater vertebrates
- marine mammals
- vascular plants, hornworts and liverworts
- lichens
- chondrichthyans (chimaera, rays, sharks, skates)
- marine macroalgae
- stick insects
- Orthoptera (grasshoppers, wētā and their relatives)
- Onychophora (peripatus or velvet worms)

Despite ongoing research work, non-lichenised fungi, mosses, freshwater macroalgae, bony marine fish, and nearly all invertebrates (terrestrial, freshwater and marine), which represent by far the majority of New Zealand's biota, are not yet treated comprehensively in the NZTCS. For more details, see Appendix 2.

Ecosystems | Ngā pūnaha hauropi

> From a whakaaro Māori perspective, Papatūānuku, the Earth mother, provides a web of support systems for her all her children – humans, birds, plants, microbes and insects – and each of them, in turn, support the functions of their mother. Mauri, the life force, sustains it all, harmonising the ecosystems and biological functions. Strong mauri means the ecosystem and its components will flourish, while depleted mauri will weaken them.
>
> Source: Marsden (2003).

Ecosystems comprise communities of living organisms and the physical and chemical environment they live in. Ecosystem state and trends are described in this section using three approaches that are applicable across all domains. These are ecosystem classification, ecosystem mapping and ecosystem integrity. A considerable amount of work has been done to develop methods (tools) for these, although data collection and management has, to date, been inconsistent and limited. For those data and mapping layers that are available, predictions and assessments are often strengthened by using combinations of available layers (e.g. Threatened Environments Classification). For the most part, however, published datasets and research only describe some types of ecosystems, in selected places (Gerbeaux et al. 2016).

Ecosystem classification | Te whakarōpū pūnaha hauropi

Classification is a way to recognise the full range of indigenous ecosystems in Aotearoa. An ecosystem classification (or taxonomy) is needed to reflect people's intuitive recognition that, for example, an alpine bog is different to a lowland swamp (although both are wetlands).

New Zealand's ecosystems are described using various classifications. While ecosystems can potentially be defined at a range of scales and there is no agreed standard across all domains, classifications are essential for identifying management or research priorities. Some terrestrial classifications are based on quantitative survey data (e.g. Wiser et al. 2016), while others take a largely qualitative view of ecological drivers and pattern (e.g. Singers & Rogers 2014). They are typically based on structurally dominant vegetation. However, while vegetation pattern is a widely used surrogate for ecosystem distribution, it does not capture all elements of indigenous biodiversity (e.g. highly mobile fauna). Freshwater systems have been grouped into data-derived classes in both Freshwater Environments of New Zealand (FENZ) and the River Environment Classification (REC). The FENZ geodatabase provides a national depiction of biodiversity values and pressures on New Zealand's rivers, lakes and wetlands. It consists of spatial data layers and information about environmental and biological patterns, with separate datasets for rivers and streams, lakes and wetlands (Leathwick et al. 2010; West et al. 2019). The REC database maps every segment of New Zealand rivers according to physical factors such as climate, source of flow for the river water, topography and geology, and catchment land cover. Several environmental classifications are available for use in the New Zealand marine environment, including several that cover both the territorial sea and exclusive economic zone. Examples include the New Zealand Marine Environment Classification (Snelder et al. 2005), Benthic-Optimised Marine Environment Classification (Leathwick et al. 2012), and a classification optimised for demersal fish (Leathwick et al. 2006), which live on or near the sea floor. Estuaries and margins have also been classified (Hume et al. 2016). These classifications can be useful for predicting the patterns in biodiversity across the marine domain and for informing the implementation of conservation and management measures. However, they have rarely been intensively tested and generally reflect spatial patterns at a single point in time, so may be of limited value for understanding the state and trend in marine biodiversity. Regularly re-running models for some classifications may provide a mechanism for better understanding temporal changes in biodiversity, including how spatial patterns in biodiversity respond to changing environmental drivers.

Ecosystem integrity | Te toitū pūnaha hauropi

What is ecological integrity, health and mauri? | He aha te toitū pūnaha hauropi, te hauora, te mauri hoki?

In mātauranga Māori approaches, factors such as mauri, iwi health and well-being, and tikanga are used to assess the health of an ecosystem. This is a wider concept than ecological integrity and encompasses intangible elements of wairua and whakapapa (McGlone et al. 2020). Although models have been developed to help translate Māori values and concepts between knowledge systems (Harmsworth et al. 2016, Rainforth & Harmsworth 2019) the components of mātauranga Māori cannot necessarily be separated out or collated for use in describing national states or trends because mātauranga Māori is often inherently place-specific:

You don't learn mātauranga, you become part of it and in time you come to see and understand what is needed to ensure that the balance is maintained. Because of this active connection to the environment you only gain mātauranga specific to the environment in which you are immersed (Robert (Pā) McGowan pers. comm. 2020).

Ecosystems with high integrity are those that maintain the full range of flora and fauna as well as the physical elements of their environmental (e.g. soil, water) and occupy their full environmental potential. These elements need to be functioning in a sustainable way. Ecosystem health is used to describe the state of an ecosystem in relation to its ability to support ecosystem services. It also needs to function in a sustainable way. However, an ecosystem may be deemed to have a high level of health but still low ecological integrity because, for example, it lacks the representation or dominance of indigenous elements (Lee et al. 2005).

The health of an ecosystem can be gauged by the presence or absence of 'typical' native species, the balance of different types, ages and sizes of organisms, physico-chemical state, and the maintenance of functions and processes. Ecological integrity is a term used to describe the degree to which many of these attributes have been modified (e.g. Fig. 6).

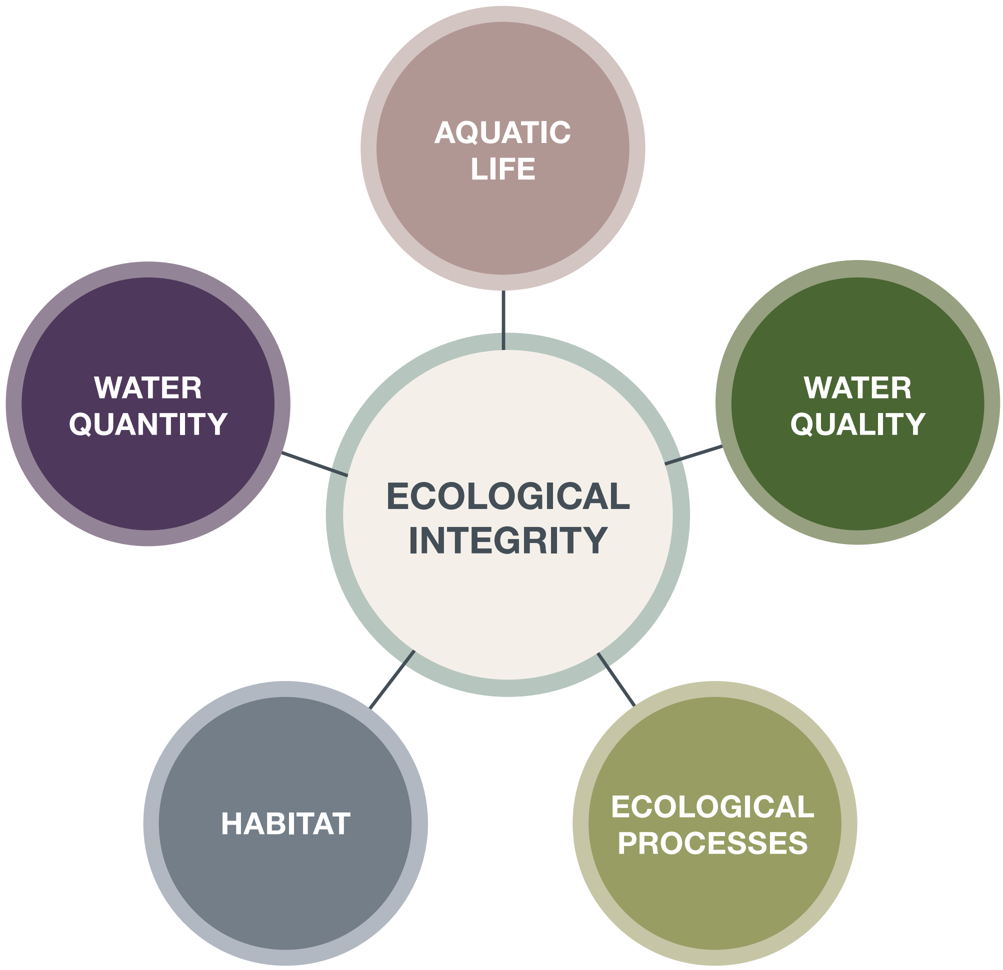


Figure 6. A framework for a freshwater ecosystem showing the five core components that inform its ecological integrity Source: Clapcott et al. (2018) (reproduced with permission of copyright holder the Ministry for the Environment).

Indicators of ecological integrity | He tohu mō te toitū pūnaha hauropi

There is insufficient information to fully assess the ecological integrity of ecosystems across Aotearoa (MfE & Stats NZ 2019a). Data collection of the indicators of ecosystem integrity is limited, as is co-ordinated curation of information that does exist. However, work has been done to develop a basis upon which to advance this area. There are standard regional government biodiversity indicators (Lee et al. 2005; Bellingham et al. 2016). DOC has used the outcome monitoring framework (OMF) originally set out by Lee et al (2005) and revised and updated by McGlone et al. (2020) to support the development of a quantitative, field-based monitoring programme for ecological integrity – data elements combine to form a measure, and multiple measures are combined to provide information about an indicator.

Several indicators would represent progress towards meeting an objective that will maintain or improve ecological integrity. The high-level outcome objectives in the framework are: 1) maintaining ecosystem processes, 2) limiting environmental contaminants, 3) reducing spread and dominance of exotic species, 4) preventing declines and extinctions, 5) maintaining ecosystem composition, 6) ensuring ecosystem representation, 7) adapting to climate change and 8) human use/interaction with nature. The spatial extent of ecosystems, and the relative proportion of these that is formally protected, are measures that are readily monitored at regional- or national-level scales using spatial datasets (see below). Most other elements of ecological integrity are more likely to be evaluated at limited sites, as there are few systematic national-scale monitoring programmes.

Monitoring ecological integrity | Te aroturuki i te toitū pūnaha hauropi

The most comprehensive and extensive systematic long-term monitoring programme presently operating in Aotearoa to report on state and trend in terrestrial biodiversity is Tier 1, undertaken by DOC across all Public Conservation Land (PCL). The Tier 1 network builds on and extends the Ministry for the Environment's (MfE's) Land-use Carbon Analysis System (LUCAS), in place since 2002 for reporting on carbon stock and change in Aotearoa New Zealand's forests and shrublands.

Tier 1 monitoring is carried out at approximately 1400 sites across PCL and involves the collection of data on structure and composition of vegetation communities, browsing mammals and birds. DOC has been reporting on status and trends in indicators and measures derived from this programme since 2013. Data from this programme routinely contribute to meeting National and International reporting obligations and several reports based on Tier 1 data are referenced in this report.

Some regional councils have established similar programmes on lands of other tenure. Citizen science programmes like the Atlas of New Zealand Birds also provide data for nationwide trend assessments (Walker & Monks 2018). These data illustrate a useful high-level state but may not pick up local detail. They also do not necessarily record more cryptic groups, although some targeted case studies (e.g. wetland bird conservation projects) help to fill this gap. Naturally uncommon ecosystems (see *Naturally uncommon ecosystems* section in the *Land domain* chapter) are poorly sampled within national programmes, with research being largely confined to inventories of specific types of ecosystem (e.g. Rogers & Wiser 2010). Sampling designs that provide for coordinated, multi-agency monitoring at a range of sites and scales (van Dam-Bates et al. 2018) will help to redress some of these deficiencies.

Freshwater assessments, too, are mostly based on spatially limited case studies – some interweaving science and mātauranga Māori (e.g. Harmsworth et al. 2011) – or from advantageous collation of surveys that are not designed to be nationally representative (e.g. Larned et al. 2018). For marine environments there are comprehensive data for some areas and for some components of biodiversity (for example, harvested fish stocks and some protected species). However, data collection and storage are not always consistent and co-ordinated (e.g. relating to coastal water quality, MfE & Stats NZ 2019b). This makes it difficult to synthesise knowledge into a clear description of national state and trend, although individual case studies can provide compelling evidence.

While it is known that many human impacts and invasive species are detrimental to ecological integrity (e.g. de Jaun et al. 2015; Clapcott et al. 2018), the precise way in which multiple pressures interact, particularly as the climate changes, remains unclear. Internationally, ecosystem monitoring is now paying more attention to social and cultural indicators (Sterling et al. 2017) and, in Aotearoa, councils must now include mātauranga Māori in freshwater monitoring plans and a growing range of tools is available to help them do this (Rainforth & Harmsworth 2019).

Recent innovations, such as spectral remote sensing use satellite or aerial imagery to interpret elements of biodiversity. This can help in assessing some aspects of ecosystem function. For example, by measuring the reflectance of two or more wavelengths, the chlorophyll *a* concentration in the ocean can be quantified, providing an indicator of marine ecosystem productivity. Research is underway to apply similar concepts to terrestrial forest flowering and fruit production. Other uses for spectral imaging include monitoring forest health (e.g. detecting kauri dieback disease) and locating wilding conifers.

There are opportunities to integrate all sources of knowledge (including mātauranga Māori, Western knowledge, whānau/hapū/iwi-led monitoring and citizen science) to improve general understanding of biodiversity and people as part of ecosystems (Lyver et al. 2017).

Spatial datasets | Ngā huinga raraunga mokowā

Ideally, it would be possible to map the distribution of all indigenous species and ecosystems so that changes in extent and condition can be assessed over time. However, this is not yet the case because spatial information is lacking for many species and ecosystems. Species distribution data is better understood for some groups (such as birds) than others (such as invertebrates). Good data on the extent and distribution of indigenous ecosystems varies in availability, detail and scale, so that trends in extent must be assessed instead from regional case studies of specific ecosystem types (e.g. Booth 2019; Robertson et al. 2019) or coarse cover classes (e.g. Cieraad et al. 2015).

A full range of terrestrial ecosystems have not been mapped nationally, though several Regional Councils have done so using the Singers & Rogers classifications (2014) or local variants of this. Mapping by vegetation cover class is the most common surrogate, as described below.

National-scale indicators used across the land domain include the New Zealand Landcover Database (LCDB), Legally Protected Areas, Land Environments of New Zealand (LENZ) and Threatened Environments Classification (TEC).

Land classifications | Ngā whakarōpūtanga whenua

New Zealand Land Cover Database (LCDB)

The LCDB uses satellite imagery to map all land in Aotearoa according to cover classes, including a range of exotic and indigenous vegetation classes. It has been updated five times between

1996 and 2018, at a minimum patch size of 1 ha, so that changes in the extent of indigenous cover can be seen, subject to a 5% margin of error (Dymond et al. 2017).

An increased availability of LiDAR (3D laser scanning) in Aotearoa will also support other indicators by providing accurate representations of topography and landforms.

Legally protected areas | Ngā wāhi whai haumaru ā-ture

Legally protected areas comprise those parts of the country (land, freshwater and sea) that are secured by law for conservation purposes (e.g. national parks, conservation covenants, water conservation orders, marine reserves). Spatial data about protected land are held in the National Protected Areas Land Information System (NaPALIS), maintained by DOC and Land Information New Zealand (LINZ). It is used to describe trends in habitat protection (Robertson 2016). Nga Whenua Rāhui kawenata (covenants) are mapped, but traditional Māori methods of protecting specific species or areas, such as rāhui and tapu, are not necessarily recorded publicly.

Land Environments of New Zealand (LENZ)

LENZ classifies landscapes according to combinations of climate, topography and soils. There are some limitations to elements of LENZ. For example, the climate component is based on averages from 1950 to 1980, and soils data are biased towards agricultural landscapes where soil sampling has been more intensive. Despite these limitations it is an extremely important tool for mapping and quantifying potential surrogate indigenous ecosystems, or land environments, based on environmental drivers.

Threatened Environments Classification (TEC)

LENZ, LCDB and Legally Protected Areas combined allow the calculation of the Threatened Environments Classification (TEC). TEC quantifies remaining indigenous land cover and legal protection and allocates different environments a 'threat status' (Cieraad et al. 2015). TEC quantifies the state and, with continued iterations of LCDB, trends in indigenous vegetation cover over each of the land environments from LENZ. This illustrates the degree of indigenous vegetation remaining within land environments, and therefore how past vegetation loss and legal protection are distributed across New Zealand's landscape (e.g. it highlights the immense loss of lowland forests on plains), along with the ability to track ongoing change.

Freshwater classifications | Ngā whakarōpūtanga wai māori

As described in the *Ecosystem Classification* section, the FENZ database was developed under a similar process to LENZ, describing the physical and biological character of rivers, lakes and wetlands. It provides for an independent, national representation of values and pressures on these environments, which can be used for conservation prioritisation and freshwater ecosystem management (Leathwick et al. 2010; West et al. 2019). REC is a database of catchment spatial attributes summarised for every segment of New Zealand's river network, which is used for classification and modelling. While neither database is used for freshwater biodiversity state and trend reporting per se, they do provide an opportunity to report on state and trend for particular freshwater ecosystem types.

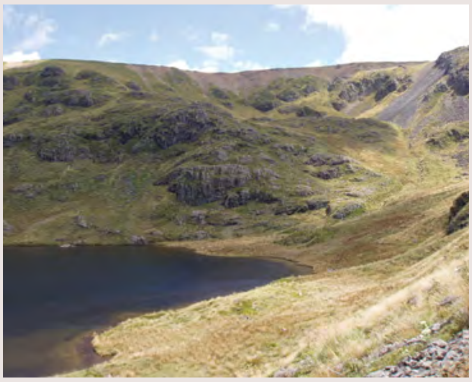
Marine classifications | Ngā whakarōpūtanga moana

A number of initiatives have involved mapping the New Zealand marine environment, including Ocean Survey 2020 and other efforts, by research institutes, industry and central and local government agencies. Collation of these data sets and using a consistent approach to mapping biodiversity would provide additional opportunities to improve reporting on the state and trend in marine ecosystems (Clark & Roberts 2008; Beaumont et al. 2010; Hewitt et al. 2011a & b; Bowden & Hewitt 2012).

Setting priorities for biodiversity conservation at the Department of Conservation

The Department of Conservation (DOC) uses a site-based prioritisation system to help guide its ecosystem and species management.

DOC uses the spatial conservation planning software 'Zonation' to identify priority sites that meet its objectives to conserve the full range of New Zealand ecosystems to a healthy, functioning state and ensure the survival of threatened species. It ranks potential management sites in an order that gives the best coverage of the full range of New Zealand ecosystems and threatened species habitat, taking into account management potential and cost.



Lake Peel lies within the diverse matrix of ecosystems which comprise the Wharepapa / Arthur Range Management Unit. The Peel Range in the background is in the adjoining Cobb Management Unit. *Photo: Simon Moore*

Sites have been selected as the best examples to represent one or more ecosystem types and/or as having potential to make an important contribution to the security of species known to need conservation management. Most sites are important for both ecosystems and threatened species.

In 2018, the rankings were updated to incorporate the integrated ranking of 1375 ecosystem-and-species management units. This included new information about populations of c. 500 species in need of conservation management. During the ranking, threatened species were weighted according to the following factors: threat status, taxonomic uniqueness and degree (or depth) of endemism. Each ecosystem type was also weighted relative to its remaining national extent meaning, for example, that wetlands, sand dunes and lowland forests tend to be weighted higher than more common and less depleted ecosystems.

Integrating ecosystem and species priorities aims to conserve species populations within sites of high ecological value where possible. This provides efficiencies where management aimed at improving ecosystem integrity also benefits threatened species.

A site's relative contribution to the overall group is assessed based on the following criteria:

- The degree to which the ecosystem type(s) at a site contribute to representation of the full range of all native ecosystem types.
- Ecosystem integrity.
- Difference made by management.
- Presence of populations of threatened species and the importance of the site's contribution to conserve those species.
- Cost.

The Zonation software uses this information to place potential management sites in a ranked order. Results are used as a decision support tool to help allocate resources for conservation. Treaty Partner priorities are part of the resource allocation process. Some sites may already be subject to conservation effort from community groups or other partners and this is factored into decision-making.

Pressures and their impacts on biodiversity | Ngā pēhanga me ō rātou pānga ki te rerenga rauropi

This chapter has been structured using the same pressure categories as described in the Global Biodiversity Crisis chapter (*What are the pressures causing these losses?*). The categories used here to describe the pressures are somewhat artificial as, in reality, many pressures act in combination, sometimes in unexpected ways. This chapter does not provide a comprehensive list of every pressure impacting New Zealand's biodiversity; but rather, an overview of the key pressures driving biodiversity loss in the country with a focus on introduced invasive species, as they are such a significant threat to New Zealand's threatened species. Other pressures that impact specific species groups are covered in the shorter 'Pressures' sections in the domain chapters (*Land* domain, *Freshwater* domain, *Marine* domain).

Natural pressures and drivers have always shaped New Zealand's ecosystems and biota, and still do today. Since human arrival, however, a variety of pressures have triggered a wave of extinctions and continue to exert momentous change. Since humans arrived in Aotearoa, at least 79 species have become extinct, 59 of which are birds. Direct and indirect pressures that are reducing the health of ecosystems globally are also causing New Zealand's native plants and animals and the ecosystems they inhabit to decline or are acting as barriers to their recovery.

Because of the many connections, biotic and abiotic, between domains, the decline of terrestrial biodiversity and ecosystems can have profound effects on marine and freshwater environments, and vice-versa. Many species rely on two of these domains – sometimes all three – at some point in their life cycles. Sometimes this reliance is present but less distinct – a marine organism may continually occupy an estuarine habitat, yet it is still subject to impacts from the land domain (e.g. predation, sedimentation or nutrient run-off). Additionally, the cumulative and complex effect of multiple and ongoing pressures is significant.

Wilding conifer control in Kaweka Forest Park. *Pinus contorta* were originally planted in some areas of New Zealand to counter erosion, but have self-seeded and caused infestations of wilding pines throughout the country (along with other introduced conifer species). *Photo: Dave Hansford*

Introduced invasive species | Ngā momo rāwaho urutomo

This section covers species that have been introduced to Aotearoa by humans, either on purpose (e.g. stoats) or accidentally (e.g. Argentine ants), and invasive species that came here naturally, such as myrtle rust, which was likely to have been carried here by wind.

German wasps (*Vespula germanica*) were accidentally introduced to New Zealand in the 1940s and have become widespread. Along with common wasps (*Vespula vulgaris*) they are a major problem in beech forests where they consume massive amounts of honeydew (as seen in this photo) which native birds, bats, insects and lizards rely on for food. They also harm our native birds and insects, and are a threat to human health and recreation. *Photo: Sid Mosdell*

Mammalian predators | Ngā konihi whāngote

Introduced predatory and omnivorous mammals, which include mustelids (stoats, weasels and ferrets), feral cats, hedgehogs, possums, pigs, mice and three species of rats, are widespread in terrestrial systems. They prey on numerous indigenous species, including birds, bats, reptiles, frogs, large invertebrates (such as wētā and giant land snails) and, in some cases, freshwater mussels/kākahi. Native species have already become extinct because of mammalian predation and were it not for islands free of mammalian predators, many more would have followed suit. Numerous birds, reptiles and large invertebrates have disappeared completely from the mainland and now survive only on islands (Towns et al. 2012). Mammalian predators are the main agent of decline for most of New Zealand's terrestrial fauna (see *Land domain* chapter) and seabirds (see *Marine birds* section of *Marine domain* chapter), and as such are targeted in multiple control or eradication programmes (see *predator free case study*).

Monitoring consistently shows that predator impacts have not reached an equilibrium, so native species will continue to decline into extinction if nothing is done (e.g. Hare et al. 2019). The heartening news is that native species usually recover well, often spectacularly, when predation pressures are removed (Nelson et al. 2018). Aerial application of baits containing the toxin 1080 are timed to reduce rat population explosions that are triggered by episodes of prolific beech seeding known as 'masting' (Walker et al. 2019). These periodic bait drops are effective because normal seeding years between masts do not support large, damaging populations of rats in beech forest. Rat control in more productive northern broadleaf/podocarp forests, where the food supply is consistently high, demands a permanently sustained effort. Stoats are also the target of aerial 1080 drops because their numbers increase with rodent abundance. They then switch prey from rodents to native species, particularly forest birds, as rodent numbers decline.

Predator Free 2050

Predator Free 2050 (PF2050) is a programme that aims to rid Aotearoa of its most damaging introduced predators – rats, mustelids (stoats, weasels and ferrets) and possums. A national Predator Free Strategy was launched in March 2020. The PF2050 programme relies critically on collaboration – no single entity can reach this ambitious goal alone. Central and local government agencies, Treaty partners, science and knowledge providers, philanthropists, innovative businesses and landowners, non-government organisations (NGOs), communities, individuals and other entities are all part of PF2050. The PF2050 Strategy drives three phases of action – mobilise, innovate, accelerate – people mobilising to take action, innovative tools and technology being created and tested, and accelerating action once people are mobilised and the technical know-how is in place.

A stoat trap being set in kiwi habitat. Trapping forms a huge part of the efforts to eliminate predators in New Zealand, and is carried out extensively by DOC, Treaty Partners, community groups and individuals. *Photo: Sabine Bernert*

The Predator Free Strategy drives action through six pathways – whānau, hapū and iwi expressing kaitiakitanga; communities taking action; supporting the kaupapa through legislation and policy; advancing our knowledge, innovation and improvement; measuring and assessing the difference that is made and moving from sustained predator control to eradication. Action under each of these pathways is supported by a national collaborative group while, more locally, regional collaborations are being set up to ensure local people can have a say about how PF2050 happens in their places.

Contributing to the innovation side of things is DOC's 'Tools to Market' project which aims to refine current predator control tools, develop new or improved tools to eradicate predators at landscape scales and expand predator control so a range of tools are available for different environments and situations. Additional research and development activities are focussed on new and improved toxins, baits and delivery systems that increase the rate of predator suppression and eradication across Aotearoa, along with improved monitoring and data management to verify results.

Mammalian browsers | Ngā kaiota whāngote

Introduced terrestrial herbivores, such as feral goats, several species of deer, rabbits, hares, tahr, chamois, wallaby species and possums (see *case study*), were among the first imported species for which concern was raised over their impacts on New Zealand's native flora. Domestic stock have also impacted indigenous vegetation through grazing, and feral pigs through rooting. Impacts are particularly severe on vulnerable ecosystems (e.g. wetlands) where trampling, eutrophication (excessive richness of nutrients) and the incidental spread of weeds occurs in addition to grazing. By removing vegetation, wild browsers also encourage or exacerbate erosion which, in turn, aggravates sediment loads in streams, lakes and coastal waters (Basher 2013; Kpodonu et al. 2019). Bare hill slopes are also less fertile and susceptible to invasion by non-palatable weeds. In addition, infestations of smaller browsers, (e.g. rabbits) support large numbers of introduced predators, (such as stoats). Some browsers (e.g. possums and red deer) are widespread, while others (e.g. Bennet's and dama wallabies) are currently restricted in distribution but will spread without intervention.

Hares, tahr (Cruz et al. 2017; Bellingham et al. 2018) and chamois target alpine and subalpine vegetation, while rabbits can reduce native grasslands to dustbowls. While populations of rabbits and hares on public conservation land are relatively stable,[14,15] populations of larger herbivores (tahr, chamois, goats and deer) are expanding to occupy increasing proportions of these lands.[16] The total abundance of tahr on public conservation land has expanded since the early 1990s. For the period of 2016–19 it wasestimated at 34,478 individuals, exceeding the limit of 10,000 animals set in the Himalayan Thar Control Plan (DOC 1993; Ramsey & Forsyth 2018).

Pigs can cause severe damage by destroying the litter layer and ground cover when they grub for roots and earthworms and have also been implicated in the spread of the kauri dieback pathogen.

Browsers prefer some plants over others, so that they change the composition of plant communities over time (Wood & Wilmshurst 2019) (see *Possums case study*). When their numbers are high, they tend to be less selective, and decimate herb and shrub layers of forest, as deer did in many parts of the country during the 1960s (Wardle 1984). Because herbivores eventually kill many of the plants they feed on, they compromise the habitats of the native flora and fauna that depend on those plants and promote less palatable species.[17] In addition, while some previous assumptions were made that introduced browsers, particularly deer, filled a herbivorous niche vacated by extinct species of moa, there is evidence that this is not the case (Forsyth et al. 2010).

Pigs, deer, goats and possums have become an important resource for Māori now that the traditional harvest of many native species is either illegal or unsustainable. Therefore, an abundance of these species may be considered a positive cultural indicator (Mataamua et al. 2010, Scheele et al. 2016). However, herbivores are also drivers of decline for many rongoā and threatened plant species, so the ability to source sufficient leaves for rongoā can be a useful indicator of ecosystem health (Scheele et al. 2016).

[14] https://www.doc.govt.nz/our-work/monitoring-reporting/national-status-and-trend-reports-2018-2019/?report=NationalHaresFactsheetWeb

[15] https://www.doc.govt.nz/our-work/monitoring-reporting/national-status-and-trend-reports-2018-2019/?report=NationalRabbitsFactsheetWeb

[16] https://www.doc.govt.nz/our-work/monitoring-reporting/national-status-and-trend-reports-2018-2019/?report=NationalUngulatesFactsheetWeb

[17] http://archive.stats.govt.nz/browse_for_stats/environment/environmental-reporting-series/environmental-indicators/Home/Land/pest-impacts-indigenous-trees.aspx

Possums | Te paihamu

Possums (*Trichosurus vulpecula*) were deliberately introduced to Aotearoa from Australia in the mid-1800s to start a fur industry. They have since inflicted heavy damage on a range of species throughout the country. Evidence shows a high impact on the mortality of favoured palatable tree species (such as rātā/northern rata trees) in comparison with avoided tree species (Fig. 7). This can result in a collapse of these preferred tree species, and a change in forest composition. Possums have also had a major impact on the density, distribution and health of native pirita/mistletoe species (Sweetapple et al. 2002), many of which are now threatened.

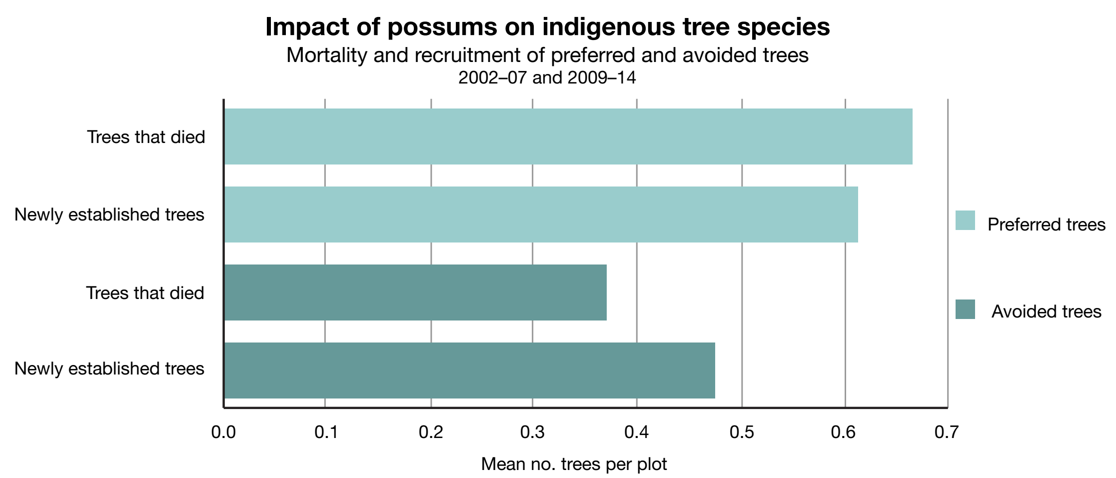


Figure 7. Impacts of possums on indigenous tree species, showing mortality and recruitment of preferred and avoided trees in 2002–07 and 2009–14. Source:[18]*. Licensed by Statistics NZ for reuse (***CC BY 4.0***).*

Control operations can, however, effectively reduce possum numbers. A combination of aerial poisoning, ground baiting and community trapping means that possum numbers, while still damaging, are currently much lower (Warburton et al. 2009) than the 70 million estimated in the mid-1980s (e.g. Keber 1985). Forsyth et al. (2018) showed that sites on public conservation land subject to aerial 1080 poison baiting either once or more than once in the preceding seven years, had possum abundances 64% and 74% lower, respectively, than sites with no control.

Sources: Keber et al. (1985); Warburton et al. (2009); Forsyth et al. (2018).

The native kohekohe tree (*Dysoxylum spectabile*) showing damage from possum browse. *Photo: Department of Conservation*

[18] http://archive.stats.govt.nz/browse_for_stats/ environment/environmental-reporting-series/environmental-indicators/Home/Land/pest-impacts-indigenous-trees.aspx

Terrestrial invertebrates and reptiles | Ngā tuaiwi-kore me ngā moko whenua

More insects invade Aotearoa than any other class of animals. As of 2017, more than 1500 non-native insect species have established here. Nearly all (1477) were unintended introductions (Edney-Brown et. al. 2018). Many prey on indigenous invertebrates. Other small introduced predators (e.g. plague skinks) are also spreading throughout the country and similarly target indigenous invertebrates.

The social, co-operative lifestyle of some introduced invertebrate species, such as wasps and ants, allows them to attain huge numbers, resulting in particularly severe impacts on their indigenous invertebrate prey. For example, during the summer, common wasps reach sufficiently high population densities in the honeydew beech forests of the northern South Island that they remove much of the honeydew before it becomes available to native birds, mokomoko/lizards and insects. Their exponential increase in numbers later in the summer then results in their native caterpillar prey having very little chance of surviving long enough to pupate, and those caterpillars being unavailable as a food source for other native insectivores (Toft & Rees 1998). Wasps have occasionally been observed attacking larger animals, with one swarm having been observed killing a moko pirirākau/forest gecko and stripping it to its bones and tendons within 20 minutes.

Early detection combined with a coordinated effort to control new threats can lead to successful eradications e.g. the great white butterfly (see case study).

Invasive great white butterfly: successfully eradicated!

2010 was the year that the invasive great white butterfly (*Pieris brassicae*) sneaked into the Port of Nelson and likely flew out from there into the gardens of Nelson City.

Caterpillars of this butterfly move in a group and skeletonise leaves. If they had spread beyond Nelson, then they would have threatened many of New Zealand's 79 native cress species and commercial brassica crops (e.g. cabbage). They are unwanted under the New Zealand Biosecurity Act 1993.

Led by DOC, agencies and the people of Nelson all pulled together to eradicate them. Hundreds of people across the city played a vital role in locating and catching the unwanted butterflies. The complex campaign required over 260,000 property searches and had cost about $5m before the great white butterfly was declared eradicated in 2016. An independent cost study estimated that if DOC, other agencies and the people of Nelson had not rallied around to eradicate the great white butterfly and it had spread beyond Nelson, then national costs of controlling this pest could have built to upwards of $41m annually.

Sources: East (2013); Brown et al. (2019).

Caterpillars of the great white butterfly were a major threat to native plants and commercial crops due to their abilities to skeletonise leaves. *Photo: Richard Toft, Entecol*

Introduced freshwater fish and invertebrates | Ngā ika me ngā tuaiwi-kore wai māori kokohu

Introduced pest fishes, such as perch, rudd, tench, gambusia, feral goldfish and carp, and introduced game fishes, which include various species of trout, char and salmon, are predators of native fishes and invertebrates in freshwater systems. Some are omnivores and browse on aquatic plants, with a serious consequence of their feeding methods being degraded water quality and clarity (Crowl et al. 1992; Collier & Grainger 2015). The Department of Conservation aims to contain at least three introduced pest fish species (koi carp, gambusia and rudd) to prevent further expansion in their range (DOC 2019a).

Non-indigenous freshwater invertebrates are also cause for concern. For example, at least 23 species of non-indigenous invertebrates have established populations in New Zealand lakes (Duggan & Collier 2018), and while their effects remain unclear, some have the potential to displace native species (Balvert et al. 2009; Burns 2013).

Invasive marine organisms | Ngā rauropi moana urutomo

It is estimated that 214 non-indigenous marine species now live in New Zealand's marine environments (MfE & Stats NZ 2019b). Some of these have the ability to compete with, and prey on indigenous species, modify natural habitats or alter ecosystem processes. The most visible of these are encrusting organisms, such as sea squirts, sponges and the invasive seaweed *Undaria*, which monopolise subtidal rocks, wharf piles and other structures, crowding out native encrusting organisms. Bivalves can also be invasive – for example, the Japanese rock oyster, which established here in the 1970s, has now largely replaced its native counterpart. In addition, exotic burrowing bivalves are abundant and widespread.

Wakame kelp (*Undaria pinnatifida*) is a type of kelp native to Japan, where it is harvested for human consumption. This seaweed is invasive in New Zealand and is present around many parts of the coastline where it grows on subtidal rocks, wharves and other structures and can crowd out native marine organisms. *Photo: Richard Kinsey*

Extensive tracts of New Zealand's coast have not yet been surveyed for marine pests and other parts have only been checked sporadically, leaving a gap in knowledge about the distribution of exotic marine organisms (Seaward & Inglis 2018). The impacts of these organisms on native species, habitats and ecosystem functions also remain poorly understood. However, some species, such as the Mediterranean fanworm, which has now become established in a number of the country's harbours, can modify habitats and nutrient cycles (Biosecurity New Zealand 2019).

Introduced weeds | Ngā otaota rāwaho

Introduced weeds can have severe and often permanent effects on native vegetation and ecosystems in general. They are also one of the main factors impacting many rongoā species.

Trends from Tier 1 monitoring (see *Ecosystem integrity* section) on public conservation land have shown no change in the overall balance of indigenous to exotic plants in forests between the first (2002–2007) and second (2009–2013) measurements (Bellingham et al. 2014). However, many of these forests lie in upland parts of the country in well-buffered stands, less prone to infestation from the range of weeds that inhabit smaller forest remnants in lowland and coastal zones. Environmental weeds detected by Tier 1 monitoring were more frequent in non-forest plots, where the most common was mouse-eared hawkweed (Bellingham et al. 2013).

Aggressive vines such as old man's beard (Ogle et al. 2000), concentrations of tall woody weeds, particularly wilding conifers (Froude 2011), dense carpets of ground-cover weeds, such as *Tradescantia* (McAlpine et al. 2014), and shade-tolerant trees such as sycamore and douglas fir (Klijzing 2002) all have negative impacts on indigenous forests and their ability to regenerate Lowland and coastal forests, particularly those smaller fragments on plains, river terraces and other fertile substrates, are particularly susceptible.

Wilding conifers can transform entire landscapes (Fig. 8) and pose a major weed problem because they can smother indigenous vegetation and are able to be dispersed long distances by wind. They were present across 6% of Aotearoa in 2014[19] and this may expand to 20% within 20 years unless rapid management action is taken (Wyatt 2018). Tier 1 monitoring has recorded wilding conifers from 2% of plots on conservation land. Some species can invade subalpine and alpine sites. Tier 1 monitoring shows that invasive conifers are more common in drier locations, close to roads and on public conservation land at the boundaries with other land tenures (Bellingham et al. 2015). As well as destroying indigenous vegetation, wilding conifers can also reduce the quantity of water flowing from a catchment by more than 40%.[20] Undertaking wilding conifer control when infestations are sparse and comprise mainly small, young pines is substantially less expensive per hectare than waiting until they develop into forests of large mature trees (Wyatt 2018).

Figure 8. Wilding conifer spread in 1998, 2004 and 2015 in Mid-Dome, Southland. Image source: Environment Southland.

[19] http://archive.stats.govt.nz/browse_for_stats/environment/environmental-reporting-series/environmental-indicators/Home/Land/land-pests.aspx

[20] https://www.doc.govt.nz/nature/pests-and-threats/weeds/common-weeds/wilding-conifers/

The weediest sites on the Tier 1 plot network are those where the original vegetation has been cleared by human activities (Bellingham et al. 2013). Many weeds are pioneer species, meaning they can quickly exploit disturbances such as fire and storm damage, which are relatively common events in Aotearoa and likely to become more frequent due to climate change. Choosing the right targets for cost-effective weed control is extremely important, as battling the most obvious species won't necessarily secure the greatest long-term benefit. Some weeds can provide the right conditions for regeneration of native tree species in some situations (see gorse and broom case study).

Weeds are also a pressure in aquatic freshwater ecosystems. *Egeria* and *Lagarosiphon* are capable of overwhelming and shading out native plant communities (Champion 2002). In addition, weeds such as willows and royal fern can hinder the restoration of wetlands (Burge et al. 2017).

Gorse and broom | Te kōhi me te tainoka rāwaho

Gorse (*Ulex europaeus*) and broom (*Cytisus scoparius*) are common weeds in Aotearoa but can also provide nursery conditions for regenerating native species in some situations. Both gorse and broom are nitrogen-fixers and so are beneficial to soil fertility. They can promote the germination and growth of native seedlings and then slowly vanish under the growing native canopy, as has occurred with broom in previously forested dry habitats east of the Southern Alps/Kā Tiritiri o te Moana. However, the altered soil nutrient level can have an impact on which native plant species can colonise and grow, both in the short and long term. Furthermore, there are still many habitats where these species are aggressive plant pests because low-statured indigenous vegetation is incapable of overtopping them.

Source: Burrows et al. (2015).

Gorse (*Ulex europaeus*) was introduced by early European settlers and is now a major invasive plant species. Despite extensive efforts to clear land of this invader, gorse can serve a useful purpose as a nurse canopy for regenerating forests. It is pictured here being overtaken by native bush at Hinewai Reserve on Banks Peninsula, Canterbury. *Photo: Michal Klajban*

Invasive fungi and microorganisms | Ngā hekaheka me ngā moroiti urutomo

Invasive microorganisms pose significant current and future biosecurity concerns in Aotearoa. Kauri dieback (see case study) and myrtle rust are two recent examples that are having widespread and devastating implications for iconic flora and the ecosystems they support. Understanding of exotic diseases is still incomplete (e.g. Tompkins & Gleeson 2006; Ha et al. 2009), but as more and more invasive species and diseases establish (e.g. myrtle rust; Beresford et al. 2018), pressures mount on native biodiversity. Stringent biosecurity measures, however, can slow this trend (Edney-Browne et al. 2018).

Mātauranga Māori and kauri dieback disease

Kauri (*Agathis australis*) is an important tree species in Aotearoa, both ecologically and culturally. In the Te Roroa rohe (the home of Tāne Mahuta, the most well-known kauri tree), the importance of kauri to the iwi is expressed in the proverb *Ko te kauri ko au, ko au ko kauri – I am the kauri, the kauri is me.*

Much of the original kauri forest has been cleared and now over 75% of what remains is in the Northland region, mostly in fragmented remnants of the ancient forests or in regenerating stands. Te Roroa people link the health of these forests closely to the mauri and mana of their communities and the generations to come. However, kauri dieback, which is caused by the pathogen *Phytophthora agathicidida*, is a major threat.

It is thought that kauri dieback disease may have been present in Aotearoa since the 1960s, but it has only been recognised in recent years. As it is spread by the movement of soil, including on the feet of visitors, many areas of forest have been closed to the public to reduce its spread and rāhui have been implemented in some areas by local iwi.

Kauri (*Agathis australis*) trees are important both ecologically and culturally, but are under threat from kauri dieback disease. The species' conservation status is therefore 'Threatened – Nationally Vulnerable'. Pictured here are dead branches of a kauri tree which has been affected by kauri dieback. *Photo: Laura Honey*

To find ways to address this threat, iwi and scientists have been drawing on the ancestral knowledge contained in mātauranga Māori to understand the context of the disease in terms of the relationships kauri have with other species, the trends, cultural health indicators and possible cures. One example of this work draws on the mātauranga of Ngāpuhi, which sees three 'waves' occurring in regenerating forests, with the first wave of plants securing, cleansing and preparing the soil for the subsequent generations of fruiting plants that restore biodiversity and then the long-lived plants such as kauri. This information, combined with knowledge of rongoā species, has helped to identify the plants that should be tested for properties that could be used to fight the disease. The initial research has found encouraging results for the use of kānuka. This research has highlighted the benefits of applying mātauranga to help with refining the wide range of avenues that could be investigated.

Sources: Lambert et al. (2008); Scott et al. (2019).

Changes in land and sea use | Ngā panoni ki ngā whakamahinga whenua me te moana

Māori arrived in a land that was almost entirely swathed in forest. However, the burning of forest stands meant conversion into tussock grasslands and scrub. European settlers then cleared much of what forest remained on the lowlands. Tracts of native forest were still being clear-felled well into latter half of last century. Clearance of forest on private and publicly owned land was substantially reduced with the dissolution of the Forest Service and by legislative controls.

In 1991, the Resource Management Act imposed stricter controls on forest clearance on private land. However, forest, wetlands, native grasslands and shrublands still continue to be reduced in extent or condition, often as a result of land use intensification (Walker et al. 2006; Cieraad et al. 2015) and urban development.[21] Figure 9 demonstrates the changes and the net loss (i.e. the difference between losses and gains) of indigenous cover types between 1996 and 2018. For indigenous forests, scrub and shrublands, this loss was 40,800 ha, and for indigenous grasslands it was 44,800 ha. More detail on loss of indigenous ecosystems is provided in the *Ecosystems* section of the *Land domain* chapter.

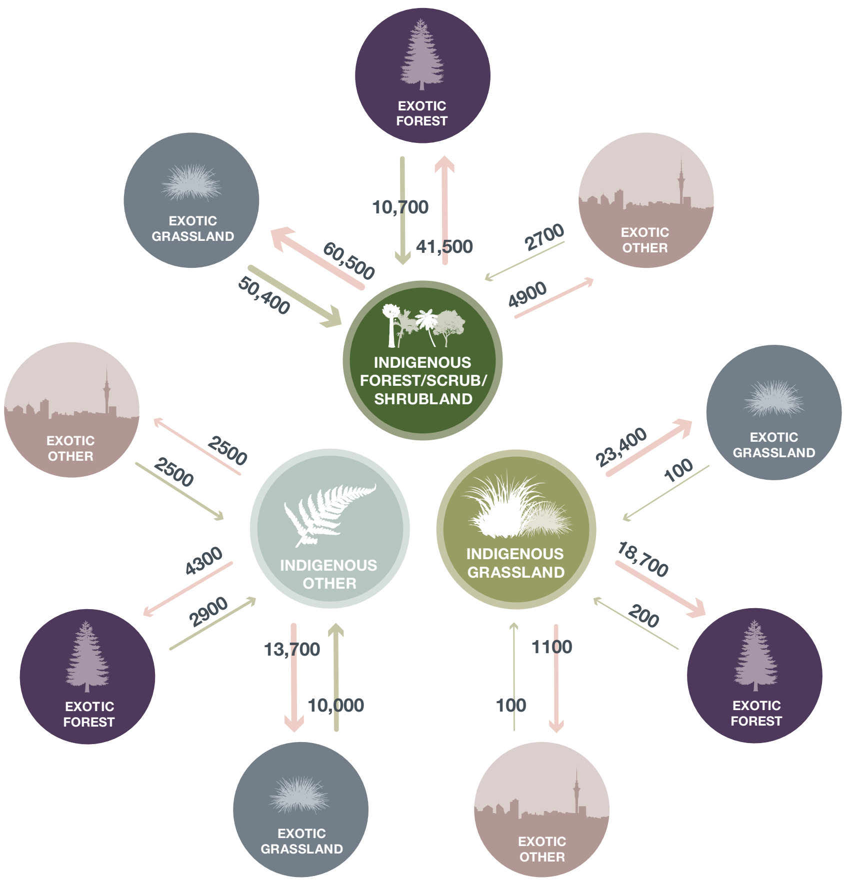


Figure 9. Changes (gains/losses) in indigenous land cover (ha) between 1996 and 2018 using the New Zealand Land Cover Database version 5.0 (2020). Note that changes to exotic forest include wilding conifer invasion.

[21] https://www.landcareresearch.co.nz/about/news/media-releases/how-is-new-zealands-landscape-changing

Habitat fragmentation is also an ongoing issue for remaining indigenous ecosystems (Lafortezza et al. 2010). Where remnant habitat is protected, it is often too small and isolated to sustain viable populations of larger species or to function in a sustainable way. Fragments suffer from edge effects as a result of storm damage and weed invasion, and urban remnants are degraded by unregulated recreation and the dumping of garden waste.

While some modified landscapes such as plantation forestry can offer habitat for indigenous species, and even threatened species (Pawson et al. 2010), ecosystem and habitat loss and degradation as a result of land-use changes still poses a substantial threat (see Fig. 9). The mass planting of exotic trees for carbon sequestration could further displace native vegetation, harbour weeds, alter water availability or heighten fire risk (Christie 2014). However, these risks may be counterbalanced, at least to some extent, by large-scale indigenous planting initiatives which includes components of the One Billion Trees programme that promote re-vegetation of native species.

Land use change has significant impacts on freshwater habitats and species, with increased sedimentation, eutrophication and physical alterations to river systems a result of increased agricultural and urban land use (see *Pollution* section and *Freshwater domain* chapter).

Of those pressures that are directly related to human activities in the marine environment, experts consider bottom trawling to be one of the greatest threats to New Zealand's marine habitats (MacDiarmid et al. 2012), with the potential to cause damage to benthic (seabed) communities. In the ten years from 2007/08 to 2016/17, the trawl footprint contacted 13% of the area that is open to bottom trawling and shallower than 1600 m and in 2016, the trawl footprint covered about 3% of the fishable area of New Zealand's marine environment (Baird & Wood 2018). Some depths and habitats have been more impacted than others, but there has been a decreasing trend in the annual footprint extent (Baird & Wood 2018; MPI 2019a).

The available data shows that, although some marine habitats are increasing in extent (mangroves for example), most are declining. While the scale of change and amount of habitat loss is a significant knowledge gap, due mainly to the cost of monitoring habitats (especially those that are underwater), some work is underway to map these habitats and the services they provide (MfE & Stats NZ 2019b). For more details see the *Marine domain* chapter. Most activities in the marine environment tend to increase in intensity towards the coast where there is considerable diversity of indigenous species and habitats. Coastal development, such as ports, sea defenses and wharves and coastal activities can alter or destroy habitats (see *Estuaries* section of *Marine domain* chapter).

Direct exploitation and harvesting | Te whakapau tōtika me te aruaru, te hao, te kato

This section covers the direct exploitation of non-living resources from nature (extraction), and direct exploitation of organisms (harvesting).

Extraction | Te unu

Pressures on freshwater ecosystems are increasing with rising demand for water resources, leading to detrimental impacts on both water quality and quantity. Pressures (e.g. water diversion, water abstraction, dams, power generation and dewatering) occur over different timescales and spatial extents. Some pressures can be characterised as constant (e.g. water abstraction for domestic supply); others as infrequent (e.g. dewatering for in-stream works). Some are highly localised (e.g. dam for power generation), while others are more widespread (e.g. small abstractions for irrigation and stock drinking water). Power schemes and large-scale dams strongly impact hydrology and fragment biological communities. The allocation of surface and groundwater consents for irrigation has the greatest potential to disrupt seasonal flows due to their prevalence throughout the country (Boddy et al. 2019). Engineering works, such as flood protection works and gravel extraction, can alter habitat, or destroy it altogether. An increasing demand for irrigation has the potential to deplete wetlands, streams and rivers, and allow saltwater to intrude into aquifers (McGlone & Walker 2011).

Extraction includes mining which continues to be a pressure in the land domain, particularly on naturally rare ecosystems, flora and fauna which occur on specific geology (e.g. coal measures and limestone) (see *Naturally uncommon ecosystems* section in the *Land domain* chapter). Seabed mining can also pose a threat to marine mammals and other elements of marine ecosystems.

Harvesting | Te aruaru, te hao, te kato

Land | Whenua

Historically, native species were a vital food source for Māori. Hunting, along with depredation by their companion animals, kurī/dogs, was responsible for the extinction of the moa as well as other large flightless species, such as the adzebills, geese and swans.

Over time, Māori developed customs such as rāhui to conserve resources or allow them to regenerate (Marsden 2003; Waitangi Tribunal 2011). It has always been an important aspect of manaakitanga (hospitality or generosity) to provide traditional local foods at hui, tangihanga and wānanga. The ability to do this depends on successful management of the ecosystem (Scheele et al. 2016).

Although introduced predators were the most important causes of extinction following European settlement, the elimination of huia was hastened by collection for the museum trade. The harvest and hunting of most species of native birds is now illegal and has been for many years, yet pārera/grey ducks, pūtangitangi/paradise shelducks and pūkeko can be shot under licence during limited open seasons. In addition, mana whenua harvest tītī/muttonbird and ōi/grey-faced petrel under permit in some areas. It is recognised that illegal activity involving harvesting of land bird and plant species (e.g. logging and sphagnum moss harvesting) does occur.

Fresh water | Te wai māori

In fresh waters, tuna/native eels are commercially harvested under a quota system, as well as recreationally and culturally. Populations of the larger longfin species, which live longer and do not breed in fresh water, are in decline. Harvest, along with habitat loss, reduced water quality, water abstraction and barriers to fish migration (such as dams) are impacting on longfin eel populations. Whitebait (legally defined as the young of five species of native galaxiid fishes) are also harvested extensively, with limited control on the quantity that can be taken by fishers except for regulation of the harvest season, equipment and capture methods. Kōura/freshwater crayfish are also subject to traditional and recreational harvest. More detail is provided in the *Freshwater fish* section.

Marine | Te moana

In the marine environment, many native species are harvested commercially, recreationally and culturally. The ability to provide kai moana (seafood) for the table is a fundamental part of Māori cultural identity and practice (Scheele et al. 2016) and commercial fisheries are also important for Māori, including as part of Treaty settlements.

Historical impacts of harvest on New Zealand's marine biodiversity are still obvious today (MacDiarmid et al. 2016). Several marine mammal species were hunted to near extinction in New Zealand waters (kekeno/seals, rāpoka/sea lions and tohorā/whales) and are nowhere near their former abundance and distributional range. In the Hauraki Gulf, top predators such as whales and dolphins, seabirds, lobsters and some species of fish, have undergone significant declines in abundance over the last 1000 years, as a result of hunting, introduction of terrestrial mammal predators and fishing (Pinkerton et al. 2015).

The take of commercially exploited marine species is managed by the Quota Management System. New Zealand fisheries management also operates in an ecosystem-based approach to fisheries management framework, where associated and dependent species and wider aquatic environmental effects are required to be taken into account. Such wider environmental effects of fishing can include bycatch, direct impacts on habitats and depletion of prey for other species such as seabirds (Gaskin 2017). 'Bycatch' describes the unintended catch of non-target species. These may include other fishes, as well as seabirds and marine mammals, which can be long-lived, slow breeding and not able to sustain high mortality rates. Considerable effort has gone into assessing the level of risk of bycatch to aquatic protected species and to reduce all incidental bycatch, but this remains an issue for some species.

The longfin eel/reherehe (*Anguilla dieffenbachii*) is an endemic fish. Longfin eels/reherehe live in freshwater habitats but migrate to the ocean to breed. Commercial, cultural and recreational harvests of eels in freshwater are all important; however, this harvest (alongside other factors such as habitat loss and reduced water quality) are impacting longfin eel/reherehe populations and they now have a conservation status of 'At Risk – Declining'. *Photo: James Reardon, JamesReardon.org*

Climate change | Te panoni āhuarangi

New Zealand's biodiversity will come under increasing pressure as a result of global climate change (Christie et al. 2020). Pressures such as ecosystem fragmentation and pests will also likely be exacerbated (McGlone et al. 2010). It is difficult to know precisely how New Zealand's biodiversity will respond to climate change in the long term. This is partly because the country's climate is already highly variable, and partly because for land ecosystems many species and habitat types are now restricted in range as a result of vegetation clearance and the introduction of invasive pests (McGlone et al. 2010).

Some species and ecosystems will be more vulnerable to climate change than others (McGlone et al. 2010). For instance, the sex of a tuatara embryo is determined by the ambient temperature, so that warming will produce more males than females (Mitchell et al. 2010). Native peketua/frogs need moist conditions to survive (Newman et al. 2013), as do land snails (Walker 2003), and kiwi need soft ground to probe for worms (Cunningham & Castro 2011), so any changes resulting in a drier climate are likely to have impacts on those species. Similarly, kōura/freshwater crayfish have been shown to be highly sensitive to climate change, primarily because of their habitat specialisation (Hossain et al. 2018). In the freshwater environment, species such as alpine galaxias, which has a restricted distribution and is reliant on colder water temperatures, will be vulnerable to the warmer temperatures and drought associated with climate change (Boddy & McIntosh 2016). Intertidal marine creatures may be subjected to warmer air temperatures when the tides are out (Willis et al. 2007). Projected future increases in ocean temperatures are also expected to have large knock-on effects for the ocean food web and fish species (Law et al. 2017). The consequences for seabirds of changes in the Southern Ocean climate are still largely unclear (Barbraud et al. 2012). Climate change may cause shifts in the distribution of prey species and the flooding of low-lying colonies, while increased storminess may interfere with provisioning, foraging and fledging.

Some ecosystems will be particularly vulnerable to climate change. Particular examples are the susceptibility of marine ecosystems to warming temperatures and ocean acidification (Law et al. 2017); coastal ecosystems to sea level rise and storm surges (Bell et al. 2017); freshwater ecosystems to drought and flooding (MfE & Stats NZ 2018) and, indirectly, through increased human demand for water (Robertson et al. 2016). Increased demand for irrigation could deplete freshwater wetlands, streams and rivers, and allow saltwater to intrude into aquifers (McGlone & Walker 2011). Ocean acidification, warming oceans and sea level rise could have significant impacts on marine species (including seabirds) and the ecosystem services associated with them, such as food production (Lundquist et al. 2011, Pinkerton 2017; MPI 2019a). Meanwhile, alpine ecosystems will also experience changes with rising snow lines and temperatures (Hendrikx et al. 2012).

Climate change will also compound many existing threats. For now, the ranges of some animal pests (e.g. ship rats, hedgehogs and wasps) are partially constrained by cold temperatures, so they may expand – latitudinally and altitudinally – with warming temperatures (Christie 2014). These pests may survive in greater abundance, expanding their ranges upslope into higher alpine elevations than where they currently occur, creating a 'thermal squeeze' situation for native species. Invasive invertebrate species, which may not survive the winter season in Aotearoa at present, may at some point be able to persist (Ward et al. 2010; Lester et al. 2013; Lester & Beggs 2018). Similarly, some weeds and invasive pathogens (e.g. myrtle rust) could respond in a similar way (McGlone et al. 2010; Beresford et al. 2018). Fires will also likely start more frequently and burn for longer (Pearce et al. 2011), giving the advantage to fire-tolerant weeds (Perry et al. 2014). Taonga species important to Māori will also be vulnerable to the interacting drivers of climate change and pest invasion. Reductions in the ranges of taonga species and altered timing of biological events (e.g. flowering and fruiting) could impact on tikanga Māori. Furthermore, traditional mātauranga of environmental signals used for tikanga could be disrupted by climate change, and could affect the social fabric of whānau, hapū and iwi by compounding the loss of knowledge for rangatahi (King et al. 2013).

The human response to climate change may also bring further threats. Mass planting of exotic trees – while beneficial for carbon sequestration – could displace native vegetation, harbour weeds, alter water availability or heighten fire risk (Christie 2014).

Pollution | Te parahanga

Many forms of pollution affect New Zealand's biodiversity, including excess nutrients, sediment, biocides, plastics, light and sound. Forms of pollution such as air pollution (smog, chemicals, particulates), water pollution (nutrients, pathogens, sediment, rubbish), soil pollution (fertiliser, agricultural chemicals, pesticides, etc.), and heavy metal pollution have severe impacts on terrestrial and freshwater ecosystems close to the sources of the pollutants.

River water quality is a major concern in New Zealand, particularly in lowland catchments, where it is generally poor (as indicated by elevated nitrogen, phosphorous and *E. coli* concentrations; Larned et al. 2016). Excessive leaching of nutrients (e.g. from agricultural fertiliser, landfills and stock effluent), into waterways and estuaries causes them to become hyper-fertile, fuelling infestations of exotic waterweeds and algal blooms. These infestations can deplete oxygen levels in the water which, in turn, kills native fishes and other organisms and the life that survives will be tolerant of degraded habitat conditions (e.g. invasive weeds and introduced snails and fishes). Heavy metal runoff to waterways – such as copper and zinc from vehicle wear and tear – can also degrade water quality in urban areas, as these contaminants can be toxic to aquatic life.

Sedimentation in lakes, rivers, wetlands and harbours occurs as a natural process following land-disturbance events such as storms. However, the arrival of humans in Aotearoa and the changes in land use associated with their activities have seen increased levels of erosion, sedimentation and eutrophication, each of which affects the quality of water and the health of the species that live in these environments. Aotearoa loses 192 million tonnes of soil each year to erosion (Manaaki Whenua - Landcare Research Annual Report 2019) and the resulting sediment loading is a major driver of biodiversity loss in lowland streams, rivers and estuaries and along coastal margins (Davies-Colley et al. 2015). For further details see *Freshwater domain* chapter.

Plastic pollution is a persistent issue for marine biodiversity (Worm et al. 2017) and is also a pressure in freshwater habitats (Mora-Teddy & Matthaei 2020). Plastics have now been found in organisms throughout the Pacific Ocean food web, including zooplankton, fish and shellfish (Desforges et al. 2015; Forrest & Hindell 2018; Markic et al. 2018). Oceanic currents and tides provide a transport mechanism for sediment and pollutants so impacts can be widespread: plastic pollution is now a problem even in remote areas of New Zealand (Wilcox et al. 2015) (see *Marine* chapter for further details). Plastic ingestion by seabirds has been recorded in colonies in Aotearoa (Buxton et al. 2013), and in necropsied corpses (Bell & Bell 2018). The impacts of plastic debris on seabirds are expected to increase as increasing amounts of plastic accumulate in the marine environment (Wilcox et al. 2015).

Oil spills kill a range of seabirds (Hunter et al. 2019). If they are captured and submitted to intensive care, oiled individuals can have high short-term survival, as was the case after the wreck of the MV *Rena* in 2011 (Gartrell et al. 2019), but the long-term survival of these birds is uncertain.

Emerging contaminants, such as those used in hygiene products, industrial chemicals and pharmaceuticals, are now turning up in some regions and these may cause adverse effects on ecological health (Stewart et al. 2016). The main sources of these contaminants are wastewater effluent, stormwater, landfill leachate and some specific industrial and marine activities. Smaller loads of some contaminants may enter the environment through recreational activities, such as sunscreen and insect repellent washing off people swimming.

Light pollution due to increasing urbanisation of the coastal landscapes and the increasing presence of brightly lit vessels at sea is known to be having an effect on seabirds and noise pollution from sources including seismic surveying are a pressure for marine mammals (see *Marine birds* and *Marine mammals* sections of *Marine domain* chapter). Light pollution may also be negatively impacting bat species (see *Bats* section *of Land domain* chapter).

Rubbish from the remains of the Fox Glacier landfill in the South Westland World Heritage Area. The dumpsite was exposed after major floods in March 2019 and large amounts of domestic rubbish were deposited over a 21 km stretch of the Fox and Cook Rivers and 64 km of coastline. *Photo: Jose Watson*

New Zealand's land, freshwater and marine environments | Ngā taiao whenua, wai māori, moana hoki o Aotearoa

The Māori concept ki uta ki tai (from the mountains to the sea) recognises the interconnectedness of all aspects of the natural world. The individual elements such as the atmosphere, surface water, groundwater, land use, water quality, water quantity and coast all act upon, and are affected by, each other. The health of each element affects the health of all the others.

Source: MfE & Stats NZ (2017a).

Aotearoa is characterised by a wide range of terrestrial, freshwater and marine environments, each of which is home to many different species, includes numerous ecosystems and is affected by different pressures.

The chapters that follow outline the current understanding of the state, trends and pressures for each of these domains, while highlighting knowledge gaps. It is acknowledged that the three domains are interconnected. Some species can move between two or three domains during their lifecycle. The trends or pressures of one domain can impact on another.

Mitre Peak/Rahotu, Fiordland National Park. Fiordland National Park is the largest of New Zealand's national parks and is home to many native species and important ecosystems. *Photo: James Reardon, JamesReardon.org*

Land domain | Te whaitua whenua

Overview | Tirohanga whānui

According to tradition, Papatūānuku is the Earth mother. As a living organism, she has biological systems and functions which provide a web of sustenance for all her children – people, animals, forests, wind and water (Marsden 2003).

This chapter describes the state, trends and pressures of indigenous terrestrial ecosystems and species groups. Ecosystems have been split into two sections – those which were widespread prior to human arrival, and those which were naturally rare. Species groups cover the range of flora and fauna that are classified within the NZTCS.

At the time of human arrival in Aotearoa, the indigenous flora and fauna on land retained some relicts from Gondwanaland before what would become Aotearoa split from this land mass, some 80 million years ago. However, there was also evidence of considerable evolution in isolation over the intervening period. Global weather patterns (including ice ages), sea level fluctuations and massive geological events and upheavals drove the character and patterns of biodiversity (see *A diverse and complex environment* section).

Around half of the indigenous terrestrial flora and fauna assessed under the NZTCS are endemic, reflecting this extensive period of geographic isolation and the subsequent evolution of species that inhabit these islands.

The harlequin gecko (*Tukutuku rakiurae*) is a rare gecko species found only on Steward Island, making it probably the world's southernmost member of the gecko family. The intricate patterning helps camouflage the geckos in their habitat of herbfields, shrublands and granite outcrops. The harlequin gecko has a conservation status of 'Threatened – Nationally Vulnerable'. *Photo: James Reardon, JamesReardon.org*

State and trends | Te āhuatanga me ngā ia

Human arrival in Aotearoa marked the beginning of significant impacts on indigenous biodiversity, ramping up substantially with European arrival in the early 1800s. Vegetation clearance has been particularly severe in coastal and lowland zones. This, combined with the impact of predators and herbivores, has had a profound bearing on the state and trends of the remaining land-based biodiversity (see *Pressures* chapter). Many of these pressures are still active and continue to be a source of degradation (MfE & Stats NZ 2018).

Of the nearly 11,000 terrestrial species assessed under the NZTCS (2019), 811 species (7%) are ranked as 'Threatened' and 2416 species (22%) 'At Risk' (Fig. 10). Since humans arrived, many species, including 57 birds that rely on land and/or freshwater habitats, have been lost to extinction.

Over one third of the country's indigenous land species that have been assessed under the NZTCS (2019) are considered 'Data Deficient' (4039 species, 37%). This group includes a very large number of fungi, lichens and insects. Birds, by contrast, are much more thoroughly studied.

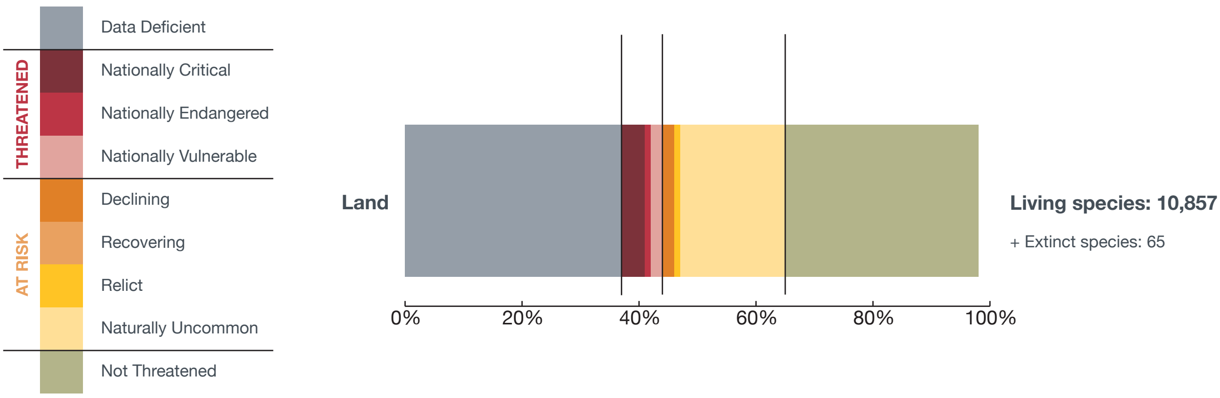


Figure 10. Conservation status (NZTCS) of resident native land species assessed under the NZTCS. Data source: NZTCS (2019).

Pressures | Ngā pēhanga

Clearance of indigenous vegetation has been driven by the need for harvesting resources such as timber, as well as the conversion of indigenous ecosystems to different land uses, primarily agriculture, plantation forestry and urbanisation. The major decline in many indigenous species, including extinctions, is largely the result of the substantial reduction in the extent and quality of habitat, as well as through direct hunting and the impact of predators and herbivores.

While some established pressures are well known, the full range of pressures and their interactions with land-based biodiversity are still not fully understood. Emerging and escalating threats from climate change, new diseases and biosecurity incursions pose urgent research challenges. Climate change is likely to exacerbate existing pressures. The range, distribution, and proliferation of many pests, for example, are all expected to increase (MfE & Stats NZ 2017b); but ecological systems are complex and it is difficult to predict exactly how climate-change pressures might interact with others and how cumulative impacts might manifest (e.g. McGlone & Walker 2011, Bishop & Landers 2019).

Although we have recently made great strides in our ability to manage many environmental pressures (e.g. landscape-scale predator control), we still have substantial gaps in our knowledge about how and when to take action. The absence of complete information for individual species compromises our ability to be able to prioritise conservation effort.

In recent years, conservation actions have begun to make a difference in some areas. Conservation management on public lands is supplemented by funding and support from voluntary, NGO and private sectors and some private owners protecting and managing biodiversity on their land through kawenata (covenants). Ngā Whenua Rāhui helps to protect the natural integrity of Māori land and preserve mātauranga Māori. Conservation actions have prevented extinction of many bird species, which are now dependent on ongoing pest control and other management for their survival.

Ecosystems | Ngā pūnaha hauropi

Before humans arrived it is estimated that around 85% of Aotearoa was covered in native forest (Fig. 11) (McGlone 1989). The remainder comprised grassland, wetland, shrubland, herbfield, alpine rockland and coastal communities, interspersed with smaller areas of naturally uncommon ecosystems, such as limestone bluffs and braided riverbeds (Leathwick et al. 2003).

A little over 7 million ha (62%) of New Zealand's total remaining native vegetation occurs on formally protected public reserve lands and privately owned covenants. A further 3 million ha (26.5%) is on sheep, beef and dairy farms, and the remaining 1.3 million ha (11.5%) occurs on land that is used for a range of other purposes (including plantations, urban areas etc.).

With the development of ecosystem classification tools and the adoption of satellite and mapping technologies, it has become easier to quantify indigenous vegetation extent and loss (see *Land classification* section). Additional tools such as cultural mapping, health indices and other mātauranga Māori monitoring methods can also provide a broader picture of states and trends (Lyver et al. 2017). Knowledge of ecosystem integrity has only started to improve in the last decade, after DOC's implementation of a national monitoring and reporting system. However, there remains a critical need to build on the knowledge of habitats and species with better and more consistent data coverage.

State and trends | Te āhuatanga me ngā ia

During the early stages of Māori habitation, and later, as numbers of European and other migrants increased, huge areas of native forest and other habitats were destroyed by fire, logging and other land clearance activities (McGlone 2001). Up to 40% of New Zealand's native vegetation was cleared within the first 150 years of human occupation (McWethy et al. 2009). The wetter, steeper high country was left largely undisturbed. While rates of loss have slowed in recent times, native vegetation continues to disappear with land-use change and intensification; today, approximately 43% of New Zealand's land area, or around 11.5 million ha (Norton & Pannell 2018), remains in native cover (Fig. 11).

Figure 12 illustrates the use of TEC (see *Threatened Environments Classification* section for details). This analysis demonstrated that 32% of New Zealand's 500 land environments had less than 10% cover of native vegetation remaining, while a further 14% had 10–20% native vegetation cover (Cieraad 2015). Twenty percent is the threshold at which ecosystem functioning becomes marginal (Walker et al. 2007). Collectively, these two categories represent around 33% of New Zealand's total land area. As shown in Figs 11 & 12, the most depleted parts of Aotearoa are in coastal and lowland areas of low relief, particularly high-fertility alluvial plains, terraces and flats.

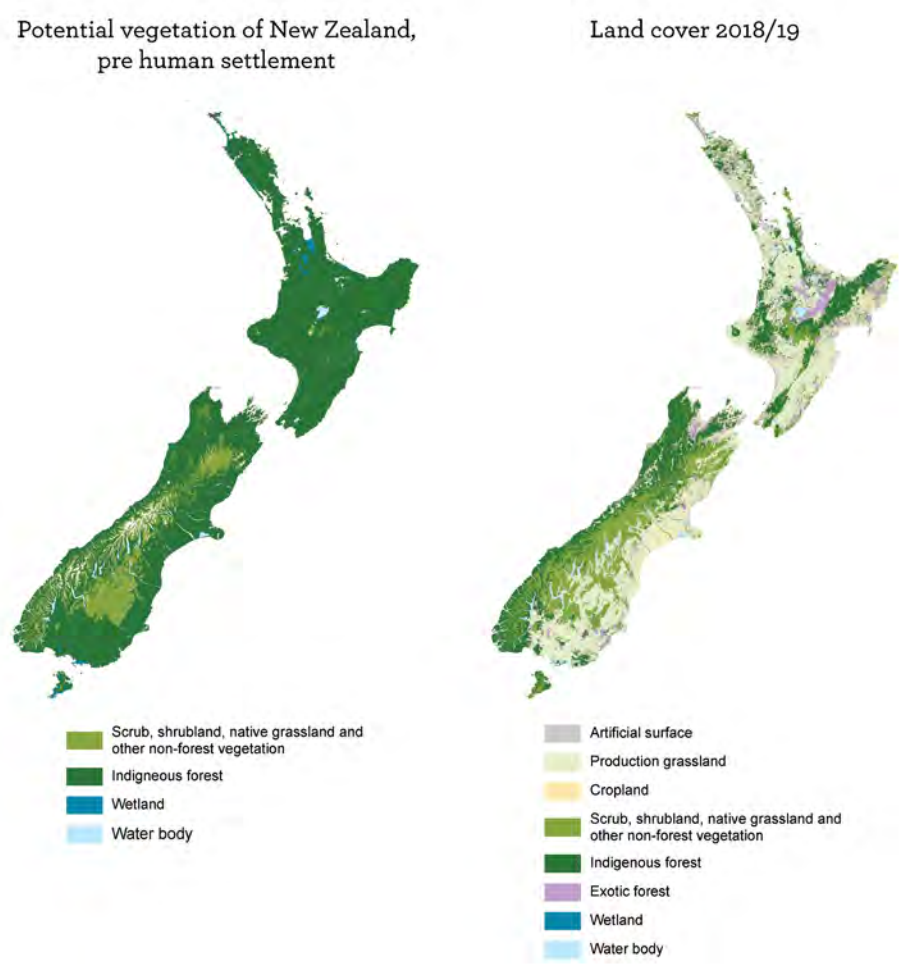


Figure 11. New Zealand vegetation cover before human occupation (740 years ago) and in recent times (2018/19). Source: New Zealand Land Cover Database version 5.0 (2020). Reproduced with permission of Manaaki Whenua - Landcare Research.

Land environments by threatened environment category, 2012

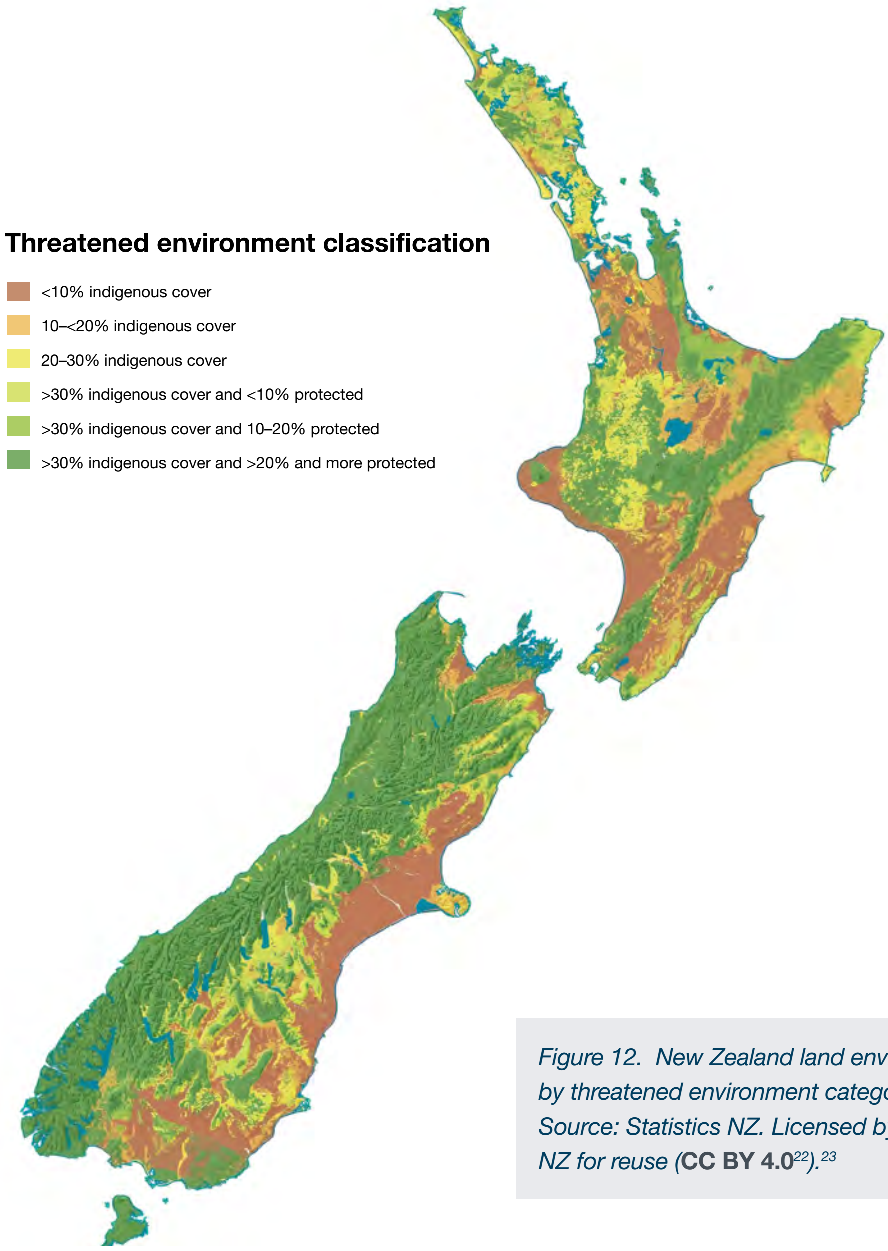


*Figure 12. New Zealand land environments by threatened environment category, 2012. Source: Statistics NZ. Licensed by Statistics NZ for reuse (***CC BY 4.0***[22]).*[23]

The most recent recorded trend for conversion of indigenous land cover between 2012 and 2018 continues the overall pattern observed between 1996 and 2018 (see *Changes in land use* section). Despite some gains from habitats reverting to native cover naturally or through restoration, the net loss of native forest, scrub, shrubland and grassland amounted to 12,900 ha. Most of these losses are due to land-use conversion for forestry, farming, horticulture, and mining) (New Zealand Land Cover Database version 5.0 2020).

[22] **https://creativecommons.org/licenses/by/4.0/deed.ast**

[23] **http://archive.stats.govt.nz/browse_for_stats/environment/environmental-reporting-series/environmental-indicators/Home/Land/indigenous-cover.aspx**

Records show that more than 95% of all native vegetation that has been lost disappeared from land that was not legally protected (Walker et al. 2008). In some regions, however, clearance of habitat for native species from public reserve lands has been disproportionally greater. For example, of the nearly 11,630 ha of Canterbury's formerly depleted but undeveloped river margins that were converted for more intensive agricultural use between 1990 and 2012, approximately 60% was privately owned, 24% was public reserve land (vested in DOC, regional council and district councils) and the remaining 16% was unallocated or unoccupied Crown land (Grove et al. 2015). These areas formed part of wider braided river floodplains and contained habitat refugia for indigenous flora and fauna, as well as having potential for indigenous restoration.

Nationally, forested ecosystems are now reduced to around 30% of their pre-human extent (Ewer et al. 2006). Despite this enormous loss, forested ecosystems are still an important part of New Zealand's biota and ecosystems. Active sand dunes, once a widespread and important landform to Māori, and an important feature of shorelines where they help control erosion, shrank by 80% between the 1950s and 2008, from around 129,000 ha to 25,000 ha (MfE & Stats NZ 2018). Between 1990 and 2008, an estimated 70,000 ha of native grassland in the South Island were converted mainly to exotic pasture: conversion rates nearly doubled between 2001 and 2008 (Weeks et al. 2013). Although these losses may appear small when viewed proportionally, they are significant for those indigenous ecosystems that are already substantially reduced in extent.

Historical and recent losses of native cover vary across council regions; in the Auckland and Waikato regions for example, almost three-quarters of the native land cover has been lost (Waikato Regional Council, Auckland Regional Council 2010), while the West Coast has retained around 80% of its native cover (Norton & Pannell 2018). Dryland parts of the country in the eastern rain-shadow zones of the Southern Alps/Kā Tiritiri o te Moana have suffered from extensive loss and modification since human settlement, particularly after the arrival of Europeans and the advent of pastoral farming (Rogers et al. 2005). Drylands make up 19% of New Zealand's land area and are home to a high proportion of the country's indigenous plants and animals.

However, the reduction in ecosystem extent is only one consideration – ecosystem health is another. Many of New Zealand's native ecosystems have lost, and continue to lose, condition and functionality. Over a decade of forest monitoring shows that some native tree species eaten by pest animals are not being replaced fast enough to sustain their populations in the long term (Belllingham et al. 2014). Subsequent losses of these trees from their forest communities is likely to have serious impacts on the available habitat and food sources for many other plants and animals. Mātauranga Māori case studies also highlight a decline in cultural health indicators of ecosystem integrity (e.g. Pauling 2007; Lyver et al. 2008; Selby & Moore 2010; Lang et al. 2012; Hikuroa et al. 2018).

There are some positive trends. The extent of private land containing biodiversity values protected through Queen Elizabeth II Trust covenants rose from 10,000 ha in 1990 to 184,210.8 ha in 2018[24]. A growing number of individuals, communities, NGOs and businesses are undertaking restoration projects (see One Billion Trees case study). Treaty of Waitangi settlements have empowered iwi to step up their investment in protection and restoration (Ruru et al. 2017).

[24] https://qeiinationaltrust.org.nz/publications-and-resources/map-of-our-protected-land/

One Billion Trees

Toitū te ngahere, toitū te whenua, toitū te tangata
If we look after the forest, if we look after the land, the land will look after us

One Billion Trees (OBT) is a government programme led by Te Uru Rākau, within the Ministry for Primary Industries. It aims to improve environmental, social and economic outcomes for people living in and visiting Aotearoa through the expansion of forestry. Forests provide an important carbon sink and a major driver of the programme is assisting New Zealand's response to climate change.The OBT programme provides financial assistance to encourage both plantation and permanent forests of exotic or native tree species. By adopting the strategic 'right tree, right place, right purpose' approach, the programme aims to encourage planting of indigenous trees in the right contexts to improve biodiversity at local and landscape scales and diversify existing land use without large-scale land conversion to production forests. The associated increase in biodiversity at landscape scales will go some way to addressing the loss of indigenous forest ecosystems.

Department of Conservation staff planting native trees.
Photo: Ligs Hoffman

The programme's aim is to plant one billion trees by 2028. Half of these are projected to be planted by commercial foresters over this period, while planting of the remaining 500 million trees is supported by a fund of $240 million which is available through a range of initiatives (e.g. joint ventures with Crown Forestry, regional council, iwi and community partnerships and direct landowner and Matariki Tū Rākau[25] grants).

Source: Te Uru Rākau (2020).

[25] Planting living memorials to honour our New Zealand Defence Force members, past and present

Pressures | Ngā pēhanga

Human activity and environmental change have had a substantial impact on the extent and condition of New Zealand's native ecosystems, and their associated biodiversity. The extent of ecosystem loss through land use change is illustrated in Figs 9 and 10 (also see *Changes in land and sea use* section). New agricultural technologies mean that farmers can now realise profits from land once considered marginal, which drives more intensive land uses that retain little or no habitat for indigenous biodiversity (Monks et al. 2019).

Human activity, infestations of pest plants and animals, fragmentation, isolation and climate change are conspiring to sap the mauri of many remaining stands of native vegetation, and regulatory protection is often lacking (McGlone & Walker 2011; Dymond et al. 2014). Introduced browsing animals such as deer, goats and possums are changing the composition of our remaining forests.

Pressures on indigenous land-based species and naturally uncommon ecosystems are explained in more detail in the subsequent sections of this chapter.

Naturally uncommon ecosystems | Ngā pūnaha hauropi mokorea noa

There are 72 discrete ecosystems that are defined as Naturally Uncommon. These occur throughout Aotearoa between the coasts and mountain tops, and covered less than 0.5% of the country's land area prior to human arrival (Williams et al. 2007). Some are relicts of formerly more common ecosystems that may have survived over long timescales.

New Zealand's naturally uncommon ecosystems are very sensitive to disturbance because they are often the result of unusual geophysical processes, such as being reliant on high concentrations of salts derived from weathering rocks, periodic disturbance regimes or climatic extremes. They are often home to unusually large numbers of threatened plants (Holdaway et al. 2012) that can tolerate the unusual conditions.

Current research on naturally uncommon ecosystems is limited. A few examples have received a lot of attention at a few sites (e.g. some coastal rock stacks and lake margins), while others are virtually unknown. Some ecosystems, such as saline geothermal springs, gorge walls and ultramafic gravel-fields have only recently been recognised and have not yet been assessed to see whether they meet the threshold to be considered naturally uncommon or threatened.

State and trends | Te āhuatanga me ngā ia

According to criteria developed by the International Union for Conservation of Nature (IUCN, Keith et al. 2013), 45 ecosystems meet the definition of Threatened: 18 Critically Endangered, 17 Endangered and 10 Vulnerable (Holdaway et al. 2012).The remainder are still naturally uncommon but are not immediately threatened (see Table 1), although there may be subgroups of these ecosystems which would be considered to be threatened under the same criteria (e.g. eastern lowland limestone and eastern 'dry' moraines).

Table 1. New Zealand's naturally uncommon ecosystems and the broader ecosystem classes they belong to. Data collated from Holdaway et al. (2012), Manaaki Whenua - Landcare Research. Landcare Research factsheets.[26]

	CRITICALLY ENDANGERED (18)	ENDANGERED (17)	VULNERABLE (10)	NOT THREATENED (27)
Inland and alpine	Inland outwash gravels Inland saline Inland sand dunes Old tephra plains Strongly leached terraces and plains	Braided riverbeds Frost hollows Sandstone erosion pavements Volcanic boulderfields Volcanic dunes	Basic cliffs, scarps and tors Boulderfields of calcareous rocks Calcareous cliffs, scarps and tors Calcareous screes Moraines Young tephra plains	Cloud forests Granitic gravel fields Granitic sand plains Limestone erosion pavements Recent lava flows Ultrabasic hills Volcanic debris flows Boulderfields of acidic rocks Cliffs, scarps and tors of acidic rocks Cliffs, scarps and tors of quartzose rocks Screes of acidic rocks Ultrabasic boulderfields Ultrabasic cliffs, scarps and tors Ultrabasic screes Boulderfields of silicic-intermediate rocks
Geothermal	Fumaroles Geothermal streamsides Heated ground Hydrothermally altered ground			Acid rain systems
Coastal	Coastal turfs Shell barrier beaches Marine mammal haulouts Seabird guano deposits Seabird-burrowed soils Damp sand plains	Active sand dunes Calcareous coastal cliffs Dune deflation hollows Shingle beaches Stable sand dunes Stony beach ridges Ultrabasic sea cliffs	Basic coastal cliffs	Coastal cliffs on acidic rocks Coastal cliffs on quartzose rocks Coastal rock stacks
Wetland	Ephemeral wetlands Gumlands	Lagoons Domed bogs Dune slacks Seepages and flushes	Estuaries Blanket mires Lake margins	Cushion bogs Pakihi Snowbanks String mires Tarns
Subterranean	Cave entrances	Sinkholes		Caves and cracks in karst Subterranean basalt fields Subterranean river gravels

[26] https://www.landcareresearch.co.nz/publications/factsheets/rare-ecosystems

The decline in indigenous vegetation cover over time aligns with the documented decline in those few threatened naturally uncommon ecosystems that have been studied and occur at a scale that can be recognised by LCDB (see *New Zealand Landcover database* section), such as active sand dunes (Hilton et al. 2000). However, most threatened naturally uncommon ecosystems are too small to show up, or are aggregated across several landcover classes and so are not able to be easily measured in the LCDB dataset themselves. Trend data for most naturally uncommon ecosystems is therefore limited to: (a) studies on parts of those ecosystems – e.g. geothermal (Lloyd et al. 2016; McQueen-Watton & Bycroft 2018) and frost flats (Delich & Singers 2019); or (b) is older, e.g. braided rivers (Gray & Harding 2007), coastal turfs (Rogers & Wiser 2010). In all of these cases, however, the trend is one of a general decline in extent. Ecosystem health is also likely to be compromised, as declines in extent often go hand in hand with declines in condition.

Pressures | Ngā pēhanga

Because of their small size and limited geographic range, many of New Zealand's naturally uncommon ecosystems – especially lowland ones – are threatened by human activity, although weeds and animal pests also play a significant role in their decline (see Fig. 13). Although these ecosystems occur thoughout Aotearoa they are over-represented in areas where people live and where land-use compromises natural processes and impacts on ecosystem integrity (Stephens et al. 2002; Rogers & Walker 2002; Wiser et al. 2013). This is particularly apparent in coastal, lowland and rural landscapes, where many sites have been degraded by agricultural intensification, irrigation and soil stabilisation with exotic plants. Specific geology is a key component of some ecosystems (e.g. coal measures, limestone, dolomite) which are also sought after for extraction, so mining is commonly a major threat.

There are regional examples of aggregations of threatened naturally uncommon ecosystems. Inland outwash gravels, salt pans, inland sand dunes and strongly leached terraces are all Critically Endangered ecosystems, confined to South Island intermontane basins and valley floors (Walker et al. 2003). These are, in turn, part of a suite of dryland ecosystems that also include braided rivers, frost hollows, several types of ephemeral wetlands and tarns, eastern dry moraines and some types of lake margins, which are all under threat. The Mackenzie Basin was once a showcase for many of these dryland rare ecosystems but has experienced progressive loss of them since human arrival. In particular, significant changes have occurred since the beginning of this century (Hutchings & Logan 2018), largely as a result of conversion to intensive agricultural use.

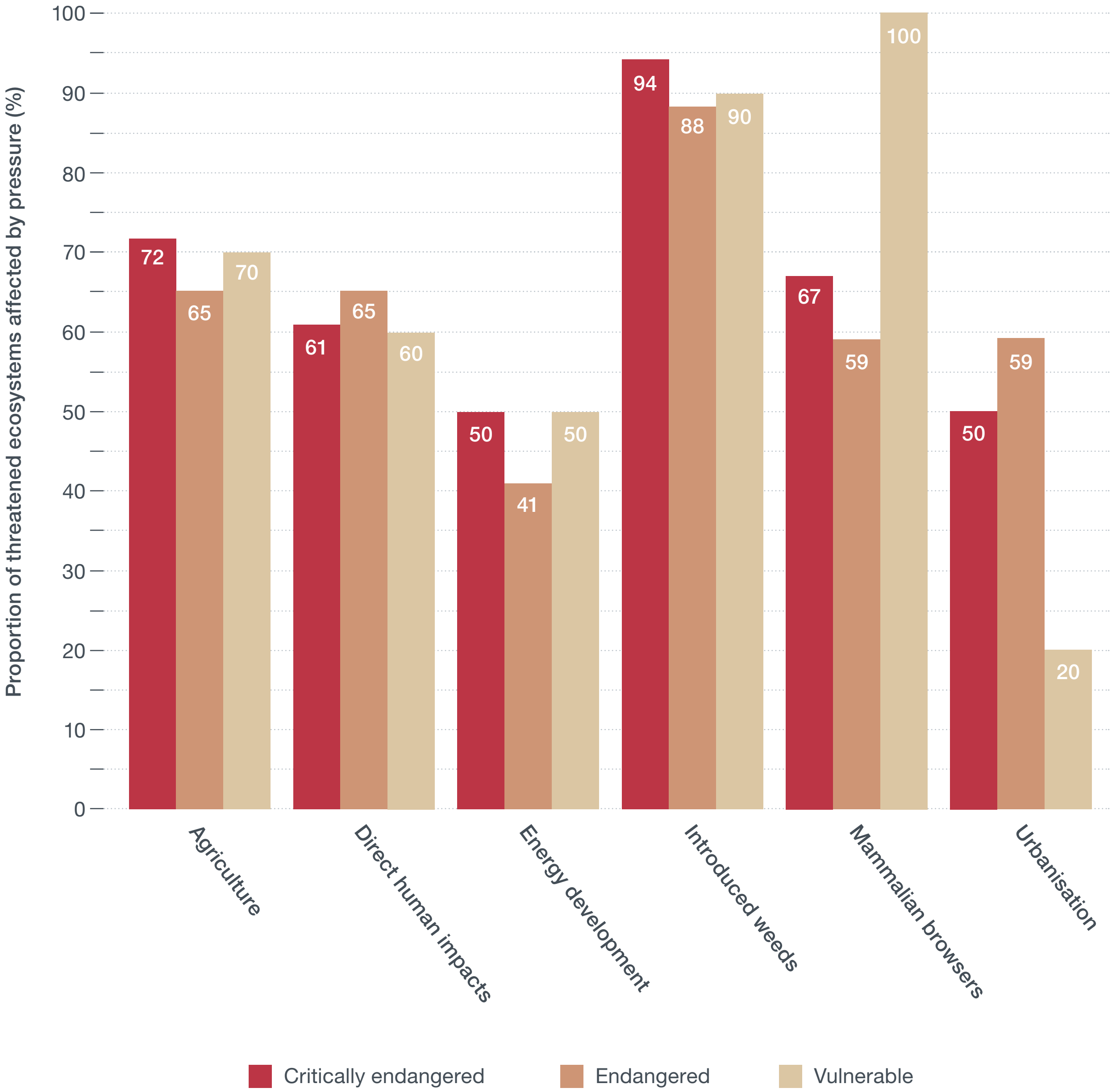


Figure 13. Pressures on New Zealand's 45 threatened naturally uncommon ecosystems. Data collated from Holdaway et al. (2012), Manaaki Whenua - Landcare Research factsheets[27].

[27] **https://www.landcareresearch.co.nz/publications/factsheets/rare-ecosystems**

Land birds (including freshwater and coastal birds) | Ngā manu ki uta (kei roto nei ngā manu wai māori, manu matāwhanga anō hoki)

Land birds are highly significant to whānau, hapū and iwi throughout the country. Traditionally they were a critical source of food, and all parts of the animal were used, for example the feathers for cloaks, and the bones for instruments and tools. Feathers and bones are valued today for toi. The behaviours of birds were closely observed and provided information for weather predictions, and sometimes to foretell the future or bring important messages for people. Some are kaitiaki for whānau, hapū and iwi. They are frequently referred to in whakataukī, waiata, mōteatea and karakia (Keane 2010a) (see Mātauranga Māori case study).

This section addresses bird species that primarily rely on habitats on land and in freshwater and coastal areas (see *Marine domain* chapter, *Marine birds* section for other indigenous bird species).

As a result of decades of work done by DOC, Birds New Zealand (formerly the Ornithological Society of New Zealand), Fish and Game New Zealand, regional councils, museums and many citizen-science projects, the distribution and conservation status of land birds in New Zealand is now well known. Much of that dataset is collated in three Birds New Zealand atlas projects that provide periodic snapshots of bird distribution since the 1970s. This allows for modelling of deeper patterns of recent distribution changes (e.g. Walker & Monks 2018). Knowledge of land bird numbers is generally inversely proportional to their abundance: the numbers of the rarest species, such as tara iti/fairy tern and kākāpō, are known precisely (e.g. Powlesland et al. 2006),[28] because most individuals are uniquely marked through the New Zealand National Bird Banding Scheme.

Population estimates for more common birds, however, rely on extrapolating densities observed at specific study sites, or five-minute bird counts done as part of national Tier 1 monitoring by DOC (see *Ecosystem integrity* section). Changes in counts or abundance indices are also recorded through national or local monitoring schemes, such as the national wader counts carried out by Birds New Zealand since 1984 (Sagar et al. 1999).

[28] https://www.doc.govt.nz/our-work/monitoring-reporting/national-status-and-trend-reports-2018-2019/?report=Kakapo_CurrentAndPredictedTrends_2019

Mātauranga Māori – kererū in Te Urewera

In the past, the kererū was abundant within Te Urewera forests. It was a significant source of food and feathers for Tūhoe Tuawhenua and still has important cultural values today. Its high status meant that historically, consumption of kererū was often restricted to important occasions, or reserved for guests and high-ranking members of the tribe.

Research has found that until the 1950s, large flocks of 300+ kererū would congregate in the Te Urewera forest during the autumn to feed on the fruit of the toromiro. This abundance was seen as a reflection of the mauri of the forest. Some early signs of decline were noted in the 1930s but particularly in the last 75 years, there has been a marked decrease in kererū numbers which has affected both the forest and the people. Many other native bird species in Te Urewera, including those not traditionally harvested, have also declined over the same period.

Within their whakapapa-derived role of kaitiaki, the mana and mauri of the Tuawhenua people is directly based on the well-being of the land and the environment. If their ecosystem is vibrant, their other key values are likely to be well supported. Conversely, failure to sustain the integrity of the environment can damage the people's cultural integrity and essential well-being. The decline in kererū numbers has been detrimental to the mana of Te Urewera as a sanctuary for kererū and the Tuawhenua people as their kaitiaki.

Metaphorical explanations for the decline in kererū have included the reduced mana the iwi has had over the kererū and forest, as well as the retraction of mauri from kererū by Tāne Mahuta. The principal biophysical mechanisms that have caused the decline in kererū numbers have been reported to be predation from introduced mammals and loss of habitat.

Te Urewera is now its own legal entity, with a governance board comprising Tūhoe and Crown representatives. Long-term qualitative monitoring by Tūhoe, drawing on their mātauranga, now guides the planned restoration of kererū, the relationship of people with the land, and wider environmental management in Te Urewera.

Sources: Lyver et al. (2008); Timoti et al. (2017).

Kererū (*Hemiphaga novaseelandiae*) are highly valued by Māori due to their significance as a source of food and feathers. Kererū are well loved by all New Zealanders and were crowned 'Bird of the Year' (by public vote) in Forest & Bird's 2018 Bird of the Year campaign. Kererū have a conservation status of 'Not Threatened'.
Photo: James Reardon, JamesReardon.org

State and trends | Te āhuatanga me ngā ia

Aotearoa has lost 57 land, freshwater and coastal bird species since human arrival – more than any other nation has lost within the last 1000 years. Many, including nine moa, four hurupounamu/wrens and the whēkau/laughing owl, were deep endemics, which means the order, family or genus was unique to Aotearoa, not just the species. These species evolved during a long isolation from the rest of the world, but the arrival of humans and the subsequent introduction of predatory mammals such as rats, cats, mustelids and dogs led to mass extinctions of land birds which were poorly adapted to escape human hunters and other mammalian predators.

Despite this history of extinction, Aotearoa has become a world leader in bird conservation research and management. This has been achieved through pioneering predator control tools, such as the use of aerially sown 1080 at landscape scales, island eradications, translocations to predator-free sites (islands or mainland sanctuaries) and boosting breeding and recruitment success through intensive management. In the last 50 years there has been a marked change in attitudes in Aotearoa towards supporting conservation of the country's remaining natural heritage, especially land birds (see Mātauranga Māori – kererū in Te Urewera case study). Great progress has been made with populations of previously declining species now increasing, with the result that many bird species are now safe from extinction.

Although 97 species (76%) of land birds are 'Threatened' or 'At Risk' (Fig. 14; NZTCS 2019), between 2008 and 2016, the total number of 'Threatened' land bird species dropped from 66 in 2008 to 43 in 2019. Of these, the number of 'Threatened – Nationally Critical' species decreased from 21 to 13. These strong population gains followed island pest eradications that benefitted birds such as the Campbell Island snipe, and intensive conservation management of species such as rowi and takahē.

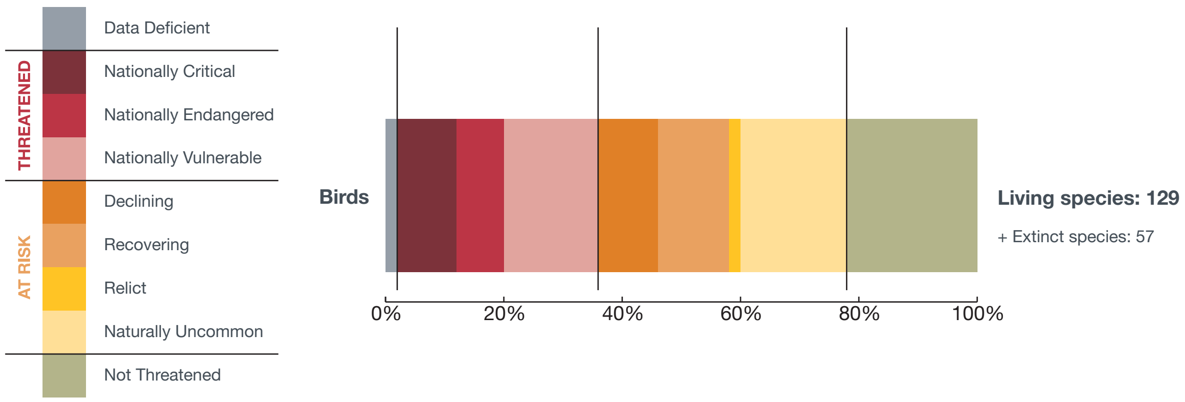


Figure 14. Conservation status (NZTCS) of New Zealand's resident native land and freshwater birds. Data source: NZTCS (2019).

Pressures | Ngā pēhanga

The extensive loss of forest ecosystems since human arrival (see *Land domain* chapter, *Ecosystems* section and *Changes in land and sea use* section) coincided with the beginning of a decline in habitat for forest birds. Losses were greatest in warm, dry, lowland and coastal environments (Ewers et al. 2006) that were converted to exotic pasture, crops and horticulture.

Habitat for inland freshwater wetland birds has also been severely depleted, with more than 90% lost in the last 150 years (Myers et al. 2013) (see Freshwater domain *Wetlands* section), especially in lowland areas. Many streams and rivers have been modified by exotic plants and fish, water abstraction, stop banks and dams, all of which compromise wetland bird habitat. Some land birds, like huia (now extinct) and kiwi, were specifically hunted as curiosities for museum collections.

Many indigenous birds are highly susceptible to predation by introduced mammalian predators. Although no new predatory mammal species has been introduced in the last 125 years, the depredations of those already here continue to have an impact on populations.

Increasing pressure lies ahead with the exacerbating effects of climate change, especially with more frequent masting events and the rat and stoat irruptions they trigger. Shifts in weather patterns could bring prolonged droughts for much of the country, and new vagrant bird species, with possible consequences for threatened native species, while sea level rise will affect coastal wetlands and the hightide roosts of waders. Lag effects from the loss of genetic diversity are likely too, in depleted and fragmented populations, and could leave some species less resilient to novel diseases.

Bats | Ngā pekapeka

Pekapeka/bats are the only native land mammal in Aotearoa and they are all endemic. The species are: pekapeka/greater short-tailed bat, pekapeka/long-tailed bat and pekapeka/lesser short-tailed bat which comprises three subspecies: northern, central and southern (O'Donnell et al. 2018). Fossil records suggest that they originated in Australia (O'Donnell 2009; Hand et al. 2015). Several authors have expressed their surprise that a greater number of families are not represented in our pekapeka/bat fauna, particularly because the Australian bat fauna is far more diverse (Daniel & Williams 1984; O'Donnell 2009). There have been occasional reports of bats that appear to have been blown over from Australia but not established here (King 2005).

A male pekapeka/southern lesser short-tailed bat (*Mystacina tuberculata tuberculata*) singing from a tree hollow on Whenua Hou (Codfish) Island. Recent research suggests that these male bats compete for female attention from their chosen singing spots. This species is now classified as 'At Risk – Recovering' as a result of increasing population sizes in managed protected areas including offshore islands. *Photo: James Reardon, JamesReardon.org*

State and trends | Te āhuatanga me ngā ia

The distribution and population sizes of pekapeka/bats appear to have reduced since the arrival of humans, and certainly since the arrival of Europeans (Lloyd 2005, O'Donnell 2005). The pekapeka/greater short-tailed bat has not been seen since the mid-1960s, shortly after its final island refuge was invaded by rats (Daniel & Williams 1984). It is now classified as 'Data Deficient' under the NZTCS (2019).

The pekapeka/long-tailed bat has the highest threat classification of 'Threatened – Nationally Critical'.

The southern subspecies of the pekapeka/lesser short-tailed bat is classified as 'Recovering' (NZTCS 2019), but only because DOC protects the main known population with predator control targeting rats and stoats (O'Donnell et al. 2018).

The most recent threat classification process under the NZTCS for the bats of Aotearoa took place in 2017 (O'Donnell et al. 2018). Four out of the five New Zealand pekapeka/bats are listed as 'Threatened' or 'At Risk' (Fig. 15; NZTCS 2019) and their threat status changed only slightly from the 2012 review (O'Donnell et al. 2018). Concerns about significant habitat loss since the previous assessment, increased impacts from vespulid wasps and continuing decline reported for populations without predator control resulted in pekapeka/long-tailed bats being re-assessed as 'Threatened – Nationally Critical' (O'Donnell et al. 2018). Long-tailed bats also have very high ongoing or predicted rates of decline (O'Donnell et al 2018). In every case where the survival rates of pekapeka/long-tailed bat populations unprotected by predator control have been studied, populations were either in decline or patterns were unclear (Lettink & Armstrong 2003; Pryde et al. 2005, 2006). The only other major change in threat status was the reclassification of the pekapeka/southern lesser short-tailed bat from 'Threatened – Nationally Endangered' in 2012 to 'At Risk – Recovering' in 2017 (O'Donnell et al. 2018). This was due to increases in population size and survival rates of populations in areas that were protected by predator control or on predator-free offshore islands (O'Donnell et al. 2018). Since this change in classification occurred, another population of pekapeka/southern lesser short-tailed bats has been identified. Whether this newly re-discovered population is stable, increasing or declining is unknown.

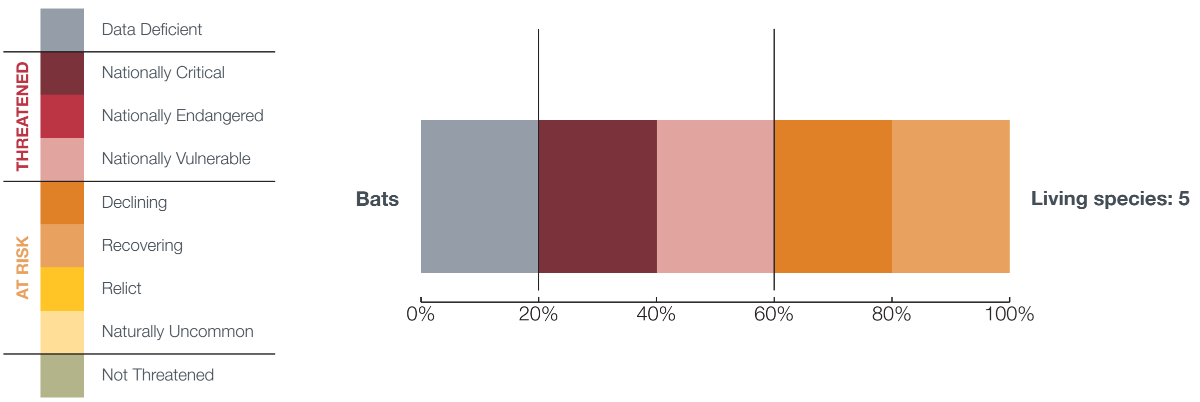


Figure 15. Conservation status (NZTCS) of New Zealand resident native bats. For the purposes of this document we use the word species to include subspecies. Data source: NZTCS (2019).

Pressures | Ngā pēhanga

In the past, declines in pekapeka/bat distribution and population sizes have been attributed to reduced availability of roost trees outside protected areas (e.g. due to logging, Sedgeley & O’Donnell 1999); depredation by a suite of introduced mammals including cats (Scrimgeour et al. 2012), rats, stoats (O’Donnell et al. 2017) and possums (O’Donnell 2005); and the disturbance of roost sites (Daniel & Williams 1984). Felling of trees containing known roosts continues (Sedgeley & O’Donnell 2004). Recent research has shown that increasing lighting, urbanisation, roads (see Jones et al. 2019 for discussion) and overnight traffic volumes (Borkin et al. 2019) are associated with less pekapeka/bat activity and felling of trees is associated with smaller colony sizes (Borkin et al. 2011). Removal and fragmentation of indigenous forest (see *Land domain* chapter, *Ecosystems* section and *Changes in land and sea use* section) and harvest of exotic forests appears to result in smaller home range sizes of both pekapeka/long-tailed bats (Borkin & Parsons 2014) and pekapeka/lesser short-tailed bats (Toth et al. 2015). Mast seeding years and the associated irruptions of predators (rats and stoats) that follows are expected to increase with increases in annual temperatures due to climate change (O’Donnell et al. 2017). Other potential effects of climate change are poorly understood but may include increasing storm damage to occupied roost trees and suboptimal conditions for the use of energy-saving torpor. Wasps have been considered a risk to pekapeka/bat populations by some researchers, but this also remains unstudied.

How to manage predators to levels that result in increased pekapeka/bat survival is known for some landscapes (in particular, southern beech forests, O’Donnell et al. 2017); however, elsewhere this remains a key knowledge gap.

The effectiveness of efforts to mitigate the impacts of urbanisation, roading and lighting on pekapeka/bats remain key information gaps (Jones et al. 2019)

Herpetofauna | Ngā moko me ngā ika oneone

In Māori tradition, reptiles are important kaitiaki and can also carry ill omens. Many iwi believe them to be descendants of Punga, a son of Tangaroa, having travelled with Tangaroa to the ocean when he fled following the separation of Ranginui and Papatūānuku (Haami 2010a).

Aotearoa is home to 108 species of amphibians and land reptiles (Hitchmough et al. 2016a; Burns et al. 2017), collectively referred to as herpetofauna. Native species included in that total are three peketua/frog species, one tuatara, and 104 mokomoko/lizards. All are endemic (NZTCS 2019).

There are major knowledge gaps for many species, particularly mokomoko/lizards, where limited knowledge of their distribution, trends and threats stems from a lack of survey and monitoring data. Furthermore, 46% of mokomoko/lizard species recognised in Aotearoa lack any formal scientific description (Hitchmough et al. 2016a).

State and trends | Te āhuatanga me ngā ia

The majority of native reptiles in Aotearoa are considered ‘Threatened’ (37 species; 36%) or ‘At Risk’ (52 species; 50%) under the NZTCS (2019) (Fig. 16). Of four species of peketua/frog, one is ‘Threatened’, two are ‘At Risk’, and one is ‘Data Deficient’ (NZTCS 2019). In addition, three frog species and two lizards are now extinct following human colonisation.

The conservation status of herpetofauna correlates closely to the presence or absence of mammalian predators (Nelson et al. 2014).

Previously sparse island populations have recovered strongly after pest mammals have been eradicated, and translocations to newly mammal-free islands have boosted security for some species, resulting in 14 lizard species, and tuatara, now being considered either ‘At Risk – Relict’ or ‘At Risk – Recovering’ (Hitchmough et al. 2016a; NZTCS 2019). However, the plight of those elsewhere remains precarious (Nelson et al. 2016) in the face of predation by invasive mammals and habitat destruction (Nelson et al. 2014; Egeter et al. 2015; Hitchmough et al. 2016b), so that population trends and conservation statuses have worsened over recent decades (Hitchmough et al. 2016a).

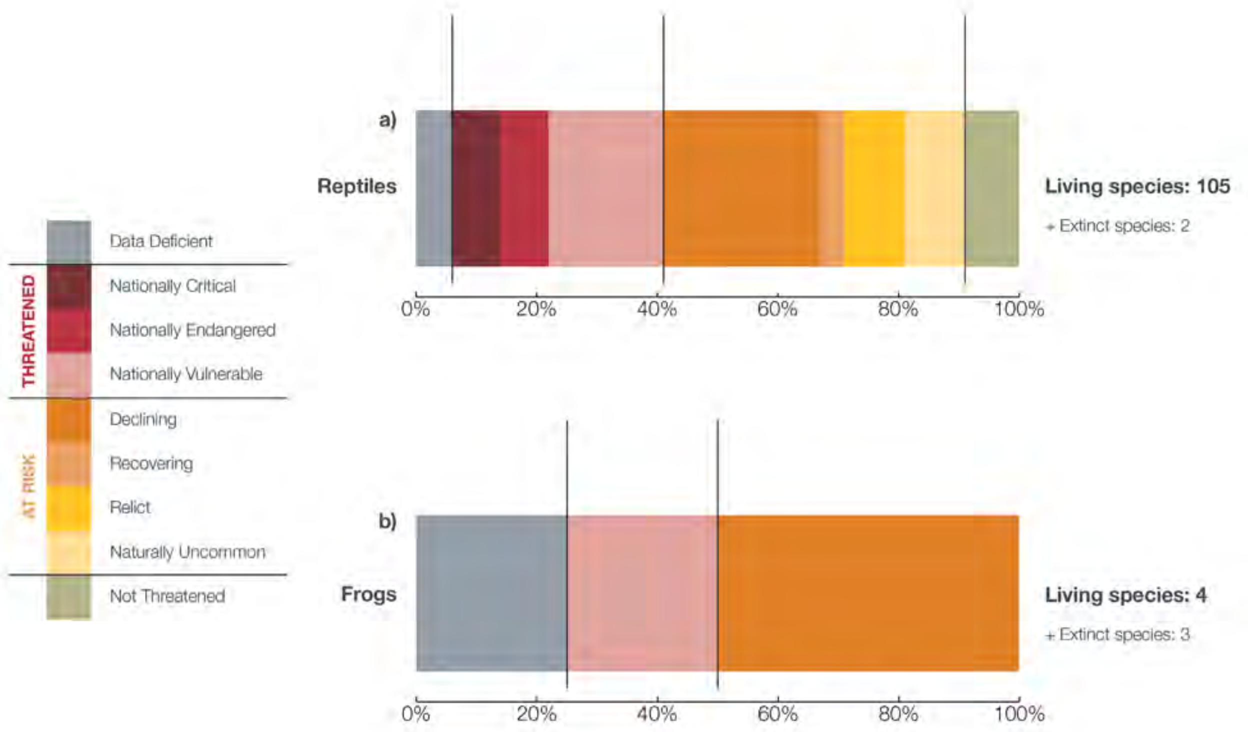


Figure 16. Conservation status (NZTCS) of New Zealand’s resident native herpetofauna (a) reptiles and (b) frogs. Note that all frogs are included in this graphic across both land and freshwater domains. Data source: NZTCS (2019).

Pressures | Ngā pēhanga

Predation by invasive mammals, habitat destruction (see *Land domain* chapter, *Ecosystems* section and *Changes in land and sea use* section) and habitat degradation are major pressures. Degradation can be driven by changes to more intensive land-use practices.

Recent success with intensive predator control and predator-proof fencing on the mainland (Reardon et al. 2012) shows promise for some populations, but outbreaks of diseases (Bell et al. 2004) and climate change – which will bring hotter, drier conditions and more storms – further threaten herpetofauna.

The disease chytridiomycosis, which is caused by amphibian chytrid fungus, is a major threat to frogs worldwide. Chytrid fungus was first detected in Aotearoa in 1999 in introduced frog species. It was detected in the critically endangered Archey's frog in 2001 on the Coromandel Peninsula and has been suggested as being responsible for a mass decline (88%) in that population between 1994 and 2002 (Shaw et al. 2013).

Flora | Ngāi tipu

Tāne (atua of the forest) and his several wives produced many children. Healing plants came from the union with one wife and timber trees from his union with another. Many plants are recorded in whakataukī. Wild food plants are the realm of the atua Haumia, and the properties of healing plants were conferred by Rongo (see *rongoā case study*). Both were central in Māori life and they are still significant today. Other flora, such as harakeke/flax, had great utility value – the muka (fibre) of tough cultivars of harakeke/flax was used to make hard-wearing ropes or footwear and the muka from softer cultivars was used for raranga and whiri (Marsden 2003; Royal 2010a; Taonui 2010).

This section includes land-based vascular flora (including all seed-bearing plants and ferns), bryophytes (mosses, hornworts and liverworts), fungi and lichens (fungus and algae that function as single organisms). It also includes a case study on the use of rongoā plants. See *Freshwater domain* chapter, *Aquatic plants* section for wetland species.

Knowledge of the taxonomy of many plant species, along with their population distributions and trend data, is incomplete. In some cases, trend data are available for families of plants e.g. pirita/mistletoes, but for many others – especially the smaller, cryptic herbaceous species – it is poor. The bryophytes, fungi and lichens are even less well known, as there are only a few trained experts working in this area. At least 8% of the indigenous terrestrial vascular flora remains undescribed (or taxonomically indeterminate) (de Lange et al. 2018a). Among other groups, that percentage is higher still.

Eighty four percent of vascular plants and about half of byrophytes are endemic (NZTCS 2019). At least half of fungi species and a small proportion of lichens are endemic, though available knowledge is incomplete.

State and trends | Te āhuatanga me ngā ia

Three hundred and seventy-nine species (15%) of native terrestrial vascular flora are assessed as being 'Threatened' and 802 species (31%) as 'At Risk' (Fig. 17; NZTCS 2019). Some threatened flora are key structural species for ecosystems and therefore impacts on them have significant ramifications for ecosystems. Examples include northern rātā and southern rātā which have been assessed as 'Threatened' in the most recent assessment as a result of myrtle rust.

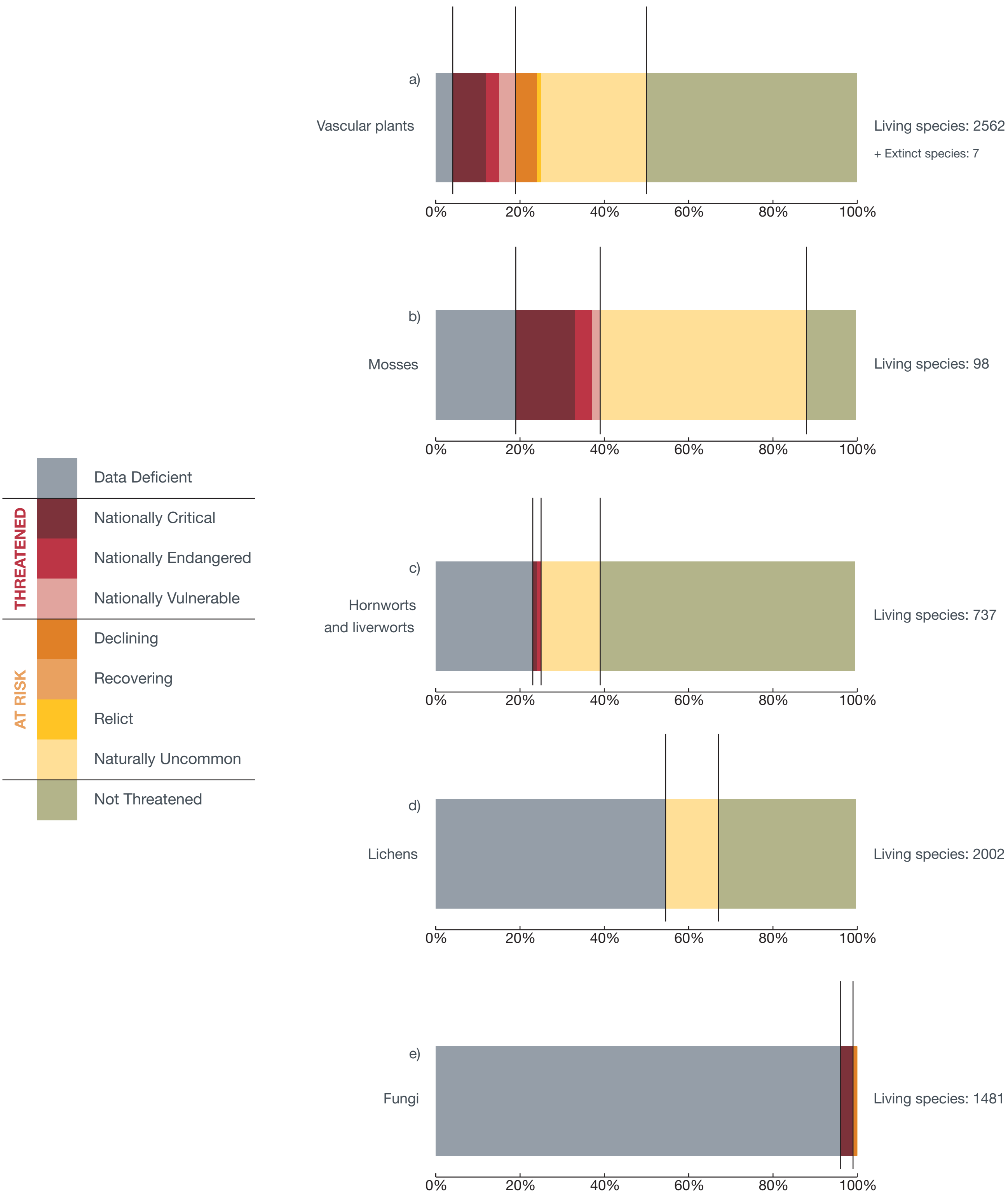


Figure 17. Conservation status (NZTCS) of New Zealand's resident native a) vascular flora, b) mosses, c) hornworts and liverworts, d) lichens and e) non-lichenised fungi, including data from pre-2008 NZTCS rankings. The NZTCS has not included a comprehensive assessment of non-lichenised fungi and mosses (see **Appendix 2***). Data source: NZTCS (2019).*

532 species (12%) of known bryophytes, lichens and non-lichenised fungi are considered 'Threatened' or 'At Risk' (Fig. 17; NZTCS 2019). However, this number reflects a considerable knowledge gap: the overwhelming bulk of liverworts and hornworts, lichens and fungi are 'Data Deficient', so cannot be assigned a more definitive conservation status. The exact proportion of 'Threatened' non-lichenised fungi is still more difficult to gauge, because only some 30% of the estimated 4500 species in Aotearoa (Buchanan et al. 2012) have been recorded.

The most recent threat classification assessment for each group found that the number of species classified as 'Threatened' and 'At Risk' has increased for every group (see Table 2). Declines in species populations were responsible for approximately 30% of changes in conservation status between 2012 and 2017. Many changes to numbers were the result of additional species being assessed for the first time, as well as increased understanding about the state of some species that had previously been assessed, especially of those previously considered 'Data Deficient', which allowed for more certainty as to their status. Because non-lichenised fungi have not been reassessed since 2007 (Hitchmough et al. 2007), there are no recent trend data that are available.

The ability to track trends over time relies on effective monitoring programmes and for many species this can be challenging. Some are very small, or cryptic, and some are not always visible year-round or occur largely below ground (e.g. fungi). There are also species that are short-lived and have fluctuating population sizes.

Pressures | Ngā pēhanga

Declines are primarily being driven by habitat degradation and loss (see *Land domain* chapter, *Ecosystems* section and *Changes in land and sea use* section), browsing and grazing by both wild and domestic animals (see *Mammalian browsers* section), and competition from weeds (see *Introduced weeds* section). Habitat loss and degradation is of particular concern for species in seral shrubland habitats and lowland forests, which are prone to clearance, fragmentation and disturbance from surrounding land uses (Dopson et al. 1999; de Lange et al. 2009). The emerging threats of myrtle rust and kauri dieback are impacting taonga species and resulted in all the myrtle species and kauri being added to the vascular flora threat listing in 2018.

Naturally rare ecosystems (see *Naturally uncommon ecosystems* section) contain high proportions of threatened vascular flora. Some of these that are associated with South Island dryland habitats such as limestone, outwash gravels and dry moraines continue to decline (de Lange et al. 2018a; Heenan & Rogers 2019).

Table 2. Change in the number of terrestrial 'Threatened' and 'At Risk' species in each group and number of species with changed conservation status since previous assessment due to observed improvements or declines in population size.[29]

Group	Change in number of Threatened and At Risk species +/-	Number of species with a change in conservation status due to an increase in population size	Number of species with a change in conservation status due to a decline in population size
Vascular flora	+207	2	61
Mosses	+4	Not assessed	Not assessed
Liverworts/ hornworts	+21	0	0
Lichens (lichenised fungi)	+85	0	4
Fungi (non-lichenised)	Not recently assessed	Not assessed	Not assessed

[29] Does not include non-resident native taxa.

Rongoā – Rob McGowan

Mātauranga of rongoā Māori has accumulated over 800 to 900 years of co-evolution of people with their local environment, based on an extensive knowing and understanding of that environment. It is much more than simply identifying species; it requires understanding of where they grow and how they interreact with other species. The majority of rongoā (medicine) plants are found on the regenerating fringe of the forest. Extensive observation of the plants and their environment, including the way they help to heal and care for the forest, provides insight into the ways they can be useful as rongoā for the people. An example is tutu, which emerges after a bush fire or some other damage to the forest. Although it is toxic it can, with appropriate expertise and care, be used externally to treat certain injuries.

Many rongoā plants have disappeared from traditional gathering areas, as the forest fringes are now dominated by exotic weed species and severely impacted by browsing animals and the lack of birds for seed dispersal. In addition, people's access to these areas is often blocked. These impediments to gaining expertise in rongoā are putting its practice at risk because it is not safe for people to pass on rongoā knowledge without their having intimate knowledge of the natural world and the plants involved.

The plants traditionally used for rongoā also tend to be excellent indicators of forest's health, or mauri. This is because they are fast growing, light demanding and tend to be susceptible to animal and insect browse and weed competition. In addition, while people are practising rongoā they will intrinsically be practising monitoring because harvesting without understanding the forest health could lead to bad outcomes. If the rongoā plants are absent, the forest may have lost the capacity to heal itself and the species that live in conjunction with them are also unlikely to be present.

For a rongoā practitioner, the first patient is the forest itself; there is a reciprocal responsibility to harvest with respect and care, and to nurture the health of the forest. Rongoā knowledge can be relearned if people can reconnect with the natural environment. Connecting to the forest and plants helps people to understand what they are being taught and it is also a way of waking up knowledge that is dormant within them. We need to see people as being 'a part' of the environment, not 'apart' from it. As the land colonises us, we become a different people because of our encounters with our environment. The more this happens, the safer the environment will be, because we will realise that we can only be well if the land we live on is well.

Koromiko (*Veronica stricta*) is one of many plants that has traditionally been used for rongoā (medicinal purposes). Koromiko was used to treat dysentery, create poultices for ulcers, and is beneficial for the kidneys and bladder. Koromiko has a conservation status of 'Not Threatened'. *Photo: Department of Conservation*

Note: The information in this case study is drawn from an interview, Robert (Pā) McGowan pers. comm. 2020.

Invertebrates | Ngā tuaiwi-kore

Many Māori creation stories include references to the insect world, te aitanga pepeke, particularly those about the rival brothers Tāne and Whiro. Whiro commanded an army of crawling and flying insects, which he set upon Tāne in repeated attempts to stop him obtaining *ngā kete o te wānanga – the baskets of knowledge* – from the heavens. With the help of the wind, Tāne foiled his brother's attacks, and took the insects prisoner, incarcerating them in the forests (Haami 2010b).

This section deals with land-based invertebrates. For details on those associated with freshwater and marine habitats, see the relevant sections within the *Marine domain* and *Freshwater domain* chapters.

The major invertebrate groups vary more between each other than birds vary from mammals because in evolutionary terms they diverged much earlier. At the family level of classification (and higher) many, although not all, are found the world over. At the genus and species level, a high proportion are known only from Aotearoa, reflecting evolution over a long period of isolation.

Around 91% of New Zealand's terrestrial fauna is endemic, and invertebrates make up the bulk of it (Gordon 2013). This diverse invertebrate fauna includes insects, land snails, spiders and worms. But there are many other groups too: pseudoscorpions, mites-ticks, flatworms, flukes, tapeworms, nemertean ribbon worms, rotifers, nematode roundworms, micro-whip scorpions, harvestmen, centipedes, millipedes and velvet-worms.

Among insects, only a few families display deep endemism, whereby the entire family is only represented in Aotearoa. These include moths (family Mnesarchaeidae), bat flies (family Mystacinobiidae), flies (family Huttoninidae), thrips (family Bryopsocidae), scale insects (family Phenacoleachiidae), micro-parasitic wasps (family Maamingiidae), mayflies (family Siphlaenigmatidae) and four beetle families (Agapythidae, Chalcodryidae, Metaxinidae and Cyclaxyridae) (Gordon 2013; Buckley et al. 2014; Holwell & Andrew 2014; Gibbs 2016).

States and trends in invertebrate biodiversity are strongly influenced by past geological processes, and to variations in regional landform and climate. That means many native invertebrates have naturally very small distributions (Collier 1993; Overton et al. 2009; Stringer et al. 2012; Buckley et al. 2014; Taylor-Smith et al. 2020).

State and trends | Te āhuatanga me ngā ia

Apart from some insects, spiders and snails, population states and trends are very poorly known for most invertebrate species, as are species-habitat associations. This limits the ability to assign a threat status. A little over 12,000 native insects are named. It is estimated that another 8000 to 10,000 species are yet to be named (McFarlane et al. 2010) from existing collections. It is likely that many more are yet to be discovered in the wild. Properly integrated, mātauranga Māori would be a powerful way to expand understanding of invertebrates from the perspective of inter-generational observation and memory.

NZTCS lists use the best available information on population trends for those invertebrates that are better known. More than half of the invertebrate species listed are either 'Threatened' (258 species, 7%), 'At Risk' (1083 species, 29%) or 'Data Deficient' (1230 species, 33%) (Fig. 18; NZTCS 2019). This reflects an historical approach to NZTCS assessments in which only species in these categories were listed. As groups of species are reassessed, NZTCS lists are becoming more comprehensive (see Appendix 2 for further detail).

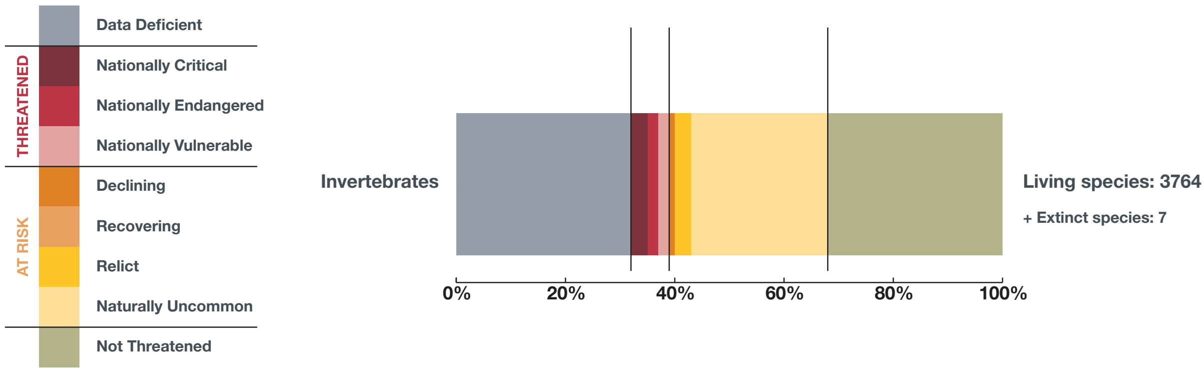


Figure 18. Conservation status (NZTCS) of New Zealand's resident native terrestrial invertebrates, including data from the pre-2008 NZTCS. The NZTCS has not included a comprehensive assessment of all invertebrates, so the statistics presented here for these groups are not comprehensive of the total New Zealand biota (see **Appendix 2***). Data source: NZTCS (2019).*

Invertebrates are a vital component of every ecosystem. Assessing the state and trend of ecosystems is a highly relevant indicator for invertebrate communities (Crisp et al. 1998; Watts & Gibbs 2000; Pawson et al. 2008; Overton et al. 2009; Brockerhoff et al. 2010; Campbell et al. 2011). Conversely, the state of invertebrate communities may be very important indicators of ecosystem integrity. Properly integrated, mātauranga Māori would be a powerful way to expand understanding of invertebrates from the perspective of inter-generational observation and memory.

Pressures | Ngā pēhanga

Every region of Aotearoa has species unique to it; consequently, the national population of some species can be vulnerable to pressures affecting quite small habitats (Taylor-Smith et al. 2020). Loss or degradation of native habitat (see *Land domain* chapter, *Ecosystems* section and *Changes in land and sea use* section) inevitably results in declines. Introduced weeds (e.g. wilding conifers) impact soil and surface invertebrate habitats. Predation by rats, mice and hedgehogs is a pressure on large, vulnerable invertebrates (King 2005; Gibbs 2009) (e.g. flightless beetles and giant wētā). Some of these species now persist only where there are no ship rats (Innes 2005; King 2005; Gibbs 2009, 2016). Possums, pigs and thrushes are an added pressure on some native land snails. Pest-free islands are crucial to the conservation of invertebrate assemblages lost elsewhere (Gibbs 1990, 2009, 2016).

Climate change poses a significant threat to the future of some invertebrate populations and communities. Invasive wasps and ants, for example, are already a serious problem for invertebrate biodiversity, and their populations are expected to increase and spread as the climate warms. More frequent and more intense wildfires are likely; a direct impact that in turn triggers an indirect one – invasion by exotic weeds (McGlone & Walker 2011), which can be catastrophic for species with very small distributions.

There are questions too, around the consequences of escalating rat and stoat control, which may have the effect of releasing predation pressure on mice (Bridgman et al. 2018; Walker et al. 2019). Higher numbers of mice could have significant ramifications for invertebrates (Bridgman et al. 2018; Wilson et al. 2018).

Freshwater domain | Te whaitua wai Māori

Overview | Tirohanga whānui

In the Māori worldview, all fresh water originates from the separation of Ranginui and Papatūānuku, and each river or stream carries its own mauri and wairua. The health of fresh water – wai māori – has always been extremely important and is known as te wai ora o Tāne – the life-giving gift of the kāwai tīpuna. Many iwi have ancestral affiliations to a river in their rohe, and as a fundamental part of their identity. Wai māori is linked to the people's knowledge of and attachment to place, and iwi have significant responsiblities as kaitiaki of wai (Ministry of Justice 2001; Mead 2004; Tipa & Nelson 2012).

This chapter describes the state, trends and pressures of indigenous freshwater ecosystems and species groups. Ecosystems have been split into the primary groups of rivers and streams, lakes, palustrine wetlands and groundwater-dependent ecosystems. Species groups cover the range of flora and fauna that are classified within the NZTCS.

New Zealand's distinctive combinations of climate, geology and landforms gives rise to great diversity in the country's freshwater ecosystems as well as its terrestrial ecosystems. For example, the tectonic uplift that gave rise to our mountains also formed the patterns of braided rivers in the eastern South Island. Glaciation events and earthquakes have driven the formation of many lakes, tarns and wetlands.

More than 425,000 km of mapped rivers and streams flow across Aotearoa New Zealand, including 70 major river catchments: 40 in the South Island and 30 in the North Island. There are some 50,000 lakes,-geothermal and cold-water springs, karst systems, and water also flows underground through 200 identified aquifers. Seven hundred and three (88%) freshwater species are endemic (NZTCS 2019), which highlights the degree of speciation that has occurred through the country's 80 million years of geographic isolation.

Teviot flathead galaxias (*Galaxias* 'Teviot'), which has a conservation status of 'Threatened – Nationally Critical', can only be found in a few small streams. The species' decline over recent years is linked to pressures such as introduction of sports fish, changes in land use (including stock access to streams) and reduction in native vegetation. *Photo: Rod Morris*

State and trends | Te āhuatanga me ngā ia

The decline in the quantity, quality and mauri of fresh water since human arrival, along with habitat and species loss, poor water flows and poor ecosystem conditions combine to disrupt the harvest of customary resources and prevent iwi from fulfilling the obligations of kaitiakitanga (Te Wai Māori 2008; Harmsworth et al. 2014; Harmsworth et al. 2016).

More than a third of monitored lakes (105) are considered to be in poor ecological health or lacking submerged plants based on the lake submerged plant index (LakeSPI).

Of the 976 freshwater species assessed under the NZTCS (2019), 136 (14%) are ranked as 'Threatened', with a further 176 (17%) as 'At Risk' (Fig. 19). Nearly a quarter of freshwater species (218 species; 22%) assessed under the NZTCS (2019) are assessed as being 'Data Deficient'. The taxonomy of many groups is not well defined, and knowledge gaps in the distribution, abundance and population dynamics of many species make it difficult to assess their conservation status. For example, freshwater invertebrates (e.g. kōura/freshwater crayfish, kākahi/freshwater mussels, insects) play a crucial role in ecosystem functioning, but their conservation is hampered by a lack of research effort.

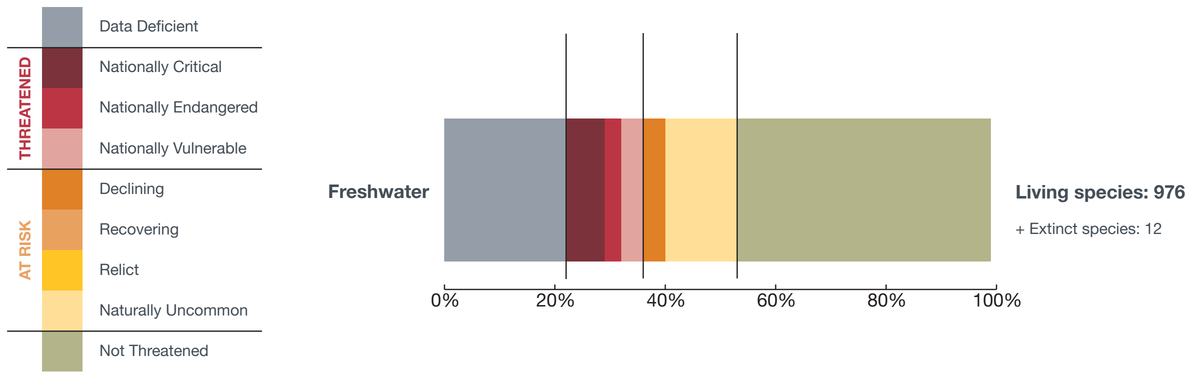


Figure 19. Conservation status (NZTCS) of resident native freshwater species assessed under the NZTCS. Data source: NZTCS (2019).

Pressures | Ngā pēhanga

Pressures in freshwater ecosystems are largely the consequences of human activities (e.g. land development, water extraction, damming), productive activities (e.g. farming and industry), invasive species and climate change (see *Pressures and their impacts on biodiversity* chapter). These pressures degrade the quality and quantity of both surface and ground water and can undermine ecosystem integrity and lead to the loss of biodiversity values.

Cumulative impacts from poor water quality, altered river flows, physical barriers, habitat modification and invasive species are the major pressures on freshwater biota. The full consequences of climate change are not fully understood, but they are expected to exacerbate the range of impacts on freshwater biota (Gerbeaux et al. 2016).

Rivers and streams | Ngā awa me ngā pūkaki

For Māori, water is the essence of all life, akin to the blood of Papatūānuku (Earth mother) who supports all people, plants and wildlife. Māori assert their tribal identity in relation to rivers and particular waterways have a role in tribal creation stories. Rivers are valued as a source of mahinga kai, hāngī stones and cultural materials, as access routes and a means of travel, and for their proximity to important wāhi tapu, settlements or other historic sites.[30] Indicators of the health of a river system (such as uncontaminated water and species gathered for food, continuity of flow from mountain source to the sea) can provide a tangible representation of its mauri.[31]

Rivers and streams have been described as 'the most impacted ecosystem on the planet' (Malmqvist & Rundle 2002). Aotearoa has more than 425,000 km of them, including over 70 major river systems. Half of that network comprises small headwater streams (MfE & Stats NZ 2017a). New Zealand's rivers are generally characterised by having short, steep catchments and highly variable flows. Rivers in public conservation land are mostly smaller headwater streams, while lowland rivers and streams generally have less protection and are more impacted by human activities in agricultural and urban land uses (New Zealand Conservation Authority 2011). The flora and fauna associated with river and streams are unique, with a high proportion of endemic species.

Braided rivers are those that flow in multiple, mobile channels over a floodplain and New Zealand has 163 river systems which have at least some braided reaches (Gray & Harding 2007). There is a diverse range of indigenous flora and fauna that occupy these habitats, including threatened species which are endemic to braided river ecosystems.

Rivers and streams are valued for their landscape, ecological, recreational, spiritual and resource values, their interconnections with land and ocean, and their intrinsic connection with identity of whānau, hapū and iwi (see Waitaki river case study). The provision of ecosystem services for municipal and agricultural drinking water, irrigation and electricity generation is vital (New Zealand Conservation Authority 2011; Gluckman 2017).

Cass River braided river floodplain with Southern Alps/Te Tiritiri-o-te-Moana in the background. Braided rivers provide habitat to a variety of threatened flora and fauna. *Photo: Colin O'Donnell*

[30] https://ngaitahu.iwi.nz/

[31] https://www.doc.govt.nz/about-us/statutory-and-advisory-bodies/nz-conservation-authority/publications/protecting-new-zealands-rivers/02-state-of-our-rivers/maori-values/#32

Waitaki River

The waters of the Waitaki River originate at the base of Aoraki Mount Cook and flow eastwards to the Pacific Ocean. This river has long been important to Ngāi Tahu as a source of identity, connection, work, leisure and sustenance. There is evidence of at least 900 years of stable human occupation along the Waitaki, with people relying on the catchment's plentiful plants, birds and fish. Food availability varied seasonally, and the people travelled widely to gather their supplies over the course of the year. A 2009 study of contemporary mahinga kai (food gathering) behaviours and an assessment of the cultural health of the Waitaki catchment showed that changes in the condition of the mahinga kai sites and the resources available meant the communities could no longer rely on the catchment for sustenance.

Before the development of dams for hydro-electricity generation on the river and its tributaries, the river's flow was low in winter, high in spring from snowmelt, and then rainfall dependent during the summer. Changed flows because of the dams have led to the loss of entire species in the region. Additionally, European settlement and regulations, as well as contamination by toxins in some areas, have detrimentally affected the mauri of the river and the ability of the people to draw on traditional resources.

Ngāi Tahu are related through whakapapa to these lands and waters, and mahinga kai remains core to their culture. As a waterbody with an intact mauri is required for a healthy ecosystem and community, a Cultural Health Index has been developed to support eco-cultural restoration at a number of sites in the Waitaki catchment so they can sustain cultural usage.

Note: The information in this case study is drawn from Tipa & Nelson (2017).

State and trends | Te āhuatanga me ngā ia

Rivers and streams in Aotearoa are monitored for state and trends by regional and local authorities, whānau, hapū and iwi, Crown and private research institutes and Government departments. More than 1000 river sites have been monitored for water quality and ecological data over the last decade. The results are reported at a regional level in the State of the Environment (SoE) reports, and at a national level under the Environmental Reporting programme by the Ministry for the Environment and Statistics NZ. However, the methods used to collate these data are inconsistent, which has a bearing on the ability to inform an accurate national view of the state of the country's freshwater biodiversity and ecosystem integrity. Monitoring sites have not generally been selected as representative; rather, they have been chosen because of their local significance, or to inform consent monitoring, investigate suspected or known issues, or simply for convenience (MfE & Stats NZ 2017a). For example, monitoring networks have few sites in native land cover, and many sites in pastoral land cover. The variables measured, sampling frequencies and methods used vary across these sites and between agencies. Models may infer data where none is physically collected (MfE & Stats NZ 2019a).

The land cover in the surrounding catchment is used to categorise rivers and streams to estimate the impact of land use on water quality. Just over 1% of New Zealand's river length flows through urban land-cover, compared with 6% in exotic forest, 41% in native forest and 51% in pastoral land cover (MfE & Stats NZ 2020). While urban rivers and streams only make up just over 1% of New Zealand's total river length, they are generally the most polluted. Modelling between 2013 and 2017 showed that median levels of nitrate-nitrogen concentrations in urban waterways were 22x higher and dissolved reactive phosphorus 5x higher than in rivers flowing through predominately native land cover. Stormwater flowing off urban roofs and roads can carry high loads of heavy metals, including zinc and copper (MfE & Stats NZ 2019a). Rivers and streams flowing through pastoral land-cover have 10x higher concentrations of nitrate-nitrogen, phosphorus 3x higher and turbidity 2x higher than those flowing through native land cover (MfE & Stats NZ 2019a).

Tangata whenua have developed monitoring methods to assess the health of waterways from a te ao Māori perspective which includes interweaving environmental and socio-cultural aspects, for example by assessing cultural health indicators and mauri (Tipa & Teirney 2006; Rainforth & Harmsworth 2019). Between 2005 and 2006, 41 sites were assessed for cultural health and recorded with the Ministry for the Environment: ; the scores were: 1 'very good', 10 'good', 21 'moderate', 8 'poor' and 1 'very poor' (MfE & Stats NZ 2017a).

Despite the issues around national freshwater monitoring, some trends and patterns in river water quality have emerged. Between 2008 and 2017, river water quality monitoring sites showed a mix of improving and worsening trends, depending on the pollutant, land cover type and the geographical location of the monitoring site. In general, the majority of monitoring sites in urban land cover showed improving trends (i.e. concentration declines) for all pollutants (Fig. 20). Across native and pastoral land cover, approximately equal numbers of sites had improving and worsening trends for all pollutants except ammoniacal nitrogen, which was improving at 75% of the sites (Fig. 20).

There is no nationally consistent long-term dataset for deposited fine sediment, but modelling suggests an average sediment cover of 29% in 2011 (compared with an estimated 8% in the absence of humans) (MfE & Stats NZ 2017a).

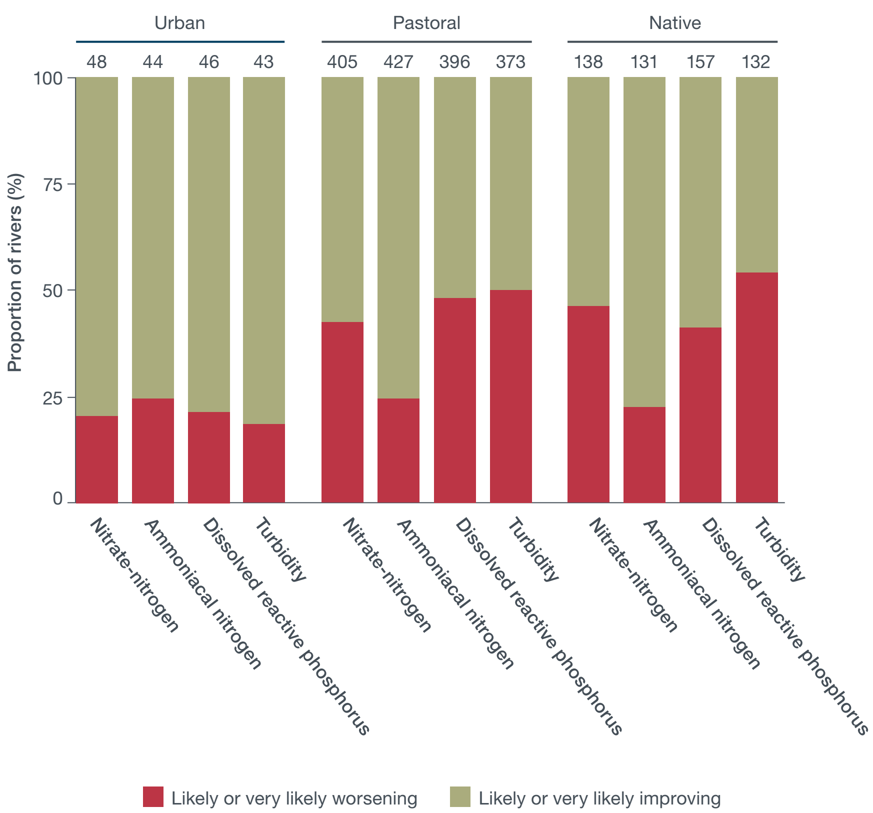


Figure 20. River water quality trends at sites with urban, pastoral and native land cover, 2008–2017. The number of monitoring sites where a trend could be assessed are shown at the top of the bars. Land-cover class is determined by the land-cover type in the upstream catchment. Figure adapted from Environment Aotearoa 2019 (MfE & Stats NZ 2019a) using material sourced from the Ministry for the Environment, Statistics NZ and data providers. Licensed by the Ministry for the Environment and Statistics NZ for reuse (**CC BY 4.0**[32]).

[32] **https://creativecommons.org/licenses/by/4.0/deed.ast**

Pressures | Ngā pēhanga

Pressures on rivers and streams can cause complete ecosystem loss in worst case scenarios. Physical habitat alteration (through changes to hydrology, siltation and riparian zones), changing water chemistry and adding or removing species (Malmqvist & Rundle 2002) are all major pressures that can contribute to a loss in ecosystem integrity. Understanding the contribution of individual pressures can be challenging. Interconnectivity between different catchments and waterbody types, variable lag times of different contaminants and variations in land cover and land use all contribute to the difficulty in isolating the effects of specific pressures. A mātauranga Māori assessment of the health and mauri of the Waitaki River is provided as a case study.

Lakes | Ngā roto

Lakes are important to tangata whenua as ancestral water bodies which are central to the identity of whānau, hapū and iwi living near them, and as mahinga kai (food gathering places). Mahinga kai traditionally provided an abundant supply of native fish, tuna/eels, kōura/freshwater crayfish, kākahi/freshwater mussels, and other species. These foods are still valued today; however, availability and access is much reduced.

Lakes are home to many native species, especially in the littoral (near shoreline) zone and support a greater diversity of native submerged plants than rivers and streams (de Winton & Schwarz 2004). Mega-invertebrates, such as kākahi/freshwater mussels and kōura/freshwater crayfish are common in some lakes.

Aotearoa has more than 50,000 lakes, but only 3820 of them are larger than 1 ha (Schallenberg et al. 2013; MfE & Stats NZ 2017a). They occur in a wide range of forms, reflecting the various geomorphic processes that created them. The most common – glacial lakes – are found in the South Island, while aeolian/dune lakes mostly dot the west coast of the North Island. Riverine lakes are found along the floodplains of major rivers (Lowe & Green 1992).

Many others are artificial, ranging from small farm ponds to large lakes formed behind major dams, such as Lake Benmore. This variety provides a correspondingly diverse range of habitats.

A few native fish, such as the Tarndale bully (‘At Risk – Naturally Uncommon’), are only known from a small number of localised lakes, while others – several galaxiids, tīpokopoko/common bully and paraki/smelt – readily form lake-dwelling populations. A variety of water birds depend on lakes for food sources including submerged plants, invertebrates and fish.

State and trends | Te āhuatanga me ngā ia

Information on the state and trend of biodiversity of most lakes is lacking. Environmental data exist for fewer than 5% of New Zealand’s lakes larger than 1 ha, and only around 150 of these lakes are regularly monitored – mostly for water quality – by regional authorities (Larned et al. 2018). Many whānau, hapū and iwi hold knowledge of the mauri of biodiversity in their local lakes. Some are monitoring and restoring that biodiversity through mātauranga Māori (e.g. Te Waihora/Lake Ellesmere, Waikato Peat Lakes and Lake Rotoitipaku).

The Lake Submerged Plant Index (LakeSPI) compares the diversity and cover of native and invasive plants in lakes. The greater the diversity and cover of native vegetation, the higher the score, so it can be used as a measure of lake health. LakeSPIs have been calculated only for 295 New Zealand lakes larger than 1 ha. Between 1991 and 2019, 100 (34%) of those were in excellent or good ecological condition, 90 (31%) were in moderate condition, and 105 (36%) were either in a poor state or lacked submerged plants altogether (MfE & Stats NZ 2020).

The Trophic Level Index 3 (TLI3) is the measure of a lake's trophic state (productivity), and calculated using total nitrogen, total phosphorus, and chlorophyll-*a* (planktonic algae) concentrations. Between 2013 and 2017, there was only enough data to calculate TLI3 for 58 lakes. Thirty-three of those (57%) were either in poor (eutrophic) or very poor (supertrophic) condition (Fig. 21; MfE & Stats NZ 2019a). For the same period modelled TLI values for over 3000 lakes larger than 1 ha found that 46% of lakes were in poor or very poor ecological health (MfE & Stats NZ 2020).

Over a ten-year period (2008–17) more sites (26) had improving rather than worsening (17) trends for TLI3 (MfE & Stats NZ 2019a). However, these observed trends are based on a very limited number of lakes. Furthermore, these improving trends may not be indicative for all lakes in Aotearoa, as case studies from many others (e.g. investigations undertaken by organisations other than councils) have found that water quality is deteriorating or at least not improving.

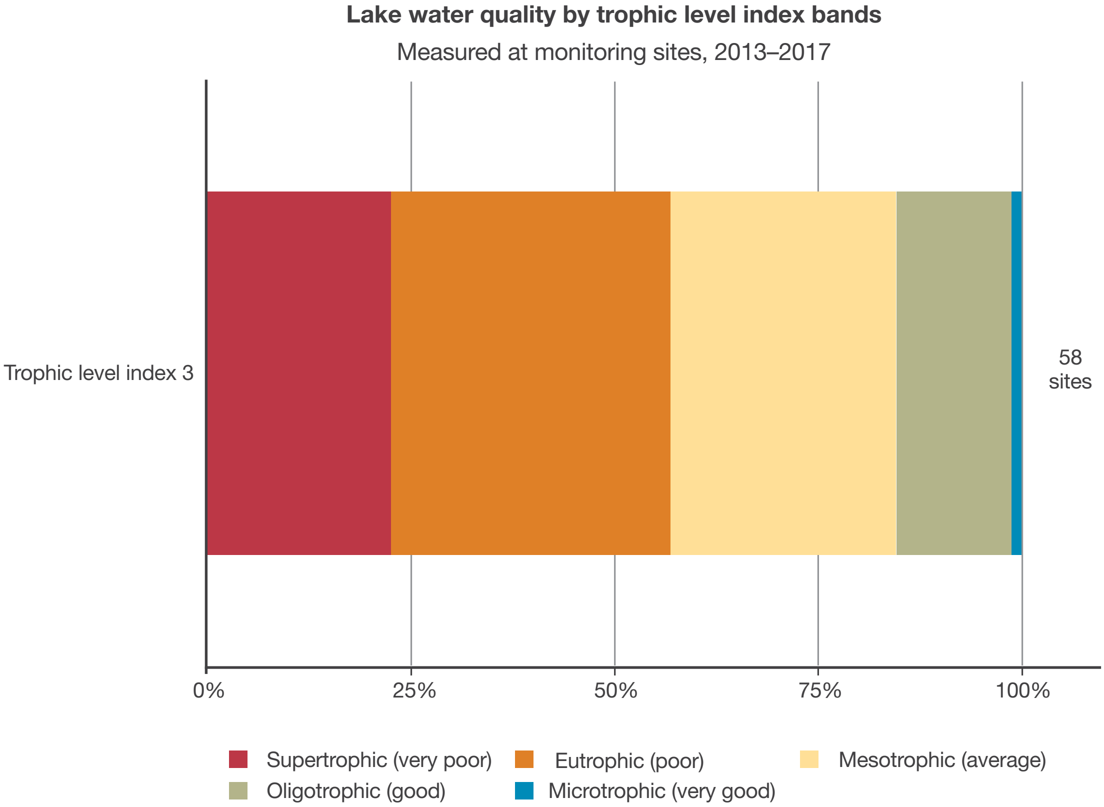


Figure 21. Lake water quality by trophic level index bands (TLI3) for 58 lakes (2013–17) measured at monitoring sites, 2013–2017. Source: Statistics NZ.[33] *Licensed by Statistics NZ for reuse (***CC BY 4.0**[34]*).*

[33] https://statisticsnz.shinyapps.io/lake_water_quality/

[34] https://creativecommons.org/licenses/by/4.0/deed.ast

Pressures | Ngā pēhanga

A suite of pressures associated with intensification of land use, species invasions and climate change affect New Zealand's lakes (Quinn et al. 2018; Özkundakci & Lehmann 2019). Ultimately, they drive biodiversity loss (Schallenberg & Sorrell 2009) and deplete mahinga kai and mauri of lakes.

Additionally, significant time lags and legacies (e.g. delayed inputs of nitrogen from past land-use change) make it difficult to quickly improve water quality and biodiversity values for many of New Zealand's degraded lakes (Quinn et al. 2018).

Wetlands | Ngā rohe kōreporepo

Wetlands are significant ecosystems to Māori for a wide range of values. They often have historical, cultural and spiritual associations. They sustain many taonga or mahinga kai species (Harmsworth 2002; Taura et al. 2017), either as habitat or as breeding grounds. Many of the most important weaving and carving plants are associated with wetlands[35].

Palustrine wetlands include bogs, fens, swamps, pākihi/gumland, ephemeral wetlands, seepages/flushes, and marshes (Johnson & Gerbeaux 2004). The different wetland types are defined by their water source – rainfall, surface runoff and/or groundwater, their water regime – duration and stability of water levels, their substrate type and corresponding nutrient status and pH. For example, bogs are predominantly rain-fed wetlands with a stable water regime and low fertility that encourages peat soils.

Wetlands support a high diversity of invertebrates, algae, birds, plants and fish (Suren & Sorrell 2010; Kilroy & Sorrell 2013). They offer refuge to many threatened species and include naturally rare ecosystems (Williams et al. 2007) (see *Naturally uncommon ecosystems* section in the *Land domain* chapter). Many of New Zealand's native wetland creatures (such as rare waikaka/mudfish, cryptic birds like pūweto/spotless crake and some non-migratory galaxiid species) rely on wetlands during all or part of their life cycle.

Wetlands provide a variety of important ecosystem services (Clarkson et al. 2013). For instance, they help to improve water quality, mitigate flooding and sequester carbon.

[35] https://www.landcareresearch.co.nz/__data/assets/pdf_file/0004/135085/Poster-1-maori-values.pdf

State and trends | Te āhuatanga me ngā ia

Remote sensing indicates that 250,000 ha of inland palustrine wetlands remain in Aotearoa – around 10% of their former extent (Ausseil et al. 2008). However, the data sources applied are >10 years old and wetland habitat has declined further since they were collected (Belliss et al. 2017). Lowland wetlands are the areas that have been most subject to land conversion, particularly swamps and marshes that were readily drained (Table 3).

A high proportion of remaining wetlands lie within conservation areas, and more than 60% of them, by area, are legally protected (Table 3). Wetland protection is biased by size: 'small' wetlands – those less than 50 ha – are not as well protected (Robertson 2016). It follows, then, that neither are the species that live in them, such the kōwaro/Canterbury mudfish, which is listed as 'Threatened – Nationally Critical'.

While wetland values are extensive, data on the hydrology, nutrient status, carbon balance, ecosystem services and biodiversity are lacking for most of New Zealand's wetlands. Some regional authorities have begun measuring indicators of wetland ecosystem integrity (e.g. Crisp et al. 2018), but up-to-date information remains a national data gap. A similar knowledge gap prevents assessment of the state of many wetland-dependent species.

Because of some focussed conservation and research programmes, a few species and ecosystems are quite well understood. For example, through the Arawai Kākāriki wetland restoration programme (see case study) the status of matuku/Australasian bittern has been reported (O'Donnell & Robertson 2016), which helped the species be assessed as 'Threatened – Nationally Critical'. Monitoring of targeted wetland systems also provides the information that their ecological condition varies from being highly degraded due to invasive species and hydrological change, to remaining relatively intact (e.g. Clarkson et al. 2011; Blyth et al. 2013). Understanding of some aspects of wetland biodiversity, such as plant communities in restiad-dominated peatlands, is also relatively good (Clarkson et al. 2004).

Table 3. The historic and present extent of inland palustrine wetlands in New Zealand, and the proportion within protected areas. Data: Robertson (2016); Ausseil et al. (2008).

Wetland type	Historical extent (ha)	Present extent (ha)	Proportion remaining (%)	Proportion remaining in protected areas (%)
Bog	153,116	40,061	26.2	78.9
Fen	192,097	37,009	19.3	46.8
Pakihi/gumland	339,458	56,909	16.8	83.9
Inland saline	1,586	292	18.4	8.8
Marsh	280,828	23,066	8.2	31.1
Seepage	2,990	2,043	68.3	29.2
Swamp	1,501,008	89,922	6.0	50.9
undefined	-	474	-	-
TOTAL	**2,471,083**	**249,776**	**10.1**	**60.3**

Arawai Kākāriki wetland restoration programme

Arawai Kākāriki is a national wetland conservation initiative led by the Department of Conservation that aims to protect five of New Zealand's most significant wetland sites by working with councils, landowners, iwi, scientists and the community.

Over the past 10 years, efforts under Arawai Kākāriki have resulted in sustained predator control to protect threatened species over more than 16,000 ha of wetlands and braided rivers, changes to the management of two flood schemes to enhance freshwater biodiversity and over 10,000 ha of weed control and surveillance to restore native vegetation.

Research is also a focus – to provide knowledge on how wetlands are changing. More than 150 science reports and presentations that support wetland conservation have been supported by Arawai Kākāriki.

Ō Tū Wharekai is a nationally important inter-montane wetland, lake and braided river site that has outstanding biodiversity values and high cultural significance to Ngāi Tahu. Pictured is Lake Heron, one of twelve lakes in the complex. *Photo: Jack Mace*

An ongoing negative trend in wetland extent is still occurring, as the area of wetlands continues to shrink by 0.5% per annum in the face of development and agricultural intensification in some regions (e.g. Southland; Robertson et al. 2019). Wetland loss is still occurring: At least 5000 ha of wetland is estimated to have been lost since 2001 (Belliss et al. 2017), but due to incomplete mapping this figure is potentially much greater. The decline of wetland-dependent species is associated with this loss of habitat (e.g. the significant population decline of matuku/Australasian bittern; O'Donnell & Robertson 2016) which now has a conservation status of 'Nationally Critical'.

While data to comprehensively report on national trends in wetland species and ecosystems are lacking, site-specific conservation programmes addressing invasive species, poor water quality and drainage to restore wetlands are being implemented in many regions.

Pressures | Ngā pēhanga

Wetlands face a range of familiar pressures. Vegetation clearance, habitat fragmentation, compromised hydrology and nutrient enrichment are widespread (see *Pressures* chapter), due to drainage schemes and agricultural intensification. Corresponding surges in nitrogen and phosphorus (Burge et al. 2020) and water loss (Sorrell et al. 2007) can deplete wetland biodiversity. Fires, forestry and urban development, invasive plants and invasive animals also continue to contribute to wetland degradation. Human-induced fires, for example, continue to burn extensive areas of bogs and gumlands, causing loss in indigenous vegetation (e.g. Clarkson et al. 2011). Climate change is projected to alter rainfall patterns across Aotearoa, increase sea levels and temperatures. All will profoundly affect the function and composition of coastal and inland wetlands.

Groundwaters | Ngā wainuku

Groundwaters are also significant to Māori, and the places where they arise from the earth are often recognised as wāhi tapu or valued for other reasons. They are frequently referred to in mōteatea, waiata and karakia. There are many different words in te reo Māori reflecting the wide range of types of water which are recognised. Some of the purest waters are often used in ceremonial practices such as whakanoa (removing tapu).

By definition, groundwater is subterranean, lying in the pore spaces of unconsolidated sediments or fractures in bedrock. Geological formations that hold or transmit groundwater are called aquifers, and around 200 have been identified in Aotearoa (MfE & Stats NZ 2015).

Because many groundwaters are closely interconnected with surface waters, ecosystems above ground often rely on them, permanently or intermittently, to support biological communities and ecological function. Such systems are termed groundwater-dependent ecosystems (GDEs). Aotearoa has a diverse array of GDEs (e.g. caves, coldwater springs of many kinds, lakes, seeps, wetlands and spring-fed streams). Together, they comprise New Zealand's largest freshwater habitat. Te Waikoropupū springs are a well-known example of a coldwater spring system.

Some GDEs occur entirely underground. These alluvial groundwater ecosystems are termed subsurface GDEs (Fenwick 2016). Little is known about the biodiversity and ecological processes of New Zealand's subsurface GDEs, despite these ecosystems being extensive in Aotearoa (Fenwick et al. 2018).

New Zealand's GDEs support diverse flora and fauna communities. For example, coldwater springs are renowned for supporting rich invertebrate faunas, including species from both surface and groundwater ecosystems (Scarsbrook et al. 2007). Springs are also important habitat for many non-migratory galaxiids.

New Zealand's alluvial aquifers appear to support diverse stygofaunal communities – those that are adapted to live underground – compared with many other places (Fenwick 2016). The country's stygofauna are predominantly endemic at the species level (Scarsbrook et al. 2003).

State and trends | Te āhuatanga me ngā ia

Despite this wealth of biota and habitats, information on the state and trend of GDE biodiversity in Aotearoa is lacking. For example, the distributions of stygofauna species are poorly known, and it is likely that many more species are yet to be discovered (Fenwick et al. 2018).

Little dedicated information exists for the environmental or physical components of many of New Zealand's GDEs. Groundwater quality monitoring between 2014 and 2018 revealed that:

- 44% of 424 sites across the country had median nitrate-nitrogen concentrations higher than what would be expected naturally (3 g/m^3), and
- 28% of 483 sites failed to meet drinking water standards for nitrate-nitrogen (11.3 g/m^3) on at least one occasion.

Between 2009 and 2018, monitoring of selected water quality variables showed that 92 sites (35%) had worsening trends for nitrate-nitrogen, 37 (28%) for ammoniacal nitrogen, 42 (28%) for dissolved reactive phosphorus (Fig. 22) (MfE & Stats NZ 2020).

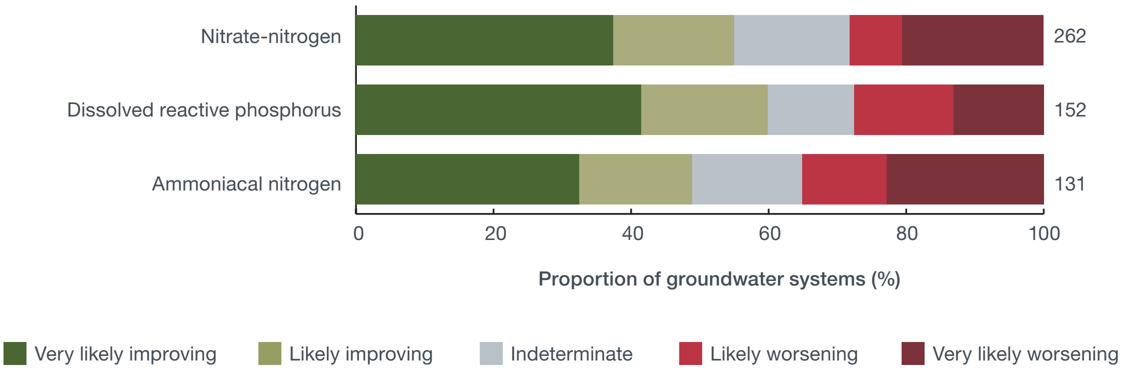


*Figure 22. Groundwater quality trend direction measured at sites, 2009–2018. The number of sites assessed of each water quality measure are listed to the right of the bars. Source: Statistics NZ.[36] Licensed by Statistics NZ for reuse (***CC BY 4.0***[37]).*

Pressures | Ngā pēhanga

In many places, GDEs are subject to multiple pressures, such as nutrient enrichment, hydrological alteration of habitat and physical alteration (or complete loss) of habitat (Fenwick et al. 2018). For subsurface GDEs, high-intensity land use is often associated with groundwater abstraction (leading to hydrological alteration), nutrient leaching (especially nitrate-nitrogen) and organic enrichment, all of which can threaten groundwater ecosystems and their ecosystem services (Fenwick et al. 2018). A major complicating factor in the relationship between land use and GDEs is that impacts on groundwater quality can take months or even decades to manifest, as lag times can be long.

Freshwater fish | Ngā ika wai māori

Freshwater fish are an important part of mahinga kai for Māori, therefore there is much mātauranga Māori on the various species and their habitat (Keane 2010b). Cultural keystone species such as īnanga/whitebait, tuna/eels, and piharau/lamprey are highly valued for sharing with visitors through manaakitanga.

Aotearoa has 51 native freshwater fish species (Dunn et al. 2018), found throughout wetlands, streams, rivers and lakes. Of these, 46 species (90%) are endemic (NZTCS 2019) and 14 (27%) of these have not been formally named and described.

Inanga/whitebait and tuna/eels migrate to and from the sea. Smaller non-migratory species are more cryptic and complete their entire life cycles in freshwater habitats. They constitute 91% of threatened freshwater fish species.

There has been a substantial improvement in the knowledge and data of New Zealand freshwater fish in the past 20 years, particularly in relation to their distribution, abundance and general habitat requirements. However, research on native fish is largely *ad hoc*, so there are still fundamental knowledge gaps around their general biology, spawning, specific habitat requirements, behaviour and taxonomy – especially within the non-migratory galaxias. There is also a lack of published research on the effects of pressures such as hydrological alteration, habitat modification and loss, and interactions with introduced species.

[36] **https://statisticsnz.shinyapps.io/groundwater_quality/**
[37] **https://creativecommons.org/licenses/by/4.0/deed.ast**

State and trends | Te āhuatanga me ngā ia

The conservation status of 51 freshwater fish species has been assessed (Dunn et al. 2018). Twenty-two (20 non-migratory and two migratory) (44%) are classified as 'Threatened', and a further 17 (nine non-migratory and eight migratory) (34%) are classified as 'At Risk' (Fig. 23; NZTCS 2019). Four of the six species defined as whitebait are either 'Threatened – Nationally Vulnerable' (shortjaw kōkopu) or 'At Risk – Declining' (giant kōkopu, īnanga, kōaro). The endemic longfin eel /reherehe is classified as 'At Risk – Declining'. The 2018 NZTCS assessment report (Dunn et al. 2018) drew predominantly on data from the New Zealand Freshwater Fish Database (NZFFD).[38]

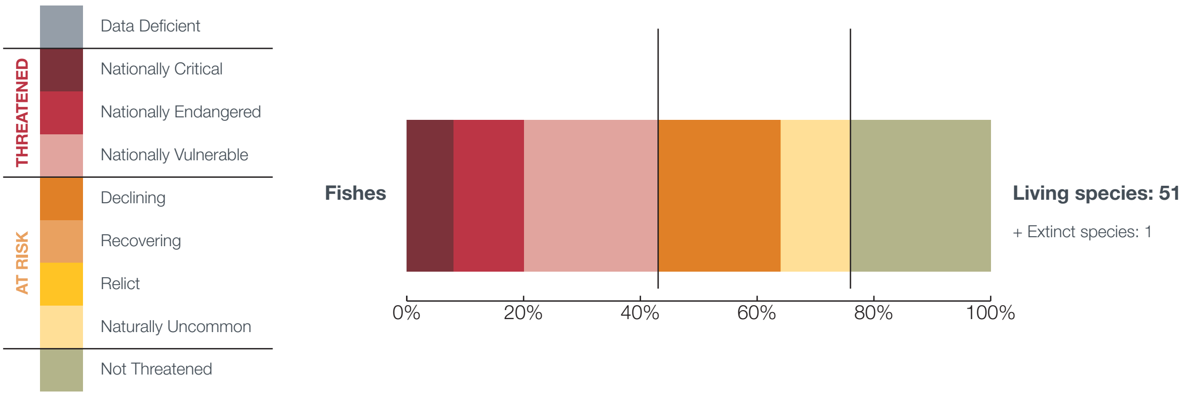


Figure 23. Conservation status (NZTCS) of New Zealand's resident native freshwater fish. Data source: NZTCS (2019).

There are few targeted population survey and monitoring programmes for freshwater fish, and that hampers quantitative trend assessments. For example, data are collected on reherehe/ longfin eel and matamoe/shortfin eel commercial catches, but beyond fished areas, little is known. Despite this, NIWA has calculated population trends based on NZFFD data for some native species (Crow et al. 2016): all were assessed as having stable or downward trends, except matamoe/shortfin eel and upland bully, which were considered to be gradually increasing. Two 'Threatened – Nationally Critical' species continue to have a downward trend: Canterbury mudfish and Clutha flathead galaxias.

Pressures | Ngā pēhanga

Freshwater fish face a multitude of pressures at all stages of their life cycle. Water abstraction for irrigation alters the hydrology of important habitats. Vegetation clearance leads to the sedimentation of waterways, which may destroy or dramatically modify critical spawning habitats. Agricultural intensification degrades water quality, as do point-source discharges of pollutants. Wetland drainage and stream modification, such as straightening and piping, denies fish habitat and mobility. Introduced sport fish, notably trout and salmon, prey on native species, and affect non-migratory galaxias in particular. Dams, weirs and other artificial features impede or block the movements of freshwater fish and other freshwater species. This often results in a reduction in fish numbers and changes to the species composition within catchments (Franklin et al. 2018). Some migratory fish species (tuna/ eels and īnanga/whitebait) face an additional pressure from being subject to recreational and commercial fishing.

[38] https://nzffdms.niwa.co.nz/

The specific impact of any single pressure is difficult to quantify because they commonly interact with other pressures and the magnitude of the pressure can vary among ecosystem types and species. Therefore, the sum of known impacts – their cumulative effects – should be considered instead. These are often underestimated: climate change, for instance, is likely to bring profound impacts as changes in river and stream flows hinder access to and from the sea. Shifting weather patterns could alter ocean currents, disrupting the migration of larval fish. Warmer water temperatures and the desiccation and loss of wetted habitat could see fish distributions shrink.

Freshwater invertebrates | Ngā tuaiwi-kore wai māori

Freshwater macroinvertebrates are organisms large enough to be seen with the naked eye (e.g. kōura/freshwater crayfish, kākahi/freshwater mussels, worms and freshwater insects like piriwai/mayflies). All lack a backbone and live for at least part of their life cycle in freshwater environments.

Some, notably kōura/freshwater crayfish and kākahi/freshwater mussels, are important mahinga kai species, and their availability can be a useful indicator of ecosystem integrity.

Freshwater invertebrates inhabit a wide range of habitats, from groundwaters to high alpine tarns. In addition to their intrinsic biodiversity and mahinga kai value, aquatic invertebrates are the bedrock of freshwater and riparian food webs, and perform vital ecosystem services, such as nutrient cycling, water purification, secondary production and bioturbation (the mixing of sediments) (Macadam & Stockan 2015).

More than 2000 freshwater invertebrate species are known from Aotearoa, and many more are likely to be undiscovered and undescribed (Gordon 2013). They are distinct from those found elsewhere: around 95% of the 670 assessed native species in the latest conservation status assessment are endemic (NZTCS 2019).

Understanding of the taxonomy, ecology and distributions of most freshwater invertebrate species is severely hampered by knowledge gaps (Drinan et al. 2020). For many species, there are few recent data around their geographic distribution, at either local or regional scales. The abundance of species, and how their populations change over time, is largely unknown. A great many species are currently unresolved taxonomically, and freshwater invertebrate taxonomic research effort has declined (Leschen et al. 2016).

A male fringed-gill mayfly (*Isothraulus abditus*). This species has a conservation status of 'At Risk – Declining'.
Credit: Olly Ball/Steve Pohe Collection

State and trends | Te āhuatanga me ngā ia

The conservation status of 670 native freshwater invertebrate species has been assessed (Grainger et al. 2018). Most species are categorised as either 'Not Threatened' (315 species; 47%) or 'Data Deficient' (178 species; 27%) (Fig. 24). Of the 78 'Threatened' species, 48 are considered 'Threatened – Nationally Critical' (NZTCS 2019).

A lack of data means that trends for most species cannot be assessed. Seventeen species changed conservation status between the 2013 (Grainger et al. 2014) and 2018 assessments, but for only one species – the tadpole shrimp – was this due to observed declines in populations which were of sufficient size to reclassify. All other status changes were the result of better understanding of species distributions. Without sufficient information, future losses of freshwater invertebrate biodiversity are likely to go largely unnoticed and unquantified.

Although the macroinvertebrate community index (MCI) is used to assess stream health in New Zealand, it is based on coarser taxonomic resolutions (typically genus level). Therefore, it provides little direct information on species-level state or trends. Nevertheless, where MCI was measured between 2008 and 2017, 38% of the 573 river sites had worsening trends, 26% had improving trends, and 37% had indeterminate trends (MfE & Stats NZ 2020).

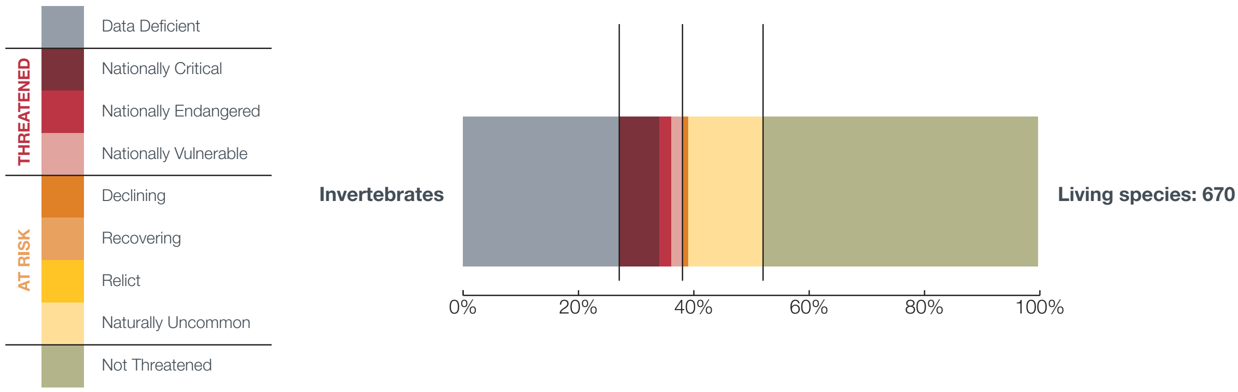


Figure 24. Conservation status (NZTCS) of New Zealand's resident native freshwater invertebrates. The statistics presented here exclude four beetles (Leschen et al. 2012), two earthworms (Buckley et al. 2015) and seven spiders (Sirvid et al. 2012) that were assessed separately in addition to those species referenced in the text. The NZTCS has not included a comprehensive assessment of all invertebrates, so the statistics presented here for these are not comprehensive of the total New Zealand biota (see **Appendix 2***). Data source: NZTCS (2019).*

Pressures | Ngā pēhanga

New Zealand's freshwater ecosystems are under stress from a range of pressures, many of which occur simultaneously (e.g. Matthaei et al. 2010; Piggott et al. 2015). However, habitat loss and modification, water pollution, invasive species and climate change pressures are recognised as the main threats to the native freshwater fauna of Aotearoa (Joy & Death 2013; Weeks et al. 2016). Harvesting may be a localised pressure for some species (e.g. kōura/freshwater crayfish).

Aquatic plants | Ngā tipu wai

Aquatic vegetation communities are vital to healthy freshwater ecosystems. They provide cover and food for a host of aquatic invertebrates, fish and birds over and above their intrinsic value. The introduced wātakirihi/watercress is a valued food source for Māori.

State and trends | Te āhuatanga me ngā ia

Twenty-four species (13%) of freshwater vascular plants are considered to be 'Threatened' and 46 (26%) are 'At Risk' (Fig. 25). Of the species that are considered 'Threatened', 12 species (7%) are 'Threatened – Nationally Critical' – the highest risk category. Eleven of the 12 known freshwater lichen species are 'Data Deficient' (NZTCS 2019).

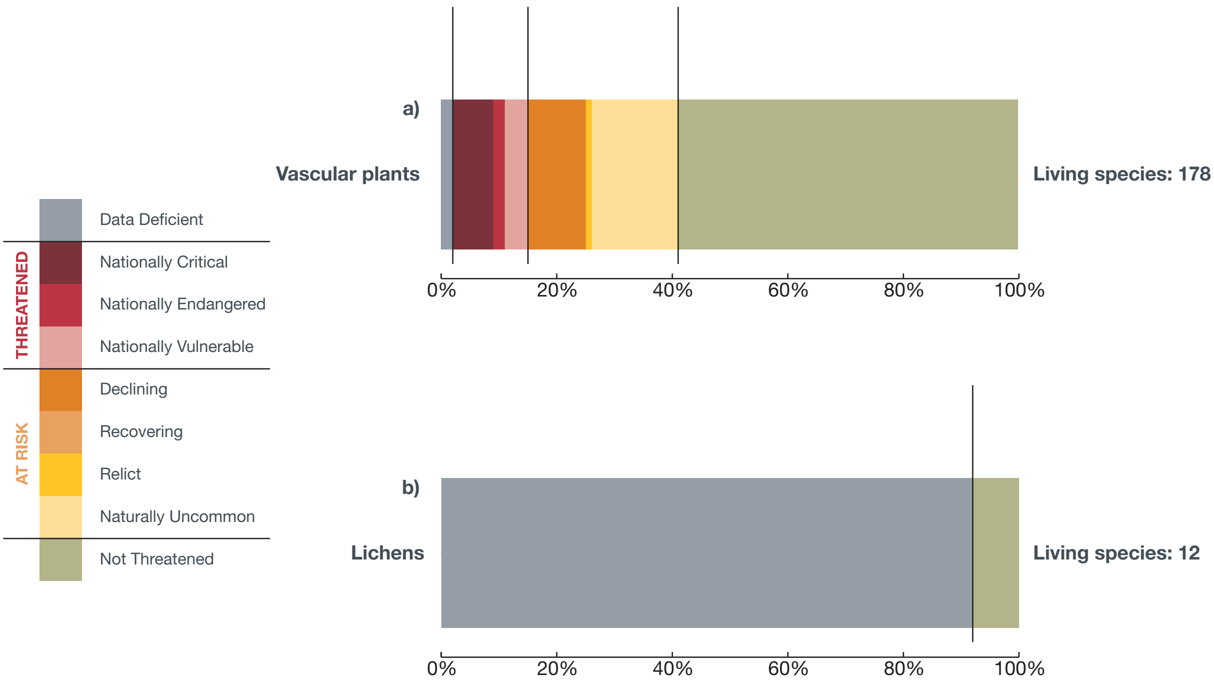


Figure 25. Conservation status (NZTCS) of New Zealand's resident native freshwater a) vascular flora and b) lichenised fungi. This graph only includes obligate freshwater vascular plant species. Species that occur in the land domain as well as the freshwater domain are included in the Flora section of the Land domain chapter. Data source: NZTCS (2019).

Pressures | Ngā pēhanga

The composition of aquatic floral communities has changed significantly since human arrival. Invasive exotic species and land use change resulting in wetland drainage, declining water quality, grazing, trampling and clearance have all taken a toll (Reeves et al. 2004). New Zealand's aquatic flora is low growing and adapted to extensive shade, but riparian vegetation loss has seen stream beds exposed to sunlight, which allows exotic species to flourish and displace native species (Howard-Williams et al. 1987). The proliferation of invasive exotic species can change patterns in dissolved oxygen, hydrology and stream habitats. Human activity has accelerated the spread of introduced species, with fragments and seeds transferred on boats, nets and machinery. NIWA has listed 41 such introduced species as pests of greatest concern in New Zealand's freshwater environments. Four are thought to have been be eradicated, while 29 are listed as 'unwanted' or 'notifiable' in the Biosecurity Act (1993).[39]

Yellow bladderwort (*Utricularia australis*) is a species of aquatic bladderwort that has a conservation status of 'Threatened – Nationally Critical'. It is carnivorous and uses its many small bladders to capture small aquatic animals. Its range has been massively limited due to competition from other aquatic plant species and from habitat loss through land drainage. *Photo: Rohan Wells, NIWA*

[39] https://niwa.co.nz/freshwater-and-estuaries/management-tools/identification-guides-and-fact-sheets/freshwater-pest-species

Marine domain | Te Whaitua Moana

Overview | Tirohanga whānui

After the separation of Ranginui and Papatūānuku, Tangaroa became the god of the sea. Tangaroa is very powerful and has many characteristics, from supportive and benign to violent and destructive. The sea and coast have always been essential sources of food and other resources and today, harvesting continues to be core to Māori culture and economy. Kai moana is essential to the ability to offer manaakitanga to guests (Royal 2010).

Māori play a critical role in the marine environment, as a Treaty partner, and due to their diverse range of rights and interests, including cultural and commercial rights under Treaty settlements (including relating to fisheries and aquaculture), and rights under the Marine and Coastal Area (Takutai Moana) Act 2011 (Royal 2010).

This chapter describes the state, trends and pressures of indigenous marine ecosystems and species groups. Coastal estuarine ecosystems are described separately from other marine ecosystems. Species groups cover the range of flora and fauna that are classified under the NZTCS with the addition of some groups which contain migratory species classified under the IUCN red list categories.

Aotearoa New Zealand has 15 times more sea area than land. Marine habitats are diverse, ranging from sheltered inlets, fiords, estuaries, seagrass beds, rimurapa/kelp forests, shellfish beds, extensive sandy coasts through to rocky coasts and reefs and the open ocean.

The extent of the country's marine environment, along with its remoteness, make it a global hotspot for marine biodiversity. Of the 12,820 described marine species, over half are endemic (Gordon et al. 2010).

Hoiho (yellow-eyed penguin, *Megadyptes antipodes*), meaning 'noise shouter' in te reo māori, were named because of their shrill call. Beloved by New Zealanders, hoiho grace the $5 note and were crowned 'Bird of the Year' (by public vote) in Forest & Bird's 2019 Bird of the Year campaign. However, they are now under serious threat due to warming oceans, human disturbance and interaction with fisheries, and have a conservation status of 'Threatened – Nationally Endangered'. *Photo: Sabine Bernert*

State and trends | Te āhuatanga me ngā ia

New Zealand's coastal water quality is degraded in some places. There has been a significant loss of some marine habitats (e.g. mussel beds and seagrass meadows) and some declines are predicted to continue (Anderson at al. 2019). However, understanding of the scale of change or loss in marine habitats is incomplete and there is currently no comprehensive picture of New Zealand's marine ecosystem quality (MfE & Stats NZ 2019b).

Of the 1552 marine species that have been assessed for their conservation status, 55 species (4%) are 'Threatened' and a further 504 species (32%) are 'At Risk', while nearly half (730 species; 47%) are 'Data Deficient' (Fig. 26; NZTCS 2019). By one estimate, barely a third of Aotearoa New Zealand's marine biodiversity has been officially described (Gordon et al. 2010). It is possible that around 50,000 species remain to be described, making it difficult to know the full conservation status of the country's marine biota (Gordon et al. 2010).

While there is good information on the trends in some species, trends in the conservation status of many elements of New Zealand's marine biodiversity are difficult to identify, mostly due to a lack of baseline and recent information, and the lack of a nationally coordinated approach to monitoring (Hewitt et al. 2014; Lundquist et al. 2015). Notwithstanding this, a few species are showing positive trends towards recovery, but others, like the popoto/Māui dolphin are not. Examples of conservation successes include the recovery of some protected species from historical harvesting (e.g. New Zealand fur seals and southern right whales).

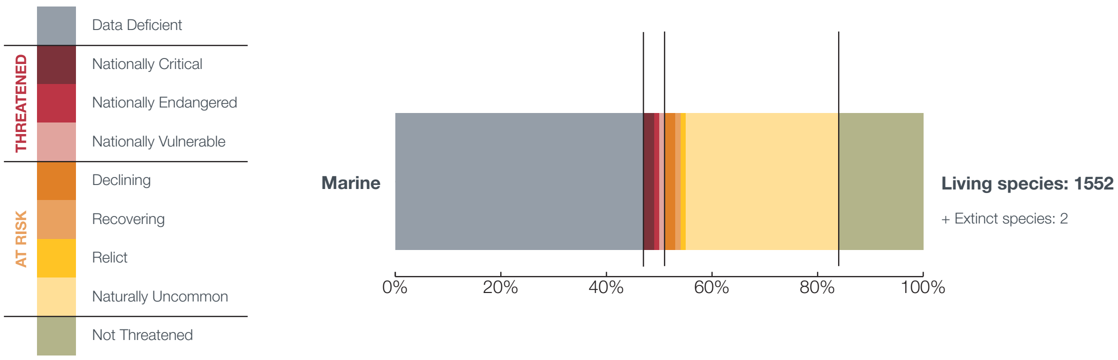


Figure 26. Conservation status (NZTCS) of resident native marine species assessed under the NZTCS. Data source: NZTCS (2019).

Pressures | Ngā pēhanga

While climate change presents the greatest threat to the Aotearoa New Zealand's marine habitats, what humans do on the land, and our activities in the sea, have profound consequences for life in the seas, particularly in the immediate to short term, and particularly in nearshore environments (see *Pressures* chapter). Sedimentation and contaminants are high in some areas along the coast and plastic pollution presents a risk to marine life across all the world's oceans.

Fishing and its wider impacts, including bycatch, can pose a risk to some species and habitats. However, the full extent of impacts from the broader marine environment is unknown and there are gaps in knowledge on the environmental limits around sustainable resource use (MfE & Stats NZ 2019a).

The implementation of marine protected areas and other conservation and fisheries management measures are acknowledged as conservation successes for the marine environment.

Ecosystems | Ngā pūnaha hauropi

The wellbeing of people and the ocean are inextricably linked from a te ao Māori perspective – if the mauri of the ocean declines, so too does the mauri of people. Oceans have always been a source of spiritual and physical sustenance to most iwi, and their resources are important for providing manaakitanga (MfE 2019).

New Zealand's marine environment spans about 30° of latitude, from the waters around the subtropical Rangitāhua/Kermadec Islands to the Subantarctic Islands, and from shallow coastal areas to trenches approximately 10 km deep. Our coastal and marine habitats are diverse, and include sheltered inlets, fiords, estuaries, seagrass meadows, rimurapa/kelp forests, shellfish beds, hydrothermal vents, seamounts, soft sediments and high-energy rocky reefs.

Currently, Aotearoa has 17,697 km^2 (0.4%) of its marine and coastal area (9.8% of the territorial sea and 0% of the exclusive economic zone) in marine protected areas that meet the strictest definition of IUCN categories (those areas protected as 100% no-take marine reserves); a further 1,268,369 km^2 (about 28% of the territorial sea and exclusive economic zone combined) is protected under a variety of other protection measures (DOC 2019b). Despite this, the country's network of marine protection is not yet representative of its range of marine habitats and ecosystems (DOC 2019b).

State and trends | Te āhuatanga me ngā ia

Since the first human arrivals, some of New Zealand's marine ecosystems – particularly those close to shore and around the mainland – have undergone significant modification. Kekeno/fur seals and rāpoka/sea lions were virtually eliminated from mainland marine ecosystems within a few hundred years of human settlement; large whales were severely exploited during the 19th and 20th centuries and there was increasing exploitation of invertebrate and fish populations as commercial fishing became established in the late 1800s (MacDiarmid et al. 2016). Along with direct removals of marine species, there has been loss and degradation of marine habitats, particularly in shallow coastal ecosystems, such as estuaries, where human pressures are greatest (MacDiarmid et al. 2012).

However, New Zealand's marine environment remains largely unexplored. More than half of the marine domain is deeper than 2000 m and beyond fishing depths (Gordon et al. 2010). In deep sea environments below 2000 m and other remote and inaccessible areas, there are ecosystems that have experienced few human pressures, or are recovering from historical impacts (including parts of the New Zealand subantarctic region, Halpern et al. 2008). In the absence of any baseline monitoring or mapping information for such areas, assessing their biodiversity values or the degree of any changes is problematic.

While Aotearoa has a wide variety of marine ecosystems, the level of knowledge regarding the scale of their change or loss is incomplete (MfE & Stats NZ 2019b). There is some data to confirm that there has been a significant loss of some habitats (e.g. mussel beds and seagrass meadows) and some declines are predicted to continue (Anderson et al. 2019). Other habitats, such as mānawa/mangroves, are increasing in extent, but there are not enough historic baselines to determine how much has already been lost or damaged, or what that loss means to other elements of ecosystem integrity (Anderson et al. 2019). Collaborating with whānau, hapū and iwi to understand the trends observed intergenerationally and transmitted orally would enhance our understanding of the trends over time.

More mapping effort is needed to document the identity, abundance and distribution of New Zealand's marine biodiversity, and there is a need to better understand the links between biodiversity and ecosystem function in marine communities (Nelson et al. 2015a; MPI 2019a). Additionally, there is currently no comprehensive picture of the country's marine ecosystem integrity (MfE & Stats NZ 2019b). For many variables, there are no national guidelines that would allow for consistent assessment of the state of coastal waters (MfE & Stats NZ 2019a). There are insufficient data to track trends in heavy metal pollution (MfE & Stats NZ 2019b) and no national strategy for emerging contaminants (MfE & Stats NZ 2019a). Sediment and water quality are routinely monitored at many coastal and estuarine sites around Aotearoa (see *Estuaries* section). However, not all habitats and regions are covered, and methodologies have been applied inconsistently across regions and agencies. This makes it difficult to compare and aggregate results at a national scale (Dudley et al. 2017).

There is some information on the recovery of ecosystems through monitoring of particular conservation or management measures (e.g. fisheries closures), customary protection areas (e.g. mātaitai and taiāpure), and marine protected areas. For example, the increase in size and abundance of predatory fish (e.g. snapper and lobsters) within Cape Rodney to Okakari Point Marine Reserve facilitated the recovery of rimurapa/kelp forests over a 25-year period by reducing the number of kina (Shears & Babcock 2003). However, for some regions and habitats, the legacy of habitat loss or modification through sedimentation and/or bottom trawling and dredging may prevent some populations and habitats from recovering (MacDiarmid et al. 2016).

Pressures | Ngā pēhanga

The pressures on marine ecosystems are varied and include sedimentation, fishing, mining, input of nutrients and contaminants, plastic pollution, noise and climate change (MacDiarmid et al. 2012) (see *Pressures* chapter). Habitat loss is particularly severe in coastal ecosystems subjected to intense human pressures and can have cascading and long-lasting effects on ecosystem services. Many of the most productive biogenic habitats (habitats created by living plants or animals) are highly vulnerable to the impacts of human activities, and their decline in extent and function can cause wider ecosystem collapse (Anderson et al. 2019). Experts have identified ocean acidification as the greatest threat to the country's marine habitats, with rising sea temperature the second (MacDiarmid et al. 2012). Both are the result of climate change. The review concluded that reef, sand and mud habitats in harbours and estuaries and along sheltered and exposed coasts were the most highly threatened habitats.

Plastic pollution is a persistent issue for marine biodiversity. Plastics have now been found in organisms throughout the Pacific Ocean food web, including zooplankton, fish and shellfish (Desforges et al. 2015; Forrest & Hindell 2018; Markic et al. 2018). Emerging contaminants, such as those used in hygiene products, industrial chemicals and pharmaceuticals, are now turning up in some regions of Aotearoa (Stewart et al. 2016).

While progress is being made in better understanding and responding to cumulative effects of pressures on the marine environment (including through the Sustainable Seas National Science Challenge; e.g. Davies et al. 2018), there remain knowledge gaps. This has been identified as one of the most urgent issues facing New Zealand's marine ecosystems (MfE & Stats NZ 2019b).

Estuaries | Ngā wahapū

Estuaries are areas where freshwater rivers or streams meet the ocean and they are one of the most productive ecosystems on the planet. As such, they are an important ecosystem for Māori, providing mahinga kai and materials. They often have strong historical, cultural and spiritual significance to whānau, hapū and iwi (see Manaaki Taha Moana case study).

More broadly, estuaries provide many benefits to human wellbeing, such as fisheries, nutrient cycling and recreation (Thrush et al. 2013). Mānawa/mangroves, saltmarsh and seagrass are of particular value for climate change mitigation as rich carbon sinks. Tidal river mouths and lagoons, and their associated intertidal sandflats, mudflats, seagrass and vegetated wetlands, provide shelter, breeding, nursery and feeding habitats for a range of species, including important commercial and recreational fish species.

Estuaries are naturally uncommon ecosystems classified as 'Threatened – Nationally Vulnerable', (Holdaway et al. 2012, see *Naturally uncommon ecosystems* section). Understanding species composition and population sizes at even the smallest of sites can be critical for biodiversity conservation (Dowding & Moore 2006; Richardson et al. 2015).

In general, there is a lack of national-scale state, trend and pressure indicators relevant to estuaries. Estuary data collected by regional councils, and catchment-scale information, habitat extent, and species data assigned to estuarine habitat types, are usually reported at regional levels.

State and trends | Te āhuatanga me ngā ia

There is no national habitat mapping scheme for estuaries/coastal wetlands in Aotearoa and the relative lack of nationwide reporting means that changes to this ecosystem type are not well documented. This poses a risk, given natural coastal wetland losses of as much as 46–50% are predicted globally in the long term (Davidson 2014). Regional councils monitor benthic macrofauna communities and a suite of pressures at various sites[40] but, again, there is very little national reporting. Some studies have looked at habitat values of estuaries and have provided an insight into their value. For example, nineteen sites, mostly estuaries, are identified as having national significance for shorebirds as critical breeding and non-breeding habitats (Dowding & Moore 2006).

Data collected on the extent of mānawa/mangroves and seagrass, an 'At Risk' species, have been compiled (see Anderson et al. 2019) and are a valuable national dataset for reporting on these habitats (e.g. Bell & Blayney 2017). Regional councils also monitor broadscale habitat changes in selected estuaries (e.g. the extent of intertidal mud, saltmarsh and seagrass). However, there is no national trend reporting of this data.

While national state and trend data are deficient, there is there also is a lack of integrated regional reporting which links estuarine pressures with biodiversity. An exception is a 2016 survey (Todd et al. 2016) of 48 sites in lower North Island estuaries which recorded 58 'Threatened' and 'At Risk' species, with the Manawatū Estuary alone supporting 35 species. Four of the 48 sites were ranked as having 'low' pressures. The three sites ranked highest for ecosystem value also had the highest number of 'Threatened' and 'At Risk' species (Manawatū Estuary, Waikanae Estuary, Lake Ōnoke and lagoons).

[40] https://www.doc.govt.nz/nature/habitats/estuaries/monitoring-estuaries-map/

Manaaki Taha Moana

Tangata whenua have long been concerned about the degradation of coastal resources, kaimoana and waterways and the negative effects of these on their cultural identity and mana. Manaaki Taha Moana was a multi-year cross-agency project in Awanui Tauranga Moana (Ngāti Ranginui, Ngāi Te Rangi, Ngāti Pūkenga) and the Horowhenua coastline (Ngāti Raukawa). It assessed the holistic health of coastal ecosystems to help restore the ecosystem services that are important to iwi and hapū.

Stocktakes and research on the state of these two coastal ecosystems have shown that the availability and health of kaimoana have both decreased significantly. Several other ecological and cultural indicators of coastal ecosystem integrity are of concern as well, and the research concluded that the cumulative effect of multiple stressors have caused the observed declines.

Land use change has been a significant factor. Between 1840 and 1991, the area of freshwater wetland around Tauranga Harbour declined by 84%. Since 1840, approximately 700 ha of saltmarsh have been lost because of land reclamation. The area of coastal (saline) wetland has increased by 17%, mostly through mānawa/mangroves expanding due to sedimentation impacts. Land converted to pasture currently creates the biggest sediment load in Tauranga Harbour (63% of the total). On the Horowhenua coast, there has been a significant reduction in the area of active sand dunes since the 1940s; for example, the 240 ha Hōkio sub-catchment has changed from being 88% dune and associated scrub vegetation in 1942 to only 8% today. The extent of wetlands has reduced from 28% in pre-European times to 2% now.

In general terms, the use and management of land and water has been compartmentalised and kaitiaki have been less able to fulfil their traditional roles. Dredging and nutrient and other pollutant inflows have been identified as key pressures. The repercussions for iwi and hapū include loss of sustenance and cultural traditions; impacts on mana and their ability to provide customary manaakitanga; dissociation of people from their ancestral places; and impacts on the inherited spiritual and practical roles of kaitiaki.

Manaaki Taha Moana has worked with iwi and hapū to combine science and mātauranga Māori to understand coastal resource trends over time, as well as the pressures and opportunities for eco-cultural restoration in the two study areas. This mahi continues under the programme Oranga Taiao Oranga Tāngata.

Note: The information in this case study is drawn from Hardy et al. (2011); Sinner et al. (2011); Smith et al. (2011); Newcombe et al. (2014) and Taiapa et al. (2014).

Land-use and freshwater data relevant to estuarine health, such as soil erosion, sedimentation and water quality and volume,[41] is presented at a regional scale, rather than for catchments, which makes it difficult to link to estuaries. In contrast, studies relating to the cultural health index for freshwater bodies[42] present data at a catchment level, recognising the concept of *ki uta ki tai (from the mountains to the sea connectivity)* which is a more accurate method for linking pressures to the state of estuaries.

Many estuaries are susceptible to eutrophication – an excess of nutrients – and associated algal blooms and sediment anoxia (deficiency of oxygen) are becoming more common (Plew et al. 2018). Monitoring data for 2013–17 showed that high nitrogen concentrations and high levels of faecal bacteria were present at coastal monitoring sites that received large amounts of water from rivers, particularly shallow estuaries. Deep estuaries have the best water quality because seawater moves freely in and out, so freshwater that enters them is well diluted by seawater (MfE & Stats NZ 2019a).

Estuaries are also susceptible to the impacts of sediment. In a study of 60 estuaries, mud content was at a level where ecological impacts could be expected in 50% of the sites, and for nutrients this level was exceeded for 31% of sites (Berthelsen et al. 2020a). Over 95% of coastal sites assessed for heavy metals in sediments fell within guideline limits (MfE & Stats NZ 2019b). However, the remaining 5% of sites that exceeded the standard for one or more contaminants were within estuaries or harbours including Tamaki Estuary (Auckland), Firth of Thames (Waikato), and Kaikorai Estuary (Otago). A recent report confirms the connection between stream fine sediment, organic enrichment and heavy metals (using regional monitoring data) with the health of estuary ecosystems around the country (Berthelsen et al. 2020b).

Pressures | Ngā pēhanga

Estuarine ecosystems face numerous interrelated pressures (see case study on Manaaki Taha Moana). Coastal development, including port and marina development, land reclamation, adjacent roading (which can restrain tidal flow), changes to water flows from stopbanks and river mouth management and dredging can alter and destroy habitats. Estuaries can be particularly vulnerable to pressures from the land. For instance, development activities can result in discharges of sediment, sewage, industrial and landfill contaminants, nutrients and heavy metals via outfalls and stormwater. Other direct pressures include weed invasion, stock trampling of wetland margins and beaches and recreational fishing and shellfish harvesting.

Feral cats and hedgehogs are primary predators of estuary wildlife (Dowding & Murphy 2001). Major estuarine weeds such as spartina and saltwater paspalum may be reported for individual sites, but are not included in marine, freshwater or land invasive weed indicators nationally under the Environmental Reporting series.

Cumulative pressures on estuaries will only be exacerbated in the future, as climate change impacts are more severely felt. These pressures include extreme weather events, increases in freshwater flow and sedimentation, acidification and/or altered air and water temperatures[43] (Willis et al. 2007; Kettles & Bell 2016). It is unclear how informative the current ocean acidification[44] and sea-surface temperature[45] monitoring will be, given little data is being collected within estuaries, which are vulnerable to the effects of climate change (Kettles & Bell 2016). 'Coastal squeeze' from sea-level rise could reduce the extent of intertidal and wetland habitats where infrastructure blocks their inland spread.

[41] https://www.stats.govt.nz/tools/environmental-indicators

[42] http://archive.stats.govt.nz/browse_for_stats/environment/environmental-reporting-series/environmental-indicators/Home/Fresh%20water/cultural-health-index.aspx

[43] https://www.mfe.govt.nz/publications/marine/our-marine-environment-2019/issue-4-climate-change-affecting-marine-ecosystems

[44] https://www.stats.govt.nz/indicators/ocean-acidification

[45] https://www.stats.govt.nz/indicators/sea-surface-temperature

Marine birds | Ngā manu moana

Seabirds hold much significance to Māori, and in various tribal regions particular species have important roles and associations. For example, feathers of tākapu/gannets and toroa/albatross are used as adornments by high-ranking leaders. Seabirds can also be carriers of important messages, tohu (signs) of events, and predictors of the weather (Keane 2010a).

Aotearoa is the global centre of seabird diversity (Croxall et al. 2012). Nearly a quarter of all seabird species breed here, and 10% of those breed nowhere else (Taylor 2000). There are 54 endemic seabird species (NZTCS 2019); more than all other countries combined (Croxall et al. 2012). Seabirds include some of the rarest birds in New Zealand (with New Zealand fairy terns, Chatham island taiko and Whenua Hou diving petrels having fewer than 100 breeding pairs) (Taylor 2000). At the other extreme, some populations of petrels are extremely abundant. For example, 2–3 million pairs of black-winged petrels nest on the smaller islands in the Kermadec Islands/Rangitāhua group (Veitch et al. 2004). Many of New Zealand's seabird species are highly migratory and utilise marine resources across all the World's oceans except the North Atlantic.

State and trends | Te āhuatanga me ngā ia

Globally, seabirds are the most threatened bird group, and this situation extends to Aotearoa.

According to the NZTCS, 28 species (32%) of New Zealand's seabirds are 'Threatened' and 52 species (59%) are 'At Risk' (Fig. 27).

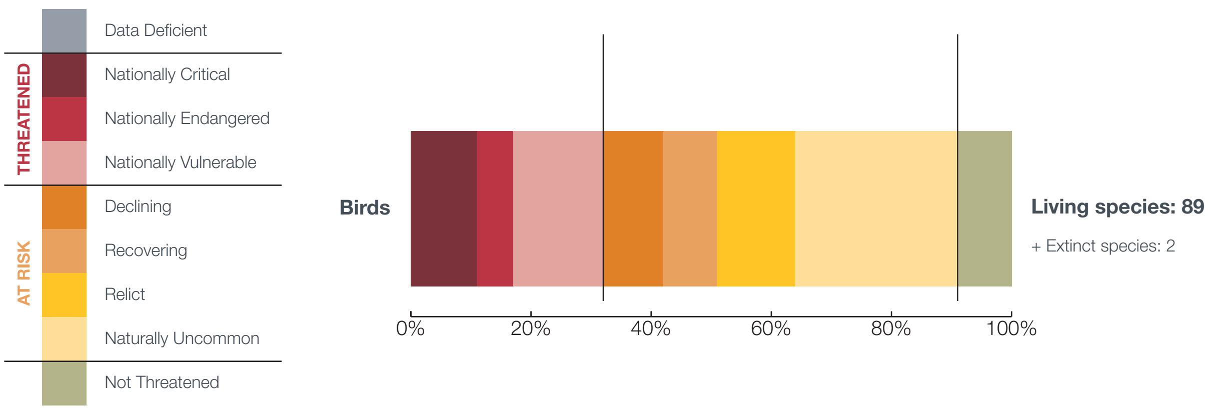


Figure 27. Conservation status (NZTCS) of New Zealand's resident native seabirds. Data source: NZTCS (2019).

There is no consistent trend in the status of New Zealand's seabirds: some species are recovering but are still vulnerable; others are in serious decline. For example, the Antipodean albatross has declined dramatically since 2005 (Walker & Elliott 2017), while the very rare Chatham Island tāiko is steadily increasing (Taylor et al. 2012). Other species are hanging on in precariously small populations, such as the tara iti/New Zealand fairy tern, with fewer than 40 individuals. Populations of more than 20% (21 of 89) of all indigenous seabird species are declining. Of the indigenous seabird species that are 'Threatened', more than 40% (12 of 28) are declining. The mitigation of terrestrial threats, such as introduced mammalian predators, has allowed many seabird populations to recover (Ismar et al. 2014). However, for some species removal of land-based threats has not been sufficient for population recovery. For example, black petrels on Hauturu/Little Barrier Island have not recovered after successful feral cat eradication in 1980 due to the ongoing impacts of fisheries bycatch on this species, both domestically and during their winter migration (Bell 2013). Over 50 species of New Zealand seabirds forage in the high seas during the breeding season and during the annual migration to favoured moulting sites. These trips expose the birds to threats from international fisheries and the higher levels of plastic pollution present in some oceans.

Assessing the impacts of fishing mortality on population trends is difficult, because it first requires good demographic data from breeding populations. Such data exist for some species (e.g. the tāiko/black petrel) but not for others. A spatially explicit risk assessment framework, which provides a better understanding of the population-level risk posed, has been developed to aid the management of fisheries bycatch. Such assessments have been applied to bycatch species including seabirds and marine mammals (MPI 2019b; Richard & Abraham 2017).

Pressures | Ngā pēhanga

The most significant terrestrial conservation threat to seabirds is predation at their breeding sites by introduced mammals (Croxall et al. 2012). The eradication of introduced mammals has been clearly shown to benefit seabird populations: tītī/Cook's petrel on Hauturu/Little Barrier Island recovered well after eradication of kiore/Pacific rats (Rayner et al. 2007).

Aotearoa is a pioneer in such island pest eradications, but it has not yet been possible to rid pests from all breeding sites. Some seabirds, such as Hutton's shearwaters (Sommer et al. 2009), tītī/sooty shearwaters (Jones 2000) and kōrure/mottled petrels (Sagar 2013) still breed on the New Zealand mainland, but their numbers are constrained by mammal predation. Seabirds nesting on braided riverbeds, such as the tara pirohe/black-fronted tern, are particularly vulnerable. This is due to factors such as river flow changes due to dam operation for hydroelectricity; invasive plants that both consume open riverbed habitat where birds would normally breed and provide shelter for introduced mammalian predators. Gravel and sand extraction, hydroelectricity development, weed encroachment and disturbance by vehicles are other potentially significant terrestrial threats to seabirds.

Barn owls have recently colonised northern New Zealand and are considered to pose a high future risk to many endangered species of seabirds (as well as reptiles and invertebrates). Weka are native throughout the ranges of many seabirds but have also been introduced to some offshore islands where they are not native. These include the Chatham Islands and southern Muttonbird Islands. Weka are known to prey upon seabird eggs and chicks and will kill adults of the smaller species. The long-term impact of cultural harvest on the population trends of tītī/muttonbirds remains unclear (Moller 2002). Other threats on land include disturbance by people, vehicles and dogs.

Bycatch in commercial fisheries is the leading marine conservation concern for many seabirds, particularly long-lived and slow-reproducing albatrosses. In 2017–18, an estimated 3328 seabirds were killed (Abraham & Thompson 2015), including some of the rarest species, such as Salvin's albatross (MfE & Stats NZ 2019b). The ability to accurately monitor bycatch levels remains constrained by little or no observer coverage in some New Zealand fisheries (Parker & Rexer-Huber 2019).

Recreational fishers can also accidentally catch seabirds, mainly with lines and set-nets (Abraham et al. 2010). Hotspots of seabird biodiversity, like the Hauraki Gulf/Tīkapa Moana (Gaskin & Rayner 2013), also receive the most recreational fishing effort (Hartill 2014).

Fisheries can indirectly impact seabirds too, by depleting their prey species (Tasker et al. 2000), or by removing species like araara/trevally which, by herding bait fish to the surface, make prey available to seabirds (Hebshi et al. 2008). Research into indirect fishing effects has begun in the Hauraki Gulf/Tīkapa Moana (Gaskin 2017). The indirect effects on seabirds are currently being investigated to assess longer term trends in fish shoal abundance and which seabird species depend on food from shoaling fish. Red-billed gull populations at offshore breeding sites (e.g. Mokohinau Islands, Three Kings) have undergone substantial declines in the past 50 years (Frost & Taylor 2018). This species has a high dependency on herded fish shoals for making sub-surface prey accessible to them.

Increasing urbanisation of the coastal landscapes and the increasing presence of brightly lit vessels at sea is known to be having an effect on seabirds (Rodríguez et al. 2017; Parker & Rexer-Huber 2019), especially nocturnally active petrels that are lured in by bright lights (mainly on foggy nights). This has resulted in bird injuries or death on vessels and birds grounded in urban areas where they are at risk from predators and traffic. There are reports of seabirds being deliberately caught by crews on the high seas to supplement rations, and this practice may be affecting New Zealand's species (Croxall et al. 2012). Toroa ingoingo/Southern royal albatrosses are among those that have been targeted on the Patagonian Shelf (Parker 2013).

Diseases in seabirds have been observed in several populations in New Zealand, especially penguins. Avian cholera was detected in rockhopper penguins in the 1980s and may have been a contributor to population declines (Taylor 2000). Diphtheritic stomatitis associated with *Corynebacterium* spp. is currently a problem observed with hoiho (Alley et al. 2017). Diseases such as avian malaria and avian pox have caused adult and chick mortality in other seabird populations (Croxall et al. 2012).

Pollution, including plastic ingestion and oil spills cause mortality in seabirds, and the impact of plastic pollution is expected to increase (see *Pollution* section of *Pressures* chapter). The impacts of climate change are unclear, although there may be wide ranging effects on seabirds (see *Climate change* section of *Pressures* chapter).

Marine mammals | Ngā whāngote moana

Marine mammals have always been closely linked to Māori life, as guides and protectors during the ancestors' waka (canoe) journeys to this country, as well as a source of food, carving materials and tools. Many tribal stories, carvings and place names describe the close connections between people and marine mammals, and different iwi have a variety of stories about the whakapapa of whales (Haami 2010).

Nearly half the world's cetacean (whale, dolphin and porpoise) species have been reported from New Zealand's waters (Gordon et al. 2010), and it is also home to many species of seals and sea lions.

New Zealand's Exclusive Economic Zone (EEZ) is one of the largest in the world, and marine mammals have only been surveyed over a small portion of it. This, in addition to the difficulty of monitoring populations that are migratory, vagrant and/or difficult to access for surveying, makes it difficult to assess their conservation status.

State and trends | Te āhuatanga me ngā ia

The NZTCS (2019) has assessed 57 marine mammal species and, of the 45 indigenous species, seven species (15%) are listed as 'Threatened', and a further three species (6%) as 'At Risk' (Fig. 28). The majority (30 species; 67%) of the marine mammal species (many of which are migratory), however, are classified as 'Data Deficient' (NZTCS 2019) with little or no information on population trends.

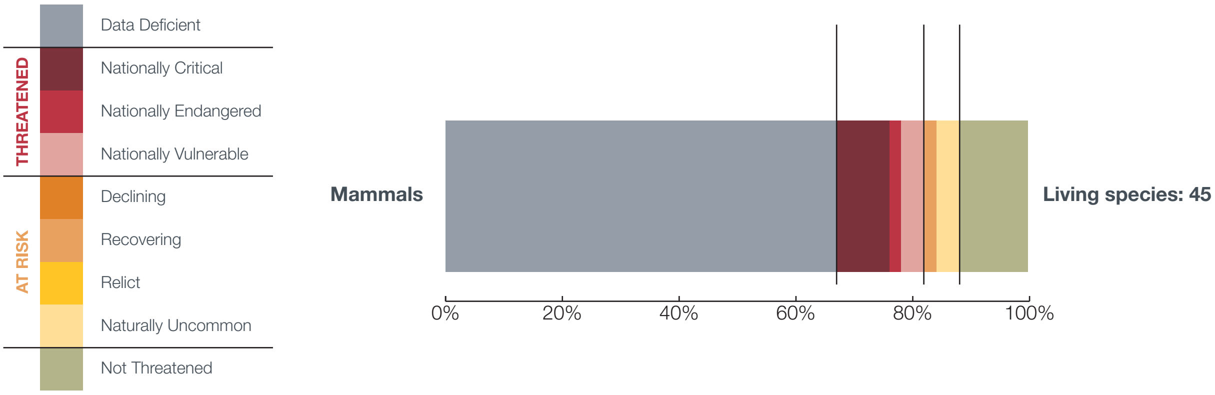


Figure 28. Conservation status (NZTCS) of New Zealand's resident native marine mammals. Data Source: NZTCS (2019).

There are currently seven marine mammals categorised as 'Threatened': Bryde's whale, popoto/Māui dolphin, ihu koropuku/southern elephant seal, maki/orca, rāpoka/New Zealand sea lion, Tūpoupou/Hector's dolphin, terehu/bottlenose dolphin, and one – tohorā/southern right whale – as 'At Risk – Recovering'. With few exceptions, the status of the majority of these species and their populations have not improved since their 2013 assessment (NZTCS 2019).

The endemic popoto/Māui dolphin is an extremely small and rare dolphin, found only off the North Island west coast. It's estimated that some 63 individuals aged one year or older survive, and that the population has been declining at around 1.5–3.0% a year since 2001 (Baker et al. 2019).

Tūpoupou/Hector's dolphin is closely related to the popoto/Māui dolphin, and its status has recently improved from 'Threatened – Nationally Endangered' to 'Threatened – Nationally Vulnerable', following population estimates that reported higher numbers of the dolphins (MacKenzie & Clement 2014, 2016; Baker et al. 2019). The new figures were estimated using a different survey methodology, so they cannot be used to deduce population trends in comparison with previous estimates. Mortality associated with fisheries bycatch likely drove significant declines in the past, but population trend estimates are clouded by uncertainty (Baker et al. 2019). Small, isolated subpopulations of tūpoupou/Hector's dolphins are likely to be more vulnerable to human impacts, and the risk of further fragmentation of the population remains a concern.

The status of rāpoka/New Zealand sea lion has improved from 'Threatened – Nationally Critical' to 'Threatened – Nationally Vulnerable' because the rate of population decline has begun to slow (Baker et al. 2019) – an estimated decline rate of more than 70% over three generations is now calculated to be around 30%. Despite some population sites looking slightly more stable, there is still an overall population decline underway, with already low population numbers (Chilvers & Meyer 2017; DOC & MPI 2017; Baker et al. 2019).

The conservation status of tohorā/southern right whale has improved from ‘Threatened – Nationally Vulnerable’ to ‘At Risk – Recovering’. Multiple estimates indicate a population increase, and a substantial growth rate of 7% per year (Carroll et al. 2013; Jackson et al. 2016). This is a pronounced recovery, even though southern right whales are still at less than 12% of their pre-whaling numbers (Jackson et al. 2016).

Overall, although there are improvements in some marine mammal populations, many species are still facing stagnant or declining numbers and are still far from what they once were prior to the 1800s.

Pressures | Ngā pēhanga

A primary threat to New Zealand marine mammal species is infectious disease. For example, cats are the host species for toxoplasma oocysts, which spread from faecal matter into the sea, where they can be ingested by marine mammals. Toxoplasmosis has been shown to kill rāpoka/New Zealand sea lions (Roe et al. 2016). Tūpoupou/Hector’s dolphins and popoto/Māui dolphins (Roe et al. 2013) may also be especially susceptible to the disease (Roe et al. 2013), with nine deaths confirmed between 2007 and 2018 (Roberts et al. 2019). This disease can also cause problems by inhibiting reproduction and causing behavioural changes in its hosts. Another contributing factor in high pup mortality in rāpoka/New Zealand sea lions is *Klebsiella pneumoniae* infection (Michael et al. 2019). These diseases are not the only ones impacting marine mammals and disease seems to be an emerging issue amongst many marine mammal species.

Fishing-related threats are another main component of destabilised populations of marine mammals. A variety of dolphin, large whale and pinniped (seal and sea lion) species have fallen victim to entanglement in New Zealand waters, either from ghost (lost and drifting) gear or as bycatch. In particular, Tūpoupou/Hector’s dolphins are especially vulnerable to inshore set net (gill net) and trawl entanglements (Dawson 1991; Slooten & Davies 2012; Hector’s/Māui Threat Management Plan in press).[46] Restrictions on set and trawl netting in some of the dolphins’ range have improved survival and population growth in those areas (Gormley et al. 2012; Slooten 2013) and this is addressed in the new Hector’s/Māui Threat Management Plan.

Vessel collisions have also been an issue, though there are promising results when mitigation measures are implemented appropriately (Constantine et al. 2015). For example, Bryde’s whales are particularly prone to ship strike in the Hauraki Gulf, but reduced ship speeds there have greatly reduced such collisions (Baker et al. 2019).

Further pressures on marine mammals include seabed mining, vessel-based tourism, environmental factors, plastics and other pollution, and noise from seismic surveying, shipping and other industrial activities (Gordon et al. 2003; Romano et al. 2004; Boren et al. 2006; Martinez et al. 2011; Levin et al. 2016; DOC & MPI 2017; Lucke et al. 2019).

[46] https://www.doc.govt.nz/our-work/protecting-species/protecting-marine-species/our-work-with-maui-dolphin/hectors-and-maui-dolphin-threat-management-plan/

Marine reptiles | Ngā moko moana

Five species of honu/sea turtle and four sea snakes naturally occur in New Zealand's waters (Gill 1997; Gill & Whitaker 2014; Godoy 2016a). While they are understood to be valued by Māori, particularly in the northern areas that they most often frequent, published sources on these associations are scarce.

Although no marine reptiles are known with certainty to breed in Aotearoa, sea temperature data suggest that the yellow-bellied sea snake is likely to be resident year-round and to breed around the Kermadec Islands/Rangitāhua.[47] Leatherback and green turtles are present year-round (Duffy & Brown 1994; Gill 1997; Benson et al. 2011; Godoy 2016a).

State and trends | Te āhuatanga me ngā ia

With the exception of the yellow-bellied sea snake, which is listed as Indigenous, all marine reptiles are currently classified as 'Non-resident Native' species by the NZTCS (2019). Leatherback and green turtles are classified as 'Migrant' (Threatened Overseas), whereas the remaining honu/turtles and all sea snakes are classified as 'Vagrant' (Data Poor, Threatened Overseas) (NZTCS 2019).

All honu/sea turtles show decreasing abundance globally (Table 4). Their population trends in New Zealand's waters are unknown but are expected to mirror those of Pacific populations.

Table 4. Status and trends of IUCN Red List of Threatened Species assessments of marine reptiles naturally occurring in New Zealand waters. Species of krait referred to are Laticauda colubrina, L. laticaudata *and* L. saintgironsi*. Source: IUCN (2018).*

Common name	Scientific name	IUCN Red List status	Population trend
Leatherback turtle	*Dermochelys coriacea*	Vulnerable	Decreasing
Green turtle	*Chelonia mydas*	Endangered	Decreasing
Hawksbill turtle	*Eretmochelys imbricata*	Critically Endangered	Decreasing
Loggerhead turtle	*Caretta caretta*	Vulnerable	Decreasing
Olive Ridley turtle	*Lepidochelys olivacea*	Vulnerable	Decreasing
Yellow-belled sea snake	*Hydrophis platurus*	Least Concern	Stable
Kraits	*Laticauda* spp.	Least Concern	Stable

[47] https://dcon01mstr0c21wprod.azurewebsites.net/our-work/reptiles-and-frogs-distribution/atlas/atlas-details/?SpeciesID=13230

Pressures | Ngā pēhanga

Globally, honu/turtles are threatened by overharvesting, degradation and loss of nesting habitat, egg and hatchling predation by feral animals, incidental mortality in commercial and artisanal fisheries, boat strike and entanglement in, and ingestion of marine debris (Seminoff 2004; Abreu-Grobois & Plotkin 2008; Mortimer & Donnelly 2008; Casale & Tucker 2017).

In Aotearoa, the major threats to honu/sea turtles are fisheries bycatch (commercial and recreational), ingestion of marine debris (particularly soft plastics), entanglement in ropes (pot float lines, marine farm structures) and boat strike (Duffy & Brown 1994; Harley & Kendrick 2006; Godoy 2016a, b; Godoy & Stockin 2018). Between 2008 and 2015, 120 honu/turtles were reported as bycatch in New Zealand's commercial fisheries, most (91%) taken by surface longlines (Godoy 2016a).

Marine fishes | Ngā ika moana

In te ao Māori, marine fish are descended from Tangaroa, and were fundamental to Māori economically, as a critical source of food and trade. This importance for sustenance, manaakitanga, and economic wellbeing continues today, with Treaty settlements providing significant commercial and customary fishing rights.

More than 1260 marine fishes are known from New Zealand's waters, the vast majority spending their entire life cycle in the marine environment, though some are diadromous, i.e. spending parts of their life cycle in fresh water and the rest in saltwater (see *Freshwater fish* section). About 22% are found nowhere else in the world (Roberts et al. 2015).

In Aotearoa, endemism is greatest in the intertidal and shallow subtidal zones, down to about 100 m depth (Roberts et al. 2015). A distinctive feature of the New Zealand fauna is the abundance and diversity of triplefins. These small, colourful bottom-living fishes occupy habitats that elsewhere are dominated by gobies and sculpins. In the absence of these competitors, the New Zealand triplefin fauna has evolved into the most diverse in the world. Aotearoa has at least 107 species of chondrichthyans (cartilaginous fishes: mangō/sharks, whai/rays and chimaeras), most of which live in deep waters. Twenty-six species (24%) are New Zealand endemics (NZTCS 2019).

Although taxonomic knowledge of the fauna has improved considerably in the last two decades, many groups contain species that have not been formally described and named, and the biology and distributions of many others are poorly known (Roberts et al. 2015). Large areas of New Zealand's EEZ are only superficially explored, so that another third again of fishes may yet await discovery (Roberts et al. 2015).

State and trends | Te āhuatanga me ngā ia

Little or no information is available on the status of the populations of most marine fishes and marine teleost (bony) fish species are currently not included in the NZTCS. The best-known species are those that are the target of commercial fisheries.

The majority of New Zealand's commercial fish stocks are considered to meet or exceed the performance measures used by fisheries managers to evaluate the status of New Zealand's fish stocks and fisheries. Most of the main commercial fish species are routinely assessed, and 84% of these fisheries stocks are presently within sustainable catch limits (MPI 2019b). In 2018, landings (tonnage of fish brought back to shore) from the routinely assessed stocks accounted for 68% of total commercial landings by volume.

Of 160 stocks evaluated, 29 were considered to be overfished in 2019 (Fisheries New Zealand 2019; MPI 2019b), including the following marine teleost fishes:

- southern bluefin tuna (migratory so no New Zealand stock structure)
- Pacific bluefin tuna (migratory so no New Zealand stock structure)
- Striped marlin (migratory so no New Zealand stock structure)
- black cardinalfish (3 stocks)
- orange roughy (2 stocks)
- Hake (1 stock)
- bluenose (5 stocks)
- tarakihi (3 stocks)
- tāmure/snapper (2 stocks)
- tarore/New Zealand sole (1 stock)
- kuparu/John dory (1 stock)

Nine of the stocks considered to be overfished, including southern bluefin tuna, Pacific bluefin tuna, black cardinalfish and two orange roughy stocks, have collapsed (Fisheries New Zealand 2019). Most of these have either been closed to commercial fishing or had catches substantially reduced.

The proportion of overfished stocks reduced from 19% in 2009 to 18% in 2019 (MPI 2019b). Assessments of three closed orange roughy stocks show that these are rebuilding. The tāmure/snapper population on the north and west coasts of the South Island is also rebuilding after overfishing in the 1980s (MPI 2019b).

As the life histories of chondrichthyans make them particularly vulnerable to overfishing, all have been assessed by the NZTCS (MPI 2014; Duffy et al. 2018; Finucci et al. 2019). Most were classified as either 'Not Threatened' (55 species; 51%) or 'Data Deficient' (42 species; 39%) (Fig. 29; NZTCS 2019). The mangō taniwha/great white shark and the basking shark are the only marine fishes classified as 'Threatened'. The mangō taniwha/great white shark is 'Threatened – Nationally Endangered', due to a very small estimated adult population size of just 590 to 750 individuals. Its population size is estimated to have been stable or in slight decline over the last 10 years (Bruce et al. 2018; Hillary et al. 2018). The basking shark was assessed as 'Threatened – Nationally Vulnerable', based upon a large decline in reported and observed bycatch in commercial fisheries and the disappearance of large seasonal aggregations from coastal hot spots. The exact magnitude and reasons for this decline are unknown (Duffy et al. 2018; Finucci et al. 2019).

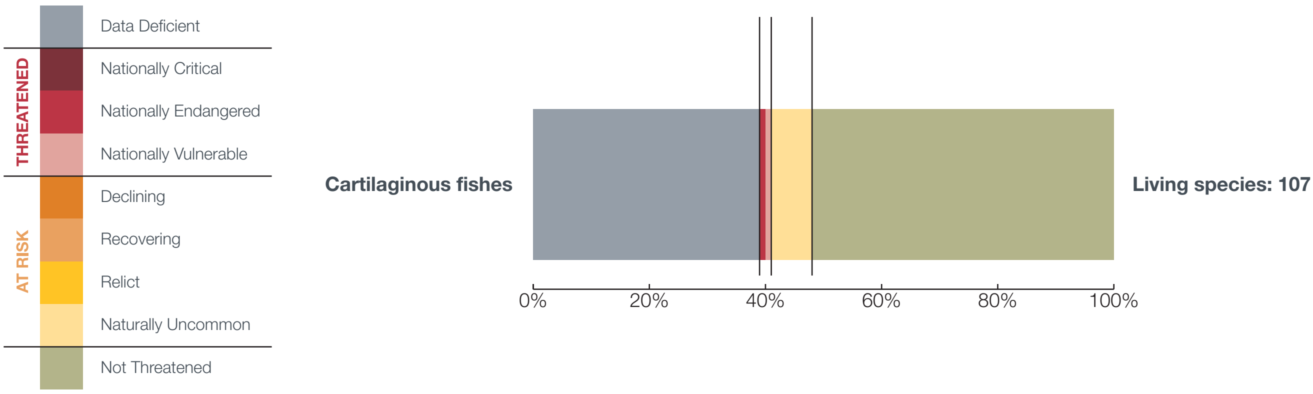


Figure 29. Conservation status (NZTCS) of New Zealand's resident native chondrichthyans (cartilaginous fishes). Data source: NZTCS (2019).

Two protected migratory species – the whale shark and oceanic white-tip shark – are threatened by fishing outside New Zealand's waters (Duffy et al. 2018; Finucci et al. 2019). Species assessed as Near Threatened by the IUCN Red List are the tiger and dusky sharks – also migratory species threatened by fishing outside Aotearoa – along with Plunket's sharks and the pepeke/prickly dogfish, which are vulnerable to deep water fishing (Finucci et al. 2019).

The conservation status of jawless and ray-finned marine fishes has not been assessed since 2005.

Pressures | Ngā pēhanga

Fishing is one of the main drivers of decline in marine fish populations throughout the New Zealand EEZ. As well as removing individuals from the population, some forms of fishing also disturb or destroy fish habitats, and there may be indirect trophic (food web) effects on populations of other species (Morrison et al. 2014a, b; MfE & Stats NZ 2019b). The legislation which guides the Quota Management System stock assessments requires that effects on associated and dependent species, trophic interactions and the impacts of fishing on seafloor habitats (including those critical to the survival of target species), are considered in decision making. However, the data to support comprehensive consideration is often lacking (Morrison et al. 2014a; MfE & Stats NZ 2019b).

In some coastal areas, these effects are compounded by habitat degradation and loss due to coastal development, excess sedimentation and other forms of pollution (Morrison et al. 2009; MfE & Stats NZ 2019b). In the long term, climate change could alter entire ecosystems, with populations of estuarine and intertidal fishes being particularly vulnerable to habitat loss from rising sea levels, and increased storminess, erosion, sedimentation and temperatures (Willis et al. 2007; Foley & Carbines 2019; Smale et al. 2019) (see *Estuaries* section). The effects of invasive species on native marine fishes are unknown.

Marine invertebrates | Ngā tuaiwi-kore moana

Shellfish have always been a significant part of the Māori diet. The seasonal shellfish harvest is an important part of the calendar, with many species gathered for immediate use, exchanges and ceremonial occasions, or preserved and stored for winter provisions (Whaanga 2010).

Marine invertebrates are a diverse suite of animals that include molluscs, corals, crustaceans, sea squirts and worms. They occupy virtually every marine habitat and can be mobile or sessile (immobile). Invertebrates play a range of important ecological roles, not least by providing biogenic, or living, habitat themselves for other creatures (Anderson et al. 2019). New Zealand's marine fauna is nowhere near fully described, but the molluscs are relatively well-known, with more than 3500 recorded species (Gordon et al. 2010). Several groups are particularly diverse in Aotearoa, including the carnivorous sponges, rock sponges, glass sponges, some molluscs, sea cucumbers and deepwater gorgonian corals (Gordon et al. 2010). Invertebrates perform vital ecosystem roles, including being prey for other species, processing detritus, grazing (which can keep plants and animals clear of algal fouling) and creating habitat. Some are also keystone predators, but in highly modified and impacted systems, the ecological role of invertebrates has been significantly diminished. Some marine invertebrates, such as kōura papatea/spiny lobster and ngū/squid, support some of Aotearoa New Zealand's most valuable fisheries.[48] Others, such as kuku/green-lipped mussels, are important aquaculture species.

As is the case across much of New Zealand's marine biodiversity, many species remain unknown and/or undescribed (Gordon et al. 2010), there is a bias in spatial sampling, for example, in shallower depths (Lundquist et al. 2015) and taxonomic expertise and collections remain a fundamental need (Nelson et al. 2015a).

State and trends | Te āhuatanga me ngā ia

The conservation status of 423 marine invertebrate species has been assessed under the NZTCS (2019). However, these represent less than 5% of the known marine invertebrate fauna, and 64 (15%) of those were classified as 'Data Deficient' (Fig. 30). Of the 423 assessed species, 11 (2%) have been assessed as 'Threatened', while 326 (77%) are considered 'At Risk' (NZTCS 2019). The extent to which the proportion of species that are 'Threatened' or 'At Risk' would change as more taxa are assessed is unknown.

Most corals are protected under the Wildlife Act 1953 as a result of their vulnerability to impacts such as harvesting for collection, fishing and seabed disturbance – black corals, gorgonian corals, stony corals and hydrocorals. Two have been assessed as 'Threatened': bamboo coral and bubblegum coral. However, knowledge of deepwater corals is limited: there are significant data and knowledge gaps around their biology, distribution, environment and threats (Tracey & Hjorvarsdottir 2019).

A 2019 Fisheries New Zealand report *The Status of New Zealand's Fisheries 2019* on the status of New Zealand's fish stocks found that, while some invertebrate stocks had a favourable status, others (e.g. some tipa/scallop and tio/oyster stocks) did not (Fisheries New Zealand 2019).

[48] **Fish monetary stock account, 1996-2018. https://figure.nz/table/KbqOXUvaW37jEt1x**

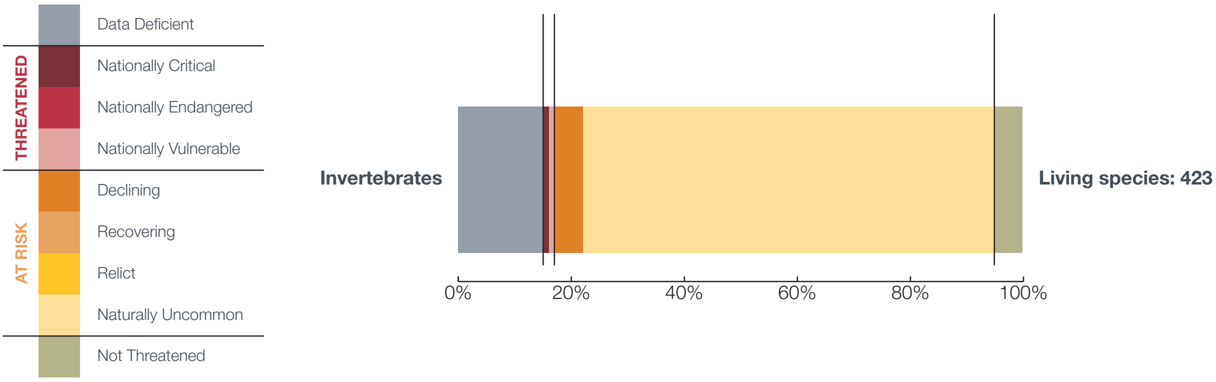


Figure 30. Conservation status (NZTCS) of New Zealand's resident native marine invertebrates. The NZTCS has not included a comprehensive assessment of all invertebrates, so the statistics presented here for these groups are not representative of the total NZ biota (see **Appendix 2***). Data source: NZTCS (2019).*

Rock lobsters are considered to be a keystone predator in some habitats (Eddy et al. 2014). However, along the northeast coast of the North Island, stocks are so reduced that there are concerns about them becoming 'ecologically extinct', meaning they are no longer fulfilling their full role in the ecosystem (MacDiarmid et al. 2013). In the Firth of Thames, intensive dredge fishing and sedimentation have caused the near total loss of kuku/green-lipped mussel beds (Paul 2012) which perform an important role in the ecosystem, including water filtration.

Management or protection measures have proven effective for some invertebrates. Marine protected areas provide protection from some threats and, when appropriately designed, placed and managed, allow depleted invertebrate populations to recover (Pande et al. 2008; Freeman et al. 2012). In some places, fisheries regulations have protected important invertebrate communities from the impacts of fishing. Some long-lived species may be slow to recover after protection has been put in place (see Tawhiti-Rahi case study).

Mātauranga Māori can provide the foundations for improving, enhancing and safeguarding populations of marine species, including invertebrates. For example, in Ōhiwa harbour, the findings from a research project that prioritised Mātauranga Māori were used to develop a management plan for kūtai/mussels, which would facilitate the restoration of this culturally and ecologically important species (Paul-Burke et al. 2018).

The Poor Knights Islands/Aorangi/Tawhiti-Rahi

The Poor Knights Islands/Aorangi/Tawhiti-Rahi in Northland were protected as a marine reserve in 1981, with additional protection measures implemented in 1998. They are a favourite location for divers. Interviews with people who dived at the islands in the 1960s and 70s and other studies identified significant long-term declines in punga pango/black corals, tube sponges, pawharu/packhorse lobster and encrusting invertebrates (which declined by 21%) over the period from the 1960s to 2011. Fishing and anchoring were identified as the major causes of the declines observed, and the interview responses included first-hand observations of punga pango/black corals being brought up on anchors or kōura/lobster pot lines. The 2011 study showed little or no recovery following no-take protection of the islands in 1998, indicating just how slow it may be for long-lived species like these to start to recover following protection.

Source: Taylor et al. (2011).

A diver inspecting a gorgonian coral at the Poor Knights Islands Marine Reserve. *Photo: Dave Hansford*

Pressures | Ngā pēhanga

Because of their universal distribution, marine invertebrates are subject to a range of natural and human pressures, including the direct and indirect effects of offshore fishing, but also pressures that originate from land. Sedimentation, onshore fishing/harvesting, coastal reclamation, collection, rubbish dumping and pollution all have the potential to affect marine invertebrates depending on aspects such as their location and particular life history characteristics. Because they perform many crucial ecosystem functions, impacts on invertebrates may have much wider consequences for marine biodiversity generally. For example, the loss of biogenic habitats, such as kūkuku/horse mussel and bryozoan beds, may adversely affect fish recruitment (Morrison et al. 2014a, b; Anderson et al. 2019).

Ocean acidification, caused by elevated carbon dioxide levels in the sea, presents a serious threat to the many marine invertebrates with shells or other calcified structures (such as carbonate skeletons) from planktonic crustacea and intertidal shellfish to kōura/lobsters and deep-sea corals (MPI 2019a; Tracey & Hjorvarsdottir 2019). Increased acidity impedes shell building and may even dissolve existing shells and skeletons. Ocean acidification has been assessed as the most serious threat to New Zealand's marine habitats (MacDiarmid et al. 2012).

The majority of marine invertebrates live in the benthos, where oxygen depletion is also a substantial pressure. This can be caused by eutrophication, a growing pressure in coastal areas (see *Estuaries* section), and which will be exacerbated by increasing seawater temperatures (Rabalais et al. 2009).

Seaweeds | Ngā rimu

Seaweeds were well known and utilised by Māori as an important food source; for example, karengo is gathered biannually in autumn and winter and used both fresh and dried (Whaanga 2010).

This section only covers macroalgae (seaweeds). It is acknowledged that there also vascular plants and lichen that inhabit the marine domain. Most of these are intertidal species and some are referred to in the *Estuaries* section.

Marine macroalgae (rimu/seaweeds) range in size from a few millimetres to large canopy-forming species more than 30 m in length. The three main groups – green, brown and red algae – are not closely related (Nelson 2013). Aotearoa has a diverse rimu/seaweed flora, consisting of about 900 described and undescribed species (Nelson 2013), including at least 46 introduced and naturalised species (Nelson et al. 2019). Rimu/seaweeds occur in most low intertidal, and shallow, well-lit subtidal, estuarine and marine habitats (Neill et al. 2012; Nelson 2013; Anderson et al. 2019). Offshore, in exceptional water clarity, rimu/seaweeds can grow at depths of almost 200 m (Nelson et al. 2015b, 2018b).

Rimu/seaweeds form the most extensive and productive benthic marine vegetated habitats globally and are essential to the function of many marine ecosystems (Nelson 2013; Nelson et al. 2015b; Krause-Jensen et al. 2018; Spalding et al. 2019). Their role in global carbon sequestration is also significant and estimated at approximately 173 TgC/year (Krause-Jensen & Duarte 2016). By forming complex three-dimensional structures on hard and soft substrates, they provide habitat for diverse communities of invertebrates, fishes and other rimu/seaweeds. Off the northwest North Island, dense beds of red and brown rimu/seaweeds offer settlement surfaces for kuku/green-lipped mussels – most of the spat used by the aquaculture industry comes from beach-cast seaweed harvested from Ninety Mile Beach. Encrusting coralline algae, sometimes called coralline paint, are a critical settlement surface for pāua (Nelson 2013).

There is no complete scientific list of the seaweeds of Aotearoa, and very few detailed studies of particular groups. Forty-four percent of the flora is currently known from five records or fewer. This makes it difficult to assess the conservation status of many species and make informed habitat management decisions (Nelson et al. 2019).

This is compounded by further gaps in knowledge, such as the distribution, extent and condition of rimurapa/kelp forests, algal meadows and rhodolith (red algae) beds, and the contribution of rimu/seaweeds to productivity and complexity in soft sediment ecosystems (Anderson et al. 2019; Nelson et al. 2019).

State and trends | Te āhuatanga me ngā ia

Rimurapa/kelp forests are widespread, occurring throughout New Zealand's waters. Overall, their condition is good, and they remain one of the most productive biogenic marine habitats, despite some local losses and changes in species composition. Algal meadows are also widespread, and many appear to be in good condition, but there are insufficient data to assess changes over time. While the known distribution of rhodolith beds is patchy, they are expected to be more widespread than existing records suggest (Law et al. 2017; Anderson et al. 2019).

In 2019, experts assessed the conservation status of 871 marine macroalgae. Seven species (1%) were considered 'Threatened' (six 'Threatened – Nationally Critical', one 'Threatened – Nationally Endangered') and five (1%) were assessed as 'At Risk – Declining' (Fig. 31). A further 105 (12%) were deemed 'At Risk – Naturally Uncommon' and 588 (68%) were found to be 'Data Deficient', while 166 (19%) were 'Not Threatened' (NZTCS 2019).

All species assessed as 'Threatened – Nationally Critical' are known from a limited number of collections from a few sites. Two of these species are only known from sites that no longer exist or have been extensively modified: one due to the impacts of the 2016 Kaikoura earthquake, and the other due to demolition of a wharf on Campbell Island which was the only known location (Nelson et al. 2019).

Three of the five species assessed to be 'At Risk – Declining' are large canopy-forming brown algae, characteristic of southern and central Aotearoa.

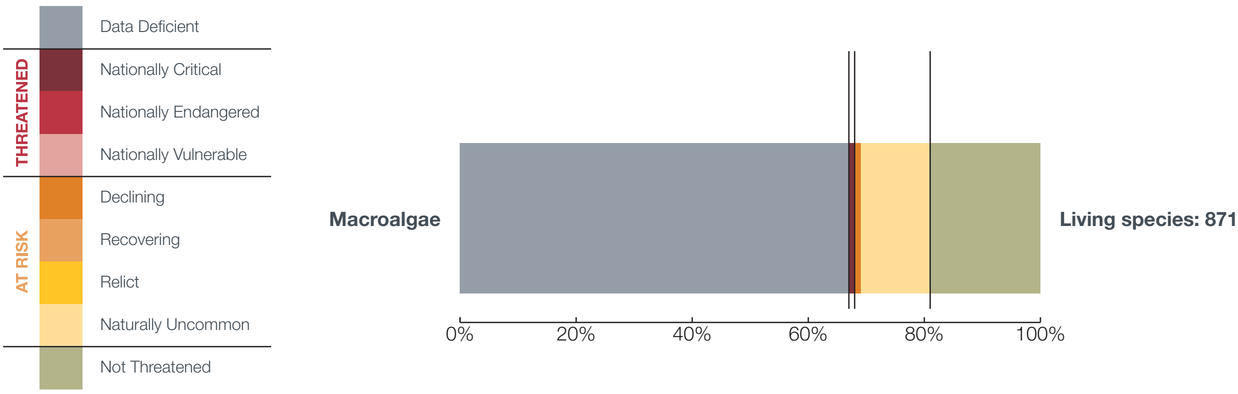


Figure 31. Conservation status (NZTCS) of New Zealand's resident native marine macroalgae. Data source: NZTCS (2019).

Pressures | Ngā pēhanga

Anthropogenic and environmental changes can affect the distribution and condition of macroalgae. Catchment development, for instance, can increase freshwater, nutrient and sediment inputs to coastal waters. Increased turbidity reduces the amount of light reaching seafloor algae, and sediments settling onto their blades further reduces their capacity for photosynthesis. Sediments can also smother settlement surfaces used for establishing new seaweeds and kill developing spores.

Excess nutrients sometimes promote growth but can also trigger dense algal blooms that shade benthic rimu/seaweeds. While intertidal species are generally tolerant of temperature and salinity fluctuations, subtidal species are not (Nelson 2013; Anderson et al. 2019; D'Archino et al. 2019;). Ocean heatwaves, such as the particularly hot summer of 2017/18 have been shown to negatively affect *Durvillaea* spp. (Thomsen et al. 2019). Subtidal seagrass, algal meadows and rhodolith beds are also vulnerable to disturbance by trawling and shellfish dredging (Anderson et al. 2019).

As a result of climate change, ocean acidification may hinder the calcification rates and growth of coralline algae. Conversely, it's possible that growth rates of fleshy rimu/seaweeds, such as rimurapa/kelps, may increase (van der Heijden & Kamenos 2015; Law et al. 2017; Krause-Jensen et al. 2018), although in New Zealand's oceans daily variations in pH exceed those projected, and so there remains doubt. Even if growth rates were to increase there is insufficient evidence to conclude that this would offset any potentially adverse effects of increased sea surface temperature, competition with other species, or changes in grazer assemblages (Hay 1990; Law et al. 2017; Thomsen et al. 2019). Changes in the ranges and abundances of some large canopy-forming brown algae species may be the result of increasing sea surface temperature (Hay 1990; Nelson et al. 2019; Thomsen et al. 2019).

Conclusion | Kupu whakatepe

Biodiversity is inherently valuable. It is central to the identity of New Zealanders and is fundamental to Māori who are intrinsically intertwined with the natural world through whakapapa (genealogy). Society can only thrive when nature and biodiversity also thrive. Nature supports life and human activity, and all aspects of our wellbeing – physical, cultural, social and economic – are dependent on the natural world and the services that it provides.

Aotearoa New Zealand is a global biodiversity hotspot. The complex landscape and seascape, isolated from the rest of the world for 80 million years, has shaped its unique biodiversity and high numbers of endemic species.

Along with the rest of the world, Aotearoa is currently experiencing a biodiversity crisis. Globally, around one million animal and plant species face extinction. Papatūānuku (Earth Mother), Ranginui (Sky Father) and their offspring are in serious trouble.

The current state of much of Aotearoa New Zealand's biodiversity demonstrates a trend of ongoing decline. The extent of this decline is variable within and between domains, ecosystems and species. Some are declining rapidly in particular locations but not in others. Some have responded to management, but for others the management requirements are either difficult to enact or are unknown.

Direct pressures causing declines include introduced invasive species, changes in land and sea use, direct exploitation for food and resources, pollution, and the increasing threat of climate change. There are complex interactions between pressures, and over time the impacts of these pressures are compounded into cumulative effects on species and ecosystems. There are gaps in our current knowledge that urgently need to be filled to understand the full extent of the biodiversity crisis, and to identify the actions needed to tackle it.

A DOC ranger releasing tieke/South Island saddleback (*Philesturnus carunculatus*) during a translocation effort. Translocations have formed a large part of the conservation effort to protect this species which has a conservation status of 'At Risk – Recovering'. *Photo: Laura Harry*

Having a clear plan of action is crucial to enable us to improve the current state of biodiversity in Aotearoa New Zealand. Intensive conservation management has already made a positive difference to the status of some ecosystems and threatened species. *Te Mana o te Taiao – Aotearoa New Zealand Biodiversity Strategy*, sets out the approaches needed to expand and build on this foundation to reduce the pressures on biodiversity and allow the natural world of Aotearoa New Zealand, and its people, to thrive.

Te Mana o te Taiao is for everyone living in Aotearoa New Zealand to own and implement. It sets a strategic direction for the protection, restoration and sustainable use of biodiversity in Aotearoa New Zealand for the next 30 years. It includes outcomes, objectives and goals that provide a pathway for success. It provides national and regional direction for all those who work with biodiversity, including whānau, hapū, iwi and other Māori organisations, central and local government, industry, NGOs, scientists, landowners, communities and individuals.

At the heart of *Te Mana o te Taiao* is the recognition that people are part of nature (Fig. 32). The people are kaitiaki (guardians) of the natural world, and the natural world is kaitiaki of the people. To achieve a future where both nature and people are thriving, transformational change is needed. Key areas of focus are:

- Tūāpapa – putting the right systems in place to tackle the biodiversity crisis,
- Whakahau – empowering action across Aotearoa New Zealand, and
- Tiaki me te whakahaumanu – addressing the direct pressures causing biodiversity decline.

Ensuring that Treaty partners, whānau, hapū, iwi and Māori organisations are exercising their full role as rangatira and kaitiaki is key to the success of the strategy.

The future we aspire to in Aotearoa is one where the life force of nature is vibrant and vigorous – *Te Mauri Hikahika o te Taiao*. Together, all New Zealanders can help to protect and restore our unique biodiversity. It is not too late to make a difference if we act now.

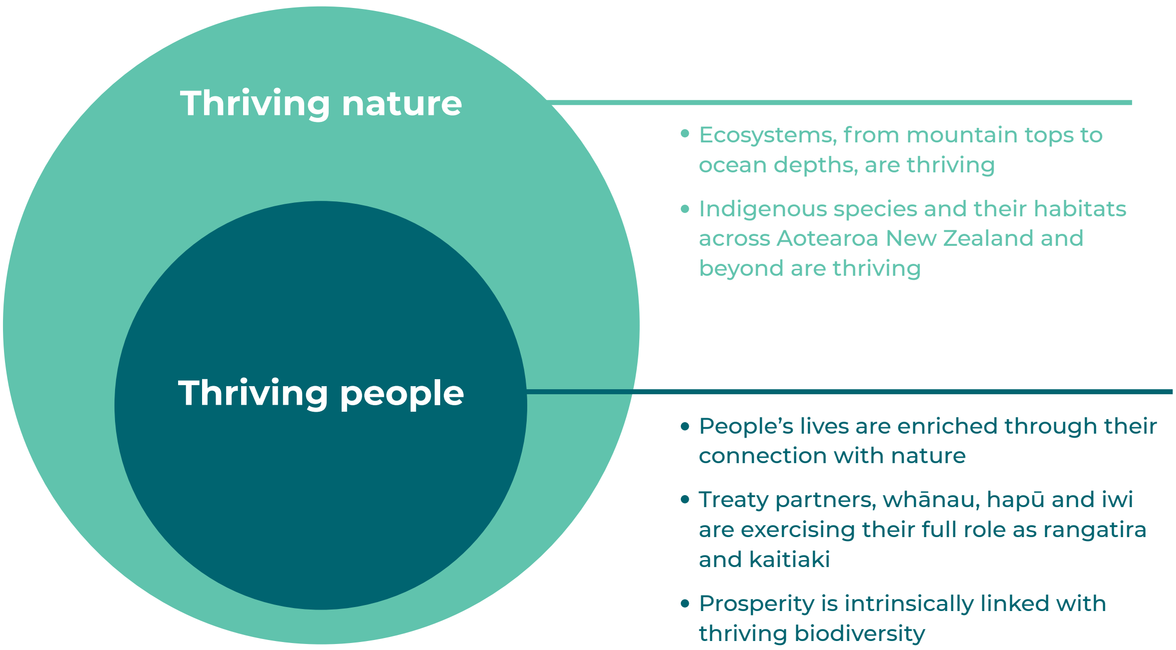


Figure 32. The 2050 outcomes of Te Mana o te Taiao - Aotearoa New Zealand Biodiversity Strategy. The strategy also sets out objectives and goals to be achieved between 2025 and 2050.

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Glossary | Kuputaka

Glossary of te reo terms

Atua	God, supernatural being, deity.
Hapū	Kinship group, clan, tribe, subtribe.
Hāngī	Earth oven; food cooked in an earth oven.
Hui	Gathering, meeting.
Iwi	Extended kinship group, tribe, nation.
Kai	Food.
Kai moana	Seafood, shellfish.
Kaitiaki	Guardian, trustee, minder.
Kaitiakitanga	The obligation to nurture and care for the **mauri** of a **taonga**; ethic of guardianship, **protection**.
Karakia	Incantation, ritual chant.
Kaupapa	Topic, policy, initiative.
Kāwai tīpuna	Ancestral line of descent.
Kawenata	Covenant.
Mātaitai reserve	An area established through regulations under the Fisheries Act 1996 to recognise and provide for the special relationship between **tangata whenua** and a traditional fishing ground. **Tangata whenua** can propose bylaws to control fishing within mātaitai reserves, which need to be approved by the Minister of Fisheries. Mātaitai reserves allow customary and recreational fishing but don't allow commercial fishing unless authorised by a bylaw.
Mahinga kai	Garden, cultivation, food-gathering place.
Mana	Prestige, authority, control, personal charisma.
Mana whenua	Territorial rights, authority over land or territory.
Manaakitanga	Hospitality, kindness, generosity, support.
Mātauranga Māori	Māori knowledge – the body of knowledge originating from Māori ancestors, including the Māori world view and perspectives, Māori creativity and cultural practices.
Mauri	Life principle, life force, vital essence.

Moana	Sea, ocean.
Mōteatea	Songs sung in traditional mode – lament, chant, sung poetry.
Muka	Prepared flax fibre.
Nga Whenua Rāhui	A contestable fund under the jurisdiction of the Minister of Conservation, established in 1990 to help Māori landholders to protect indigenous forest and other **ecosystems** in a way that is responsive to their spiritual and cultural needs.
Papatūānuku	Earth, Earth mother.
Rāhui	To put in place a temporary ritual prohibition, closed season, ban, reserve.
Rangatahi	Younger generation, youth.
Ranginui	**Atua** of the sky, sky father.
Raranga	To weave, weaving.
Rohe	Boundary, district, region, territory, area.
Rongo (Rongo-mā-Tāne)	**Atua** of the kūmara and **cultivated** foods.
Rongoā	Remedy, medicine, treatment, solution (to a problem).
Taiāpure	A management tool established under the Fisheries Act 1996 in an area that has customarily been of special significance to **iwi** or as a source of food or for spiritual or cultural reasons, to provide recognition of rangatiratanga and of the right secured in relation to fisheries by Article II of the Treaty of Waitangi. Taiāpure can only be established in estuarine or coastal waters. All types of fishing are allowed in a taiāpure unless its management committee recommends changes to the fishing rules and the Minister of Fisheries approves them.
Taha wairua	Spiritual realm, spirituality.
Tangaroa	**Atua** of the sea and fish.
Tangata whenua	People of the land; the indigenous people of New Zealand. In relation to a particular area, it means the **iwi** or **hapū** that holds **mana whenua** over that area.
Tangihanga	Funeral, weeping.
Taonga	Treasure, anything prized – applied to anything considered to be of value including socially or culturally valuable objects, resources, phenomena, ideas and techniques.
Tapu	Sacred, prohibited, restricted.
Te ao Māori	The Māori world; a Māori perspective/world view.

Te ao mārama	The world of life and light, physical world.
Te reo	The [Māori] language.
Tikanga	Custom, practice, correct protocol – the customary system of values and practices that have developed over time and are deeply embedded in the social context.
Toi	Art.
Wai	Water, stream, river.
Wai māori	Freshwater.
Waiata	Song.
Wairua	Spirit, soul – spirit of a person which exists beyond death.
Wāhi tapu	Sacred place, sacred site.
Waka	Canoe.
Wānanga	To meet and discuss, deliberate, consider.
Whakaaro Māori	Thinking embedded in a **te ao Māori** perspective.
Whakapapa	Genealogy, genealogical table, lineage, descent.
Whakataukī	Proverb, formulaic saying.
Whānau	Extended family, family group.
Whiri	Plait, weave.

Glossary of English terms

Amphibian	An animal of the class Amphibia. The only **native** amphibians found in New Zealand are frogs.
At Risk species	**Species** assessed according to the **New Zealand Threat Classification System** as being likely to become 'Threatened' should **pressures** on their populations worsen. Includes four subcategories: 'Declining', 'Recovering', 'Relict' and 'Naturally Uncommon'**.**
Autecology	The study of the interactions of an individual organism or a single **species** with the living and non-living factors of its environment.
Benthic (zone)	The ecological region at the bottom of a body of water, including the **sediment** surface and some sub-surface layers.
Benthic (organism)	Organisms that live in the **benthic** zone.

Biodiversity	Biological diversity or the variability among living organisms from all sources, including land, marine and freshwater **ecosystems** and the ecological complexes of which they are a part; this includes diversity within **species** (including **genetic diversity**), between **species** and of **ecosystems** (based on the definition of the **Convention on Biological Diversity**).
Biodiversity hotspot	A region with a high concentration of **species** richness and endemism which is under threat.
Biosecurity	The exclusion, eradication or management of **pests** and diseases that pose a risk to the economy, environment, or cultural or social values, including human health.
Biota	All the living organisms at a particular locality.
Browsers	Herbivorous animals that generally feed on high-growing plants rather than grasses
Bryophyte	A group of non-**vascular plants** that do not produce flowers or seeds. This group includes mosses, hornworts and liverworts.
Bycatch	**Species** not targeted by a fishery but caught incidentally during fishing operations. Once caught, they can be landed, discarded or released.
Catchment	Area of land in which rainfall drains towards a common watercourse, stream, river, lake or **estuary**.
Chondrichthyan	An animal of the class Chondrichthyes, also known as cartilaginous fishes. This group includes sharks, skates, rays and chimaeras.
Climate change	Changes in global or regional climate patterns that are evident over an extended period (typically decades or longer). May be due to natural factors or human activities.
Coastal turfs	Plant communities of salt tolerant, low-growing herbs, sedges, and grasses, seldom more than 3 cm tall. They are usually tightly interlaced and ground smothering, and occupy coastal promontories exposed to wind and salt.
Conservation	'The preservation and **protection** of natural and historic resources for the purpose of maintaining their **intrinsic values**, providing for their appreciation and recreational enjoyment by the public, and safeguarding the options of future generations' (Conservation Act 1987).
Convention on Biological Diversity	An international agreement on biological diversity that came into force in December 1993. The objectives of the Convention are the **conservation** of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources.

Cultivar	A **cultivated** variety (genetic strain) of a **domesticated** crop plant.
Cumulative effects	Changes to the environment caused by the combined impacts of past, present and future human activities and natural processes.
Customary use and cultural harvest	The traditional practice of taking natural resources. These are mostly indigenous birds, fishes and plants, but also include other traditional materials, such as bone and stone.
Data	The facts that result from direct observations or measurements. They can take the form of raw results from **monitoring** – such as the number of **species** in a particular area.
Data Deficient species	**Species** for which there is so little **information** available that an assessment through the **New Zealand Threat Classification System** is not possible.
Deep endemic	A **taxon** that is **endemic** at the order, family or genus level.
Demersal (zone)	The ecological region close to the floor of a body of water. The demersal zone occurs just above the **benthic** zone.
Demersal (organism)	An organism that lives in the **demersal** zone.
Domain (ecological)	The freshwater domain comprises fresh water in all its physical forms. This includes fresh water in rivers, lakes, streams, wetlands and aquifers. The land domain comprises the soil, the underlying rock and what is on the land surface, such as vegetation and human-made structures. The marine domain extends from the seashore to the outer limits of Aotearoa New Zealand's exclusive economic zone and includes the continental shelf.
Domesticated or cultivated species	**Species** in which the evolutionary process has been influenced by humans to meet their needs (**Convention on Biological Diversity**). In the context of this document, they include both introduced and **indigenous species** that have been domesticated or cultivated.
Driver	A factor that may cause multiple **pressures**, or a cascade of effects, to act on an **ecosystem** or a population of a **species**.
Ecological integrity	The full potential of indigenous biotic and abiotic features and natural processes, functioning in sustainable communities, **habitats**, and **landscapes**. At larger scales, ecological integrity is achieved when **ecosystems** occupy their full environmental range. An **ecosystem** may have high **ecosystem health** (that is, be functioning well) but low ecological integrity (e.g. by lacking representation or dominance of indigenous elements) but the reverse cannot be true.

Ecosystem	A community of plants, animals and microorganisms in a particular place or area interacting with the non-living components of their environment (e.g. air, water and mineral soil).
Ecosystem health	Ecosystem health describes the fundamental physical and biological **state** of an **ecosystem** in relation to its ability to support services. A **healthy ecosystem** is stable and sustainable, maintaining its organisation and autonomy over time and its **resilience** to stress. Ecosystem health can be assessed using measures of **resilience**, vigour and organisation.
Ecosystem management	A management philosophy intended to sustain the integrity of **ecosystems**.
Ecosystem management unit	Sites which include one or more of the best examples of the range of indigenous **ecosystems** in New Zealand.
Ecosystem services	The benefits obtained from **ecosystems**. Examples include: a) Supporting services (e.g. nutrient cycling, soil formation, **habitat** creation) b) Provisioning services (e.g. food, fresh water, wood, fibre, fuel) c) Regulating services (e.g. water purification, climate regulation, flood regulation, disease regulation) d) Cultural services (e.g. aesthetic, spiritual, educational, recreational).
Endemic species	**Indigenous species** that breed only within a specified region or locality and are unique to that area. Aotearoa New Zealand's endemic **species** include birds that breed only in this country but may disperse to other countries in the non-breeding season or as sub-adults.
Ephemeral wetlands	A class of seasonally wet wetlands, nourished by either groundwater or an adjacent **waterbody**. They often lack a surface outlet. They mostly occur on mineralised substrates, in climates where seasonal variation in rainfall and evaporation encourages ponding in winter and spring, and partial or complete drying in summer months or in dry years.
Erosion	The wearing-away of land by the actions of water, wind, or ice.
Eutrophication	The excessive build-up of nutrients in a body of water, frequently due to run-off from land, which causes the dense growth of periphyton.
Estuary	A semi-enclosed coastal body of water with an open connection to the sea and within which sea water mixes with freshwater from land run-off, usually a river.
Exclusive Economic Zone (EEZ)	The area of ocean from the outside edge of the territorial sea (which covers inland waters, harbours and the area out to 12 nautical miles from the coast) out to 200 nautical miles from the coast. The resources of New Zealand's EEZ are under New Zealand control.
Exotic	See **Introduced species**.

Extinction (species)	The loss of a **species**. The moment of extinction is generally considered to be marked by the death of the last individual of that **species**.
Feral species	A **domesticated species** that has become wild.
Full range (ecosystems)	A comprehensive and representative range of natural **habitats** and **ecosystems** that reflects the known diversity of **habitats** and ecological communities remaining in Aotearoa New Zealand.
Fungus (non-lichenised)	An organism within the kingdom Fungi. This includes mushrooms, moulds, yeast and toadstools.
Genetic diversity	The variability in the genetic make-up among individuals within a single **species**. Specifically, it is the genetic differences among populations of a single **species** and among individuals within a population.
Genetic material	All or part of the DNA of a genome or all or part of an organism resulting from expression of the genome.
Gondwana	The southern supercontinent that started to break up about 150 million years ago, consisting of what are now South America, Africa, Antarctica, Arabia, Australia, India, Madagascar and New Zealand.
Gorgonian	An animal of the order Gorgonacea, comprising colonial anthozoan corals that have a stiff branching skeleton. This group includes sea whips and sea fans.
Gumlands	Seasonally wet, predominantly rain-nourished wetlands found on low fertility, low pH, sometimes peaty, skeletal soils that are waterlogged in winter where kauri (*Agathis australis*) formerly grew (the gum was produced by the kauri trees). They can occur on flat, rolling or sloping land in high rainfall areas and often have leached upper soil horizons with or without peat, and a mineralised lower horizon that restricts water flow.
Habitat	A combination of environmental factors that provide the food, water, cover and space that a living thing needs to survive and reproduce.
Healthy (ecosystem)	See **ecosystem health**.
Herpetofauna	The collective group of animals including **reptiles** and **amphibians**.
Indicator	A measure (for example, distance from a goal, target, threshold or benchmark) against which some aspects of performance can be assessed. The use of an indicator enables the significance of a statistic to be determined; for example, the extent to which an objective is met.
Indigenous biodiversity	The diversity (or range) of **indigenous species**. This includes diversity within and between **species**.

Indigenous species	**Species** that occur naturally in Aotearoa New Zealand.
Indigenous vegetation	Any local indigenous plant community containing throughout its growth the complement of **native species** and **habitats** normally associated with that vegetation type or having the potential to develop these characteristics. It includes vegetation with these characteristics that has been regenerated with human assistance following disturbance but excludes plantations and vegetation that have been established for commercial purposes.
Information	**Data** that have been organised, integrated and, to some extent, analysed. **Data** that are made meaningful as a result of being collected, processed, organised and interpreted in light of some hypothesis.
Intensification (agriculture)	An increase in the stocking rate of animals, or an increase in the level of **production** from a given area of land.
Intrinsic value	Value that is not dependent on monetary value or usefulness, but a natural part of the item itself.
Introduced species	Plant or animal **species** that have been brought to Aotearoa New Zealand by humans, either by accident or design. A synonym is '**exotic species**'.
Invasive introduced species	**Non-indigenous species** whose introduction or spread threatens **biodiversity**, food security, and/or human health and **wellbeing**.
Invertebrate	An animal without a backbone or spinal column. Insects, spiders, worms, slaters and many marine animals such as corals, sponges and jellyfish are examples of invertebrates. Invertebrates make up the vast majority of all animal **species**; only fish, **amphibians**, **reptiles**, birds and mammals are not invertebrates.
Lake Submerged Plant Index (LakeSPI)	Compares the abundance of **native** vs invasive plant **species** in a lake. Higher LakeSPI scores – more **native** plants – are associated with better water quality.
Landcare Research	Manaaki Whenua – Landcare Research is the New Zealand Crown Research Institute that focuses on management of land resources for **conservation** and for **primary production**.
Landscape/ seascape	The visible features of an area of land, coastline or island, including physical landforms, marine or lake-body associations, living flora and fauna, abstract elements such as light and weather conditions, and human effects.
Lichen/lichenised fungi	A plant-like organism made up of algae or cyanobacterium living in a symbiotic relationship with fungi. Lichens grow on surfaces such as rocks, tree trunks and footpaths.

Littoral zone	The part of a river, lake or sea near to the shore.
Lizard	Animals in the suborder Lacertilia, within the class Reptilia. New Zealand examples include **species** of gecko and skink but does not include tuatara.
Marine environment	See **domain (ecological)**.
Migratory species	A **species** that moves from one **habitat** to another to complete its life cycle.
Monitoring	The act of measuring change in the state, number or presence of characteristics of something.
Native	See **Indigenous**.
Naturalised	A **species** or other **taxon** originating from a region outside New Zealand but reproducing freely and maintaining its position in competition with indigenous **biota** in New Zealand.
Nature	A holistic term that encompasses the living environment (te taiao) – i.e. all living organisms and the ecological processes that sustain them. By this definition, people are a key part of nature. This strategy uses the term '**biodiversity**' to refer to biological diversity and 'nature' when considering the wider processes, functions and connections of the natural environment, of which **biodiversity** is a part.
New Zealand Threat Classification System	The system used to assess the conservation status of Aotearoa New Zealand's **native species**. Categories include '**At Risk**', '**Data Deficient**', '**Not Threatened**' and 'Threatened' (also defined in this glossary).
NIWA	National Institute for Water and Atmospheric Research. NIWA is the Crown Research Institute providing a scientific basis for the sustainable management of New Zealand's atmosphere, marine and freshwater **ecosystems** and associated resources.
Non-indigenous biodiversity/ species	**Species** that have been brought to Aotearoa New Zealand by humans, whether intentionally or unintentionally. A synonym is '**introduced species**'.
Not Threatened species	**Species** that have been assessed under the **New Zealand Threat Classification System** (NZTCS) and do not fit any of the other categories.
Palustrine (wetland)	Relating to a system of inland freshwater wetlands, such as marshes, swamps, and lake shores, characterized by the presence of trees, shrubs, and emergent vegetation.
Pathogen	A bacterium, virus, or other microorganism that can cause disease.

Pest	An organism that has characteristics that are regarded by people as injurious or unwanted.
Pinniped	An animal in the suborder Pinnipedia. This includes seals, sea lions and walrus.
Predator	An organism that feeds on another living organism (its prey).
Pressure	Any factors that act as direct **drivers** of **biodiversity** loss. Can be natural, introduced or more directly human-induced.
Primary production	The **production** of goods and services from the primary sector, such as agriculture, horticulture and forestry.
Private land	Land in private ownership – that is, land not managed by the Department of Conservation or any other public body.
Production (landscape)	Areas which are used predominantly for the production of primary products, for example meat, fish, fibre and timber.
Protected area	A geographically defined area that is protected primarily for **nature conservation** purposes or to maintain **biodiversity** values, using any of a range of legal mechanisms that provide long-term security of either tenure or land use purpose. It may be publicly or privately owned.
Protection	Looking after **biodiversity** in the long term. This involves managing all threats to secure **species** from **extinction** and ensuring that their populations are buffered from the impacts of the loss of **genetic diversity** and longer-term environmental events such as **climate change**. This includes, but is not restricted to, legal protection.
Reptile	Animals within the class Reptilia. In New Zealand this includes lizards and tuatara.
Resilience	**Species** definition: the ability of a **species**, or variety or breed of **species**, to respond and adapt to external environmental stresses. **Ecosystem** definition: The ability of an **ecosystem** to recover from and absorb disturbances, and its capacity to reorganise into similar **ecosystems**.
Restiad	Restiads are a family of annual or perennial rush-like flowering plants **native** to the southern hemisphere.
Restore (ecology)	The active intervention and management of modified or degraded **habitats**, **ecosystems**, landforms and **landscapes** in order to reinstate indigenous natural character, ecological and physical processes, and cultural and visual qualities.

Rhodolith	Rhodoliths are a **benthic** marine algae that resemble coral. Rhodoliths settle on the sea floor to form brightly coloured beds which forms **habitat** for a diversity of other marine organisms.
Sediment	Particles or clumps of particles of sand, clay, silt, or plant or animal matter carried in water.
Sedimentation	The process of settling or being deposited as a **sediment**.
Seral	A seral community (or sere) is an intermediate stage in an **ecosystem** advancing towards its climax community.
State	What is known about the current situation for a specific group of animals, plants, or ecosystems.
Survey	Systematically observing, counting or measuring characteristics at a defined location over a defined period of time.
Species	A group of living organisms consisting of similar individuals capable of freely exchanging genes or breeding. In this document we use the term to include subspecies and varieties.
Taxa/taxon	A unit used to describe a group of organisms of any rank, such as subspecies, **species**, family or class.
Taxonomy	The science of classifying organisms based on shared characteristics.
Tectonic	Relating to the structure of the earth's crust and the forces or conditions within the earth that cause movements of the crust.
Teleost	A bony fish of the subclass Teleostei.
Terrestrial	Relating to land. Types of terrestrial **ecosystems** include forests, grasslands, deserts and mountains.
Threatened species	**Species** assessed according to the **New Zealand Threat Classification System** as facing imminent **extinction** (or a reduction to just a few small, safe refuges, which makes them highly susceptible to stochastic events) because of their small total population size and/or rapid rate of population decline. This includes three sub-categories: 'Nationally Critical', 'Nationally Endangered' and 'Nationally Vulnerable'.
Torpor	A physiological state characterised by a controlled reduction in metabolic rate and associated body temperature.
Transformative change	A fundamental, system-wide reorganisation across technological, economic and social factors, including paradigms, goals and values.
Trend	The general direction of change based on the best **data** and knowledge available – which in many cases wouldn't necessarily account as a 'trend' in the strictest statistical sense due to lack of datapoints over time.

Trophic Level Index (TLI)	A measure of a lake's **trophic state**, calculated on total nitrogen, total phosphorus, chlorophyll *a* (planktonic algae) concentrations, and water clarity. TLI increases with increasing **eutrophication**, and higher TLIs generally mean poorer quality **habitat** for aquatic **biota** and **habitats** that are more prone to algal blooms.
Trophic state	The abundance of nutrients in a given body of water.
Turfs	A low vegetation type (generally less than 3 cm tall) of mainly herbaceous plants. They are prostrate and tightly interlacing, and form a ground-hugging, often dense, carpet of intertwined plants of numerous **species**.
Vascular plants	Include ferns, flowering plants and trees, but do not include mosses and liverworts.
Vertebrate	Animal with backbone; **amphibians**, **reptiles**, birds, mammals and fish. See **Invertebrate**.
Waterbody	A body of water forming a physiographic feature, for example, lake, wetland or **estuary**.
Weed	A plant that is considered to be unwanted or a nuisance. The term is often used to describe **native** or non-native plants that grow and reproduce aggressively.
Wellbeing	The health, happiness and prosperity of an individual or group. In this strategy, wellbeing is discussed in terms of material wellbeing (income and wealth, jobs and earnings, and housing), health (health status and work–life balance), security (personal security and environmental quality), social relations (social connection, subjective wellbeing, cultural identity and education), and freedom of choice and action (civic engagement and governance).

Appendix 1 – Number of indigenous resident data deficient and threatened species by life form

Taxonomic group	Year of assessment	Data Deficient	Nationally Critical	Nationally Endangered	Nationally Vulnerable	NZTCS report
Amphibians	2017	1			1	Burns et al. 2018
Aphids	2010	4	3			Stringer et al. 2012
Bats	2017	1	1		1	O'Donnell et al. 2018
Birds	2016	2	23	15	33	Robertson et al. 2017
Chondrichthyans (chimaeras, sharks and rays)	2016	42		1	1	Duffy et al. 2018
Coleoptera (beetles)	2010	51	34	7	3	Leschen et al. 2012
Diptera (flies)	2010	90			1	Andrew et al. 2012
Earthworms	2014	105				Buckley et al. 2015
Fleas	2014	3			1	Heath et al. 2015
Freshwater fishes	2017		4	6	12	Dunn et al. 2018
Freshwater invertebrates	2018	178	48	14	16	Grainger et al. 2018
Fungi	2005	1416	49			Hitchmough et al. 2007
Hemiptera (true bugs)	2010	63	6			Stringer et al. 2012
Hornworts and liverworts	2014	171	8	5	3	de Lange et al. 2015
Hymenoptera (ants, wasps, bees)	2014	118	2			Ward et al. 2017
Land snails	2010	138	28	11	8	Mahlfeld et al. 2012
Lepidoptera (butterflies and moths)	2015	47	25	12	30	Hoare et al. 2017
Lichens	2018	1107	6	2	8	de Lange et al. 2018b
Macroalgae	2019	609	6	1		Nelson et al. 2019
Marine invertebrates	2013	60	6	1	4	Freeman et al 2014
Marine Mammals	2019	30	4	1	2	Baker et al. 2019
Minor invertebrate groups	2010	4	10		8	Buckley et al. 2012
Mosses	2014	20	14	4	2	Rolfe et al. 2016
Nematodes (roundworms, eelworms)	2010	51	3		1	Yeates et al. 2012
Onychophora (velvet worms)	2018	1				Trewick et al. 2018
Orthoptera (grasshoppers)	2014	30	2	2	4	Trewick et al. 2016
Parasitic mites	2010	2	2		6	Buckley et al. 2012
Powelliphanta (giant land snails)	2005	1	8	28	5	Hitchmough et al. 2007
Reptiles	2015	7	8	8	21	Hitchmough et al. 2016
Spiders	2010	527	2	1		Sirvid et al. 2012
Stick insects	2014	1	1			Buckley et al. 2016
Vascular plants	2017	107	213	76	114	de Lange et al. 2018a
TOTAL		4987	516	195	285	

Appendix 2 – Comprehensiveness of assessments of most groups of species in the NZTCS

Taxonomic rank	Name	Description	Freshwater	Marine	Land
Phylum	Fungi	mycorrhizal, parasitic, saprotrophic, predatory	No taxa assessed	No taxa assessed	Some taxa assessed
	Fungi	lichens (lichenised and lichenicolous fungi)	All known taxa assessed	All known taxa assessed	All known taxa assessed
Phylum	Chlorophyta	green macroalgae	Some taxa assessed	All known taxa assessed	Not applicable
	Ochrophyta	brown macroalgae	Not applicable	All known taxa assessed	Not applicable
	Rhodophyta	red macroalgae	Some taxa assessed	All known taxa assessed	Not applicable
	Tracheophyta	vascular plants (lycophytes, ferns, conifers, flowering plants)	All known taxa assessed	All known taxa assessed	All known taxa assessed
	Anthocerotophyta	hornworts	All known taxa assessed	Not applicable	All known taxa assessed
	Bryophyta	mosses	Some taxa assessed	Not applicable	Some taxa assessed
	Marchantiophyta	liverworts	All known taxa assessed	Not applicable	All known taxa assessed
	Bryozoa	bryozoans	Not applicable	Some taxa assessed	Not applicable
	Cnidaria	hydroids, jellyfish	Not applicable	Some taxa assessed	Not applicable
	Echinodermata	brittle stars, crinoids, sea cucumbers, sea urchins, starfish	Not applicable	Some taxa assessed	Not applicable
	Nematoda	roundworms, eelworms	Some taxa assessed	Some taxa assessed	Some taxa assessed
	Nemertea	ribbon worms	No taxa assessed	No taxa assessed	Some taxa assessed
	Onychophora	peripatus or velvet worms	Not applicable	Not applicable	All known taxa assessed
	Platyhelminthes	flatworms	Some taxa assessed	Not applicable	Some taxa assessed
	Porifera	sponges	No taxa assessed	Some taxa assessed	Not applicable
Subphylum	Myriapoda	centipedes, millipedes	Not applicable	Not applicable	No taxa assessed
Superclass	Osteichthyes	bony fish	All known taxa assessed	No taxa assessed	Not applicable
Class	Amphibia	frogs	All known taxa assessed	Not applicable	All known taxa assessed
	Anthozoa	corals	Not applicable	Some taxa assessed	Not applicable
	Aves	birds	All known taxa assessed	All known taxa assessed	All known taxa assessed
	Bivalvia	bivalved shellfish	Not applicable	Some taxa assessed	Not applicable
	Cephalopoda	octopuses, squids	All known taxa assessed	Some taxa assessed	Not applicable
	Gastropoda	slugs, snails	All known taxa assessed	Some taxa assessed	Some taxa assessed
	Mammalia	mammals	Not applicable	All known taxa assessed	All known taxa assessed
	Reptilia	geckos, skinks, snakes	Not applicable	All known taxa assessed	All known taxa assessed
	Chondrichthyes	cartilaginous fishes (chimaera, rays, sharks, skates)	Not applicable	All known taxa assessed	Not applicable
	Polychaeta	bristle worms	All known taxa assessed	Some taxa assessed	Not applicable

All known taxa assessed · Some taxa assessed · No taxa assessed · Not applicable

Taxonomic rank	Name	Description	Freshwater	Marine	Land
Infraclass	Acari	mites, ticks	No taxa assessed	No taxa assessed	Some taxa assessed
Infraclass	Diplostraca	clam shrimps, water fleas	All known taxa assessed	Not applicable	Not applicable
Order	Amphipoda	amphipods	Some taxa assessed	Some taxa assessed	Not applicable
Order	Araneae	spiders	Not applicable	Some taxa assessed	Some taxa assessed
Order	Coleoptera	beetles	All known taxa assessed	Not applicable	Some taxa assessed
Order	Decapoda	crayfish, shrimps	All known taxa assessed	Some taxa assessed	Not applicable
Order	Diplura	two-pronged bristletails	Not applicable	Not applicable	Some taxa assessed
Order	Diptera	flies	Some taxa assessed	No taxa assessed	Some taxa assessed
Order	Ephemeroptera	mayflies	All known taxa assessed	Not applicable	Not applicable
Order	Euhirudinea	leeches	No taxa assessed	No taxa assessed	Some taxa assessed
Order	Gordioidea	Gordian worms	All known taxa assessed	Some taxa assessed	No taxa assessed
Order	Hemiptera	true bugs	All known taxa assessed	Not applicable	Some taxa assessed
Order	Hymenoptera	ants, bees, wasps	Not applicable	Not applicable	Some taxa assessed
Order	Isopoda	woodlice and their relatives	Some taxa assessed	Some taxa assessed	No taxa assessed
Order	Lepidoptera	butterflies and moths	All known taxa assessed	Not applicable	Some taxa assessed
Order	Mantodea	praying mantis	Not applicable	Not applicable	All known taxa assessed
Order	Mecoptera	scorpion flies	All known taxa assessed	Not applicable	Not applicable
Order	Megaloptera	dobsonflies	All known taxa assessed	Not applicable	Not applicable
Order	Mysida	mysid shrimps	All known taxa assessed	No taxa assessed	Not applicable
Order	Notostraca	tadpole shrimp	All known taxa assessed	Some taxa assessed	Not applicable
Order	Odonata	dragonflies, damselflies	All known taxa assessed	Not applicable	Not applicable
Order	Opiliones	harvestmen	Not applicable	Not applicable	Some taxa assessed
Order	Opisthopora	earthworms	All known taxa assessed	Not applicable	All known taxa assessed
Order	Phasmatodea	stick insects	Not applicable	Not applicable	All known taxa assessed
Order	Phthiraptera	lice	Not applicable	Not applicable	Some taxa assessed
Order	Plecoptera	stoneflies	All known taxa assessed	Not applicable	Not applicable
Order	Siphonaptera	fleas	Not applicable	Not applicable	All known taxa assessed
Order	Trichoptera	caddisflies	All known taxa assessed	Not applicable	Not applicable

All known taxa assessed · Some taxa assessed · No taxa assessed · Not applicable