Our environment 2025
Tō tātou taiao

New Zealand's Environmental Reporting Series
Te Kāhui Pūrongo Taiao o Aotearoa

Ministry for the Environment
Manatū Mō Te Taiao
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Message to readers

If there has been one constant in Aotearoa New Zealand's environment, it is change. Geologically young, our country has been forged out of dramatic tectonic forces, carved by the winds and water of the Roaring Forties, and populated by unique biodiversity that has evolved in isolation. Ever since people arrived on these shores, we have accelerated this change as we cleared land for food and fibre, built our homes and businesses, and developed new ways to power our economy and get around.

This three-yearly report on the state of the environment shows how people continue to drive change in our land, water and coasts. It also describes how we, in turn, are affected by the changes we cause – in both positive and negative ways.

Much of what you'll read here is cause for ongoing attention and concern. The report highlights real risks to people, communities and places which, left unaddressed, threaten our livelihoods and quality of life for generations to come.

However, the report also tells a story of hope.

There is evidence that some negative trends in our environment are stabilising, or reversing, due to choices people have made about how we live, or as a result of specific management interventions.

In the Ministry for the Environment's companion document *Our environment, our lives: The stories behind the numbers* we spotlight some of the important work being led by communities, iwi and Māori, local government, farmers, businesses and government that's bringing about tangible improvements for people and our precious places.

There is no doubt New Zealand, like all places on our planet, has major challenges ahead. These include increased pressures on our environment, communities and economy from extreme storm and weather events driven by the growing impacts of climate change.

We have a great opportunity to draw on evidence and data to build our resilience to those forces and impacts. Armed with this knowledge we can make informed decisions about our lives and businesses, ensuring New Zealand can leverage the potential of being best prepared for the future.

Our environment 2025 is jointly produced by the Ministry for the Environment and Stats NZ. Our teams of analysts and scientists work independently of the government to organise this evidence and provide New Zealand with a benchmark for reporting that is factual, reliable and robust.

We also recognise the contributions of Māori knowledge and practices in guiding our environmental stewardship, and the role and contribution of business and farming communities in gathering and sharing data. Equally vital to this report is the critical expertise and evidence provided by regional councils and the scientific community. Building a comprehensive evidence base requires strong partnerships and collaboration across all sectors and communities to support the collective effort to protect and restore New Zealand's environment.

This vital work helps New Zealanders understand the inseparable connection between people and the built and natural environments on which we depend. It shows us there are things we can do to further improve our economy, nature and lives, and it helps provide us with the evidence needed to know where to put our efforts.

James Palmer
Secretary for the Environment

Mark Sowden
Government Statistician

Introduction

About Our environment 2025

Our environment 2025 is the latest three-yearly state of the environment report produced by the Ministry for the Environment and Stats NZ under the Environmental Reporting Act 2015.

It is known as a synthesis report – it brings together key findings from the regular six-monthly reports that cycle the five domains of **air, freshwater, marine, atmosphere and climate, and land**. The last synthesis report released was *Environment Aotearoa 2022.* Where previous synthesis reports have been named *Environment Aotearoa*, this report has been intentionally named *Our environment 2025* to align with the naming of domain reports (eg, *Our air*, *Our freshwater*).

Our environment 2025 provides a picture of the whole environment and its interconnections, showing how changes to different parts of the environment impact on each other.

The environment includes people. Our lives and livelihoods are intertwined with environmental systems and processes in countless complex ways. Human actions are responsible for driving changes in the state of the environment, and our lives are also affected by those changes.

Effective decision-making about the environment relies on an accurate and accessible knowledge base. The purpose of the report is to provide high-quality information about how and why our environment is changing, and the resulting impacts. Evaluating specific policies and advice on responses to environmental issues is out of scope for environmental reports under the Environmental Reporting Act 2015, and therefore they are not discussed here.

Report structure

In line with the focus on how humans both impact and are impacted by environmental change, the report begins and ends with people.

Section 1 covers **drivers**, exploring how collective decisions made by people in many different areas add up to influence environmental change – from global economic and geopolitical factors to changing demographics, new technologies and our individual choices.

The next five sections cover each of **the five environmental domains**. Each chapter reports on:

- the pressures our choices place on that domain
- how these pressures result in changes to the state of the environment
- the impact of these changes on ecological systems and native species
- new and updated data and evidence since the 2022 report.

Many of the activities that drive changes in our environment begin with how we use and manage **land** (section 2). Pressures arising from our land-use decisions affect many native species, and flow through into the other domains.

What happens on land flows into **freshwater** (section 3). Erosion, pollution and run-off affect the water quality of lakes, rivers and groundwater. Although some freshwater bodies are in a reasonably healthy state, this affects the species and ecosystems that depend on them.

Rivers and streams enter the **marine** environment (section 4). Pollution and sedimentation that reach our coasts and oceans, as well as fishing practices, put coastal and marine habitats under threat. Some of these pressures have decreased in recent years, while others are increasing.

Human actions also drive changes to the **air** (section 5). Transport, home heating, agriculture and industry lower air quality. While air pollution has been declining in many areas, it can still pose risks to our health.

Changes to the other domains are amplified by changes in the **atmosphere and climate** (section 6). Rising temperatures and changing weather patterns increase many of the pressures in other parts of the environment, along with the threats to native species and ecosystems.

Section 7 covers **impacts on people, society and the economy** across all domains. It reports on the effects of interconnected changes to the environment on our health, property, places and livelihoods.

The report then outlines some **knowledge gaps** (section 8) and areas where reporting on the environment could be strengthened. The aim is to improve the knowledge base from which we make decisions about our impacts.

Data sources

The data used in this report came from many sources, including Crown research institutes and central and local government. Further supporting information was provided using a 'body of evidence' approach. This includes peer-reviewed, published literature, and grey literature such as government reports. It also includes Māori knowledge (mātauranga Māori) and observational tools to identify changes in the environment.

All the data, including references to scientific literature, were corroborated and checked for consistency with the original source. The report was produced by a team of analysts and scientists from within and outside the Ministry for the Environment and Stats NZ. It was also reviewed by a panel of independent scientists. The indicators and the most recent updates are on the Stats NZ indicator web pages (see Environmental indicators). Reports released under the Environmental Reporting Act 2015 are produced independently of government ministers.

More detailed context for the use of some of the data and evidence in this report is provided in *Our environment 2025 Technical annex | Tō tātou taiao Āpitihanga hangarau* ('Technical annex'), and hyperlinks to the technical annex are included where this evidence is used.

Our environment

All parts of the environment are connected to each other, and to people.

People

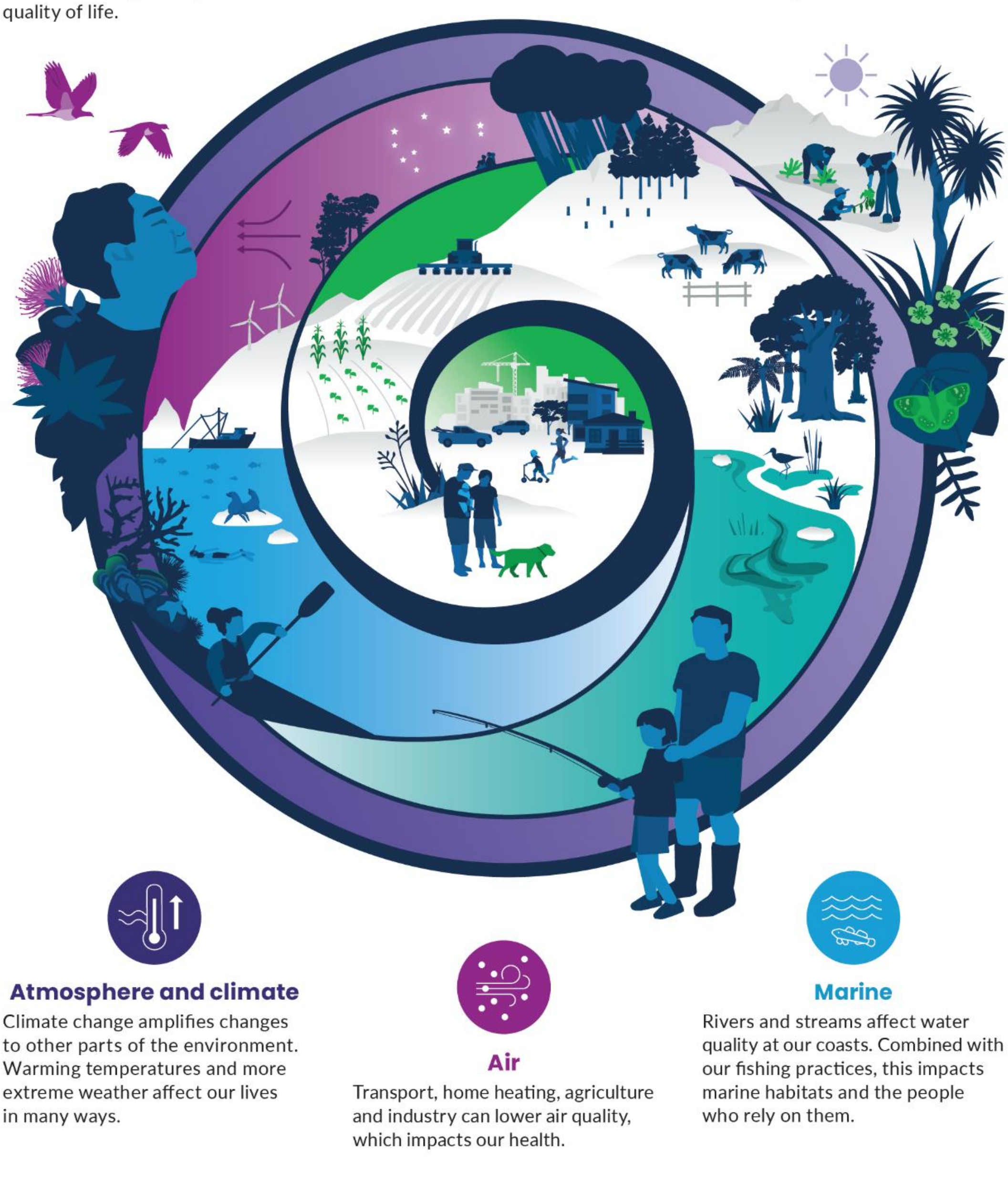
We are part of the environment. Our activities and decisions drive changes in the environment, and these changes shape our quality of life.

Land

How we use the land begins a cycle of environmental impacts and brings changes to our lives and livelihoods.

Freshwater

What happens on land flows into our lakes, rivers and groundwater, affecting ecosystems and biodiversity as well as our health.



Atmosphere and climate

Climate change amplifies changes to other parts of the environment. Warming temperatures and more extreme weather affect our lives in many ways.

Air

Transport, home heating, agriculture and industry can lower air quality, which impacts our health.

Marine

Rivers and streams affect water quality at our coasts. Combined with our fishing practices, this impacts marine habitats and the people who rely on them.

1. Drivers

Introduction

We depend on the environment to support our basic needs, lifestyle and livelihoods. The environment we rely on includes the ecosystem services that nature provides, such as services that provide clean air and water, pollinate crops and maintain a stable climate. Natural infrastructure (eg, forests, wetlands, soils and rivers) plays a crucial role in maintaining these services. Natural systems not only support agriculture and forestry, but mitigate the impacts of natural disasters and climate change. However, using and modifying the environment to meet our needs can put pressure on nature and its ability to sustain us (IPBES, 2019; see *Our land 2024* and section 7: Impacts on people, society and the economy).

In this context, 'drivers' are the social, cultural, demographic and economic activities that create pressures on the environment. These forces can act collectively and at a variety of scales from global to national, local and even individual. Many are dynamic and interconnected, and are evolving in response to changes in society, the economy and the environment (IPBES, 2018).

Global drivers such as geopolitics, international markets and demographics influence the decisions we make locally in different ways, as do our own values. These decisions include how we live and travel and what we buy (IPBES, 2022, 2024a). Along with factors such as population change and new technologies, our decisions combine to either increase or decrease environmental pressures.

International influences

Aotearoa New Zealand operates within a complex and dynamic geopolitical system, where global events drive the political, social, economic and environmental forces that shape our nation. Our economy and way of life rely heavily on international consumer demand for our export products, and for access to vital commodities we cannot produce here. However, global instability – caused by factors such as wars, pandemics and the escalating impacts of climate disruption – poses significant risks to both our economy and our environment.

These destabilising forces affect global markets, which directly influence our export-driven economy (MFAT, 2023a). For instance, international pressures and customer demand drive businesses to calculate and reduce their carbon footprints, as major overseas customers work toward 2030 emission targets (EECA, 2025). Environmental certifications are now essential for maintaining market access and securing premium prices for exports. Losing such certifications could not only lower economic performance but also cause further degradation of the environment by weakening the incentive to use sustainable practices.

The rapid rise of initiatives such as the Taskforce on Nature-related Financial Disclosures and 'nature positive' strategies highlight the growing importance of nature markets for market access. These changes come with shifts in agricultural lending practices. International lenders often require impact and climate change assessments. These examples show that while some international drivers pose challenges, others foster positive change.

Finally, the growing instability in global geopolitics threatens the viability of international agreements that protect the environment. As the impacts of climate change intensify, the weakening or collapse of these agreements could have significant consequences for the nation's environmental health, and for collective efforts to address global challenges such as biodiversity loss and carbon emissions.

Livelihoods and the economy

Our overall quality of life and wealth are closely tied to the health of the economy. All of these factors rely on a healthy, productive environment. Resilient and enduring economic growth is essential to improving living standards and quality of life, while looking after the environment on which we depend (Galt & Nees, 2022; MBIE, 2023).

Unlike most developed economies in the Organisation for Economic Co-operation and Development (OECD), New Zealand exports are mostly primary sector products (MPI, 2024a). International demand for primary sector products is strong, and is predicted to continue to rise with ongoing growth in both the global population and wealth, as well as international climate disruptions (FAO, 2024; MPI, 2023a; MPI, 2024a; OECD-FAO, 2023). Tourism also forms a significant part of the export sector (Stats NZ, 2025). The export economy – and our gross domestic product – rely heavily on productive land, available freshwater, oceans and scenic environments (MPI, 2023a; see *Our land 2024* and *Our freshwater 2023*).

The industries that rely on productive environments, such as agriculture and fishing, can also put pressure on the natural systems that support them. This can lower productivity and degrade the wider environment, giving rise to the effects outlined in section 7: Impacts on people, society and the economy.

Population growth and demographic change

New Zealand's population is growing and ageing. It grew by about 750,000 between 2013 and 2023 (Stats NZ, 2024a, 2024c). Population projections indicate the population of New Zealand has a 90 percent probability of increasing to between 5.55 and 6.65 million by 2048, meaning it is highly likely to grow by at least 400,000 compared with 2022 (Stats NZ, 2022a). In 2023, people aged 65 years and older made up 16.6 percent of the population, up from 14.3 percent in 2013; children under 15 years of age made up 18.7 percent, down from 20.4 percent in 2013 (Stats NZ, nd). These ageing trends are expected to continue over the coming decades (Stats NZ, 2022a).

These changes are major drivers of other demographic trends, such as where we live, work and build. This in turn can have significant implications for the pressures we place on the environment. With more people comes greater demand for land to build on, and for more energy and public infrastructure as towns and cities grow. Depending on how we build, accommodating this growth can displace or degrade – or preserve and restore – the environment and natural infrastructure we depend on (Auckland Council, nd; EHINZ, nd-a; MfE, 2023a; New Zealand Infrastructure Commission, 2024; Public Health Agency, 2022; see *Our land 2024*).

Individual choices

The way we live our lives – where we live, what we buy and how we spend our time – ultimately determines how much impact we have on our environment. Some cause-and-effect relationships are immediate and obvious, but many are subtle, only noticeable over the longer term, and can seem far-removed from our daily lives. This complexity can mean that economic, social, cultural and environmental trade-offs from our decisions are not apparent (Acaroglu, 2019; Deloitte, 2023; Gkargkavouzi & Halkos, 2024; Vega, 2024).

Living in a country with a developed economy and high purchasing power, we have significant choice in what we consume (Miller et al, 2017; OECD, 2024; Reserve Bank of New Zealand, nd; Watkins et al, 2021). These choices, such as what we eat and where it comes from, create demands for domestic and imported goods, driving production locally and internationally. These economies and their supply chains can put pressure on the environment. For example, the amount of greenhouse gas emissions associated with imported goods in 2019 was about equal to the emissions we produced here (Stats NZ, 2021a).

Our consumption habits also affect how much waste we generate. New Zealand has one of the highest per capita rates of waste generation in the developed world, though there are inconsistencies in how different countries report this (OECD, 2024). Most waste from households is disposed of in municipal landfills, and the amount going to landfills has stabilised in recent years (MfE, 2024a).

Where we live and work, and how we travel, also drive environmental pressures. A preference for standalone housing and private land, for example, drives the expansion of cities into rural areas (MfE 2023a; PCE, 2023). Vehicle ownership per person in New Zealand is among the highest in the world, with vehicle use contributing to our high per-capita emissions and to global climate change (MfE, 2024c; see section 5: Air). In 2023, 85 percent of New Zealanders who worked away from home, and 45 percent who studied away from home, commuted in private vehicles (Stats NZ, 2024c).

Technology and innovation

Technology and innovation play a large role in shaping how we understand and respond to environmental change. From data to urban planning and agriculture, innovation drives both positive and negative impacts.

Data tools are transforming how we monitor and manage the environment. Technologies like satellite images, sensors and mapping systems can help track water quality, forest health, or urban growth in real time. In New Zealand these tools could be increasingly used to manage and monitor freshwater, biodiversity and land-use change in more efficient ways (DOC, 2023; Reid & Castka, 2023). Advanced models, machine learning and artificial intelligence can then analyse these data to predict future trends and plan for climate change (AI Forum NZ, 2022; Giupponi et al, 2022). However, it is also important to consider the energy use of these systems and ensure fair access to technologies.

In towns and cities, development can displace or degrade existing natural infrastructure. This reduces ecosystem services and carbon storage, impacting on climate mitigation potential.

However, developing more innovative and green or nature-based infrastructure, such as restoring streams, re-establishing floodplains and preserving or creating wetland ‘sponges’ (eg, Making Space for Water initiatives), can conserve and improve ecosystems (Auckland Council, 2024; PCE, 2023; Tasman District Council, nd; see *Our land 2024* and *Our freshwater 2023*).

In rural areas, innovation provides a chance to expand and improve the economy, which may either reduce or increase environmental pressures (FAO, nd; MPI, 2017). Improvements in farming methods, irrigation, equipment and wastewater treatment have already increased output while attempting to minimise environmental harm (Ekanayake & Hedley, 2018; Fernandez, 2017; Macintosh et al, 2025; Monaghan et al, 2021). Emerging technologies like low-emission stock feed and resource-efficient crops could minimise agricultural emissions and ensure productivity (Caradus, 2023; Climate Commission, 2021; Driver et al, 2023; NZAGRC, 2021; Roques et al, 2024).

Climate change

Geopolitical forces overseas (including global economic trends) significantly affect climate change in New Zealand, and have given rise to international policies and agreements (eg, the Paris Agreement) to respond to these drivers. Geopolitical tensions and conflicts can also disrupt supply chains, leading to fluctuating energy prices and availability. This in turn affects our energy consumption patterns and emissions (Skilling, 2022; Winkelmann et al, 2019). The economy, largely driven by the primary sector and tourism, contributes to greenhouse gas emissions (see section 6: Atmosphere and climate). Population growth, particularly in cities, exacerbates these effects by increasing the demand for housing, transport and services (MfE, 2023a; PCE, 2023). As the country's population and economy continue to grow, so does its reliance and impact on the environment, contributing to climate change.

Climate change can amplify drivers and pressures in other environmental domains. For more detail on this complex relationship, see section 6: Atmosphere and climate. Rising temperatures and changing weather patterns give rise to droughts and reduced water availability, increasing tensions over water resources. Extreme weather events, such as cyclones, can disrupt infrastructure, agriculture, tourism and food systems, leading to economic instability. Population displacement due to climate-induced events, such as coastal erosion and flooding, can put extra pressure on people and property (see section 7: Impacts on people, society and the economy). This interconnectedness means that climate change poses a critical challenge for the environment and economy (IPBES, 2019).

2. Land

Introduction

The land and ecosystems of Aotearoa New Zealand are globally unique and nationally significant. Land offers us resources, and supports our livelihoods and economy, property and places, along with our health and quality of life.

For some Māori, connection to land is through whakapapa (ancestral lineage), placing people in a special relationship as a part of ecosystems (Harmsworth, 2022a; Timoti et al, 2017). These connections are emphasised in Māori language (te reo Māori), where the word 'whenua' means both 'land' and 'placenta' – to give nourishment and sustenance (Harmsworth & Awatere, 2013).

Diverse plants and animals are endemic to New Zealand (found nowhere else in the world). Ecosystems, soils and landscapes also have their own intrinsic value, and conserving our natural spaces is important to the majority of New Zealanders (DOC, 2011).

The activities that drive changes in our environment are often based on land. The choices we make today about how we use the land, and our activities on it, are central to whether we see improvements or deterioration not only on the land, but in downstream freshwater and marine environments, and in the air and atmosphere.

Land-use practices for agriculture, forestry and urban development contribute significantly to declines in freshwater quality and biodiversity. Pollution from excess sediment, nutrients, pathogens and contaminants harm our freshwater and marine ecosystems (see section 3: Freshwater and section 4: Marine). Land use and management influence air quality, and are central to mitigating and adapting to climate change (see section 5: Air and section 6: Atmosphere and climate).

Actions on land have both immediate and longer-term consequences. We are also still facing the legacy effects of human deforestation. For example, sedimentation (Sabetian et al, 2021), increased vulnerability to invasion by non-native species (Brownstein & Monks, 2024) and extinction debts (Walker et al, 2023) for places and species where ecosystems are now below a threshold level so they cannot recover.

This section looks at two important issues. The first is about **soil and land use**: how we use and manage the land and the issues this creates for soil erosion, soil health and contamination, and urban greenspaces and land fragmentation. The second looks at changes in **terrestrial habitats and native species**, and how they are threatened by habitat loss and invasive species.

For the wider effects, see section 7: Impacts on people, society and the economy.

New and updated land indicators and evidence since *Environment Aotearoa 2022*

Updates to livestock numbers and irrigated land indicators

Since the large increase in intensification of land use between the 1980s and mid-2010s, this trend has stabilised, with small shifts since the last indicator updates. Dairy cattle numbers have declined since the peak in 2014. However, the area of irrigated agricultural land increased between 2019 and 2022, implying that more intensive farming has continued to expand.

(See Land use and management has intensified, putting pressure on soil health, water quality, and indigenous biodiversity.)

Waste data new to reporting

Data that are new to the environmental reporting series show the large amount of waste that New Zealanders sent to municipal landfills each year between 2021 and 2023, compared with international reporting. Between 2018 and 2023, the household and municipal waste disposed per person stabilised, after increasing between 2012 and 2018.

(See Waste and contaminants pollute soil and water.)

Updated erosion indicators

Indicator updates confirm previous reporting, showing that 5 percent of New Zealand's land is classified as highly erodible, and risks of erosion by landslide remain the most common class of erosion risk. Erosion is likely to further increase in combination with predicted higher-intensity rainfalls due to climate change.

(See Erosion varies regionally, placing pressure on downstream freshwater and marine environments.)

Updated extinction threat indicator: indigenous terrestrial birds and reptiles

Indicator updates for indigenous terrestrial birds and reptiles show a high proportion of species remain threatened with extinction, or at risk of becoming threatened.

(See Many indigenous terrestrial species are threatened with or at risk of extinction.)

Updated national assessments of extinction risk for indigenous bats and frogs, and indigenous terrestrial invertebrates and vascular plants

Updated assessments by the Department of Conservation show most of our indigenous bat and frog species, and almost half of our indigenous terrestrial vascular plant species, remain threatened with extinction or at risk of becoming threatened. Updates also show that of the assessed indigenous terrestrial invertebrate species, a significant proportion remain threatened or at risk.

(See Many indigenous terrestrial species are threatened with or at risk of extinction.)

Soil and land use

Soil is the foundation of all land-based ecosystems, from tussock grasslands and wetlands to forests and agricultural landscapes. Healthy soils support biodiversity, cycle nutrients, filter contaminants and store carbon (Hewitt et al, 2015; Stevenson, 2022). From a mātauranga Māori (Māori knowledge) perspective, soil has an ancestral lineage that we are a part of (Harmsworth, 2022a).

Our activities on land affect soil condition and terrestrial environments, and have a flow-on impact on all other environmental domains. The following subsections outline these aspects of soil and land use:

- **erosion** – how soil erosion is affecting different parts of the environment, and how land use and land cover changes can exacerbate this natural process
- **land use and management** – how these practices affect soil health, and contribute to waste and contamination
- **urban densification** – how this puts a strain on green spaces, while urban expansion and the fragmentation of highly productive land affect its capacity to grow food. The way we manage urban development not only affects the 84 percent of us living in urban areas (Stats NZ, 2024d), but also has significant consequences for communities across the country.

Erosion affects land, freshwater and coastal environments, and is exacerbated by human activities and climate change.

Erosion varies regionally, placing pressure on downstream freshwater and marine environments.

- New Zealand has naturally high rates of erosion, due to geology and climate. However, these rates have increased due to vegetation clearing for agriculture, and climate change-related events (MfE, 2024i).
- An estimated 182 million tonnes of eroded soil entered New Zealand's rivers in 2022. This places pressure on receiving environments downstream (see indicator: Estimated long-term soil erosion: Data to 2022, section 3: Freshwater and section 4: Marine).
- In 2022, 5 percent (12,693 square kilometres) of the land was classified as highly erodible. This is land without protective woody vegetation, which is at risk of severe mass-movement erosion. The risk of erosion varies regionally (see indicator: Highly erodible land: Data to 2022 and Technical annex).
- Climate change exacerbates some degradation processes such as landslides, erosion and sedimentation. Soft rock hill country in both the North and South islands is particularly vulnerable. Climate change is predicted to increase erosion rates, though by how much depends on the future climate scenario. Under a low emissions pathway, regional sediment loads are predicted to increase by 1 to 49 percent across the country by 2090, while a higher emissions pathway could see increases of 18 to 233 percent over this period (Neverman et al, 2023; Smith et al, 2023; see section 6: Atmosphere and climate).
- Erosion is a significant concern on Māori land, as over 80 percent of it consists of hilly or mountainous terrain. This makes it highly susceptible to major erosion events such as landslides (Awatere et al, 2021).

Forest management practices can both relieve and put pressure on the environment.

- Tree cover reduces the risk of mass-movement erosion on steep slopes, by protecting soils from wind and rain. Tree roots also stabilise soil (Basher, 2013; Li et al, 2019; Phillips et al, 2023; Rey, 2021). How well this protects against erosion depends on the species, type and age of the forest, and on the root growth encouraged by different soil types and local climate (Phillips et al, 2023).
- For example, in Hawke's Bay and the Wairarapa hill country after Cyclone Gabrielle, it was estimated that land covered by indigenous forest had a lower probability of landslides

than with other land cover types. Land under exotic or indigenous forest is less likely to slide than hill-country pastoral land (McMillan et al, 2023).

- How exotic plantation forests are managed can affect erosion risk, especially on steep slopes. Land can be vulnerable to erosion for several years after harvest, as there is no forest canopy and the roots decay over time, reducing protection from mass-movement erosion (Marden et al, 2023; Phillips et al, 2015; 2024).
- The risk of gully erosion is affected by planting density, and how much of the area around water courses is set aside as a buffer. These buffers are freed from the disturbance of planting and harvesting cycles, and are more likely to be permanently stabilised by native riparian cover (Marden & Seymour, 2022).
- Other issues arising from forest management and harvest can include loss of water-regulating functions, including run-off, and adding to the risks of pest invasion (Jones et al, 2023; Messier et al, 2022; NIWA, nd-b).
- The ways that forests are managed and cleared on steep terrain have generally increased the amount of sediment entering rivers (Larned et al, 2020; Marshall et al, 2023).

The area of exotic forest has expanded, mostly due to the conversion of exotic grassland.

- In 2018, about half (about 12,635,000 hectares) of New Zealand was covered with native ecosystems, and about half (about 13,741,000 hectares) was primarily covered with farms, pasture, plantation (exotic) forests and urban land uses (see indicators: Indigenous land cover, Exotic land cover, Urban land cover).
- Exotic forests covered about 2.1 million hectares in 2018. The area of exotic forest increased by 220,922 hectares (12 percent) between 1996 and 2018 (see indicator: Exotic land cover). This is mostly on hill- and high-country land (MPI, 2022). Of land cover converted to exotic forest between 1996 and 2018, 75 percent was from exotic grassland (see indicator: Exotic land cover).
- Plantation forest currently consists of around 90 percent radiata pine, the remainder being Douglas fir, cypress and eucalyptus (MPI, 2023b). Plantations can also comprise native species such as mānuka, which can be used for honey production (Lambie et al, 2021).

Land use and management can affect the productivity of our land, and contribute to pollution through waste and contaminants

Land use and management have intensified, putting pressure on soil health, water quality and indigenous biodiversity.

- Agricultural land use intensified between the 1990s and mid-2010s. This increased the number of livestock and the yields per hectare, and added more fertilisers and irrigation (Manderson, 2020; Wynyard, 2016; see *Environment Aotearoa 2022*). Intensification can compromise the health of soils and freshwater (Monaghan et al, 2021; Snelder et al, 2021; see section 3: Freshwater).
- Much of the intensification is due to a switch from sheep and beef farming to irrigated dairy farming, driven by increasing profitability in the dairy industry (Wynyard, 2016). Dairy cattle numbers nearly doubled from 3.4 million in 1990 to a peak of 6.7 million in 2014. However, the number declined to 5.9 million in 2023 (see indicator: Livestock numbers: Data to 2023 and figure 1).

- The area of irrigated agricultural land nearly doubled between 2002 and 2022, reaching 762,000 hectares, or 5.8 percent of the total farm area. Most of this increase occurred in Canterbury, which had 63 percent of the irrigated land in 2022. More than half of irrigated agricultural land in New Zealand is used for dairy farming (see indicator: Irrigated land: Data to 2022).
- Sales of nitrogen fertiliser consistently increased between 1991 and 2019, from 62,000 to 452,000 tonnes (a 629 percent increase). Sales of phosphorus increased from 94,000 tonnes in 1991 to a peak of 219,000 tonnes in 2005 (a 133 percent increase). They then dropped to 154,000 tonnes in 2019 (a 30 percent decrease from the peak) (see indicator: Fertilisers – nitrogen and phosphorus).
- Despite increases in nitrogen fertiliser and irrigation, gains in pasture eaten on dairy farms have slowed since 2001/02. After increasing 1.48 percent per year between 1990/91 and 2001/02, pasture eaten increased 0.26 percent per year between 2002/03 and 2019/20. This is an early indication that extra fertiliser or irrigation is, on average, yielding a smaller increase in grazeable feed (Chapman et al, 2024).
- Agricultural and horticultural intensification, coupled with changes in land use and land cover, contributes to the loss, fragmentation and degradation of indigenous habitats and the species they support (Clarkson, 2022; DOC, 2020).

Soil quality at monitored agricultural sites is not always within target ranges.

- Soil quality is monitored routinely through seven indicators, with an emphasis on chemical and physical properties across nine land uses. Target ranges are defined for each of the indicators that describe a compromise between optimal crop yield and fewest environmental impacts. Soil quality issues of most concern include compaction (as measured by macroporosity) and elevated phosphorus levels (as measured by Olsen phosphorus) (see indicator: Soil quality and land use and *Our land 2021*).
- Forty-nine percent of sites were below the target range for macroporosity for 2014 to 2018, indicating that compacted soil limited the flow of oxygen and water (see indicator: Soil quality and land use).
- Sixty-three percent of 450,000 soil samples collected between 2001 and 2015 had Olsen phosphorus levels above the target range. Elevated Olsen phosphorus that washes or leaches into waterways can lower fresh and coastal water quality (McDowell et al, 2020[1]).

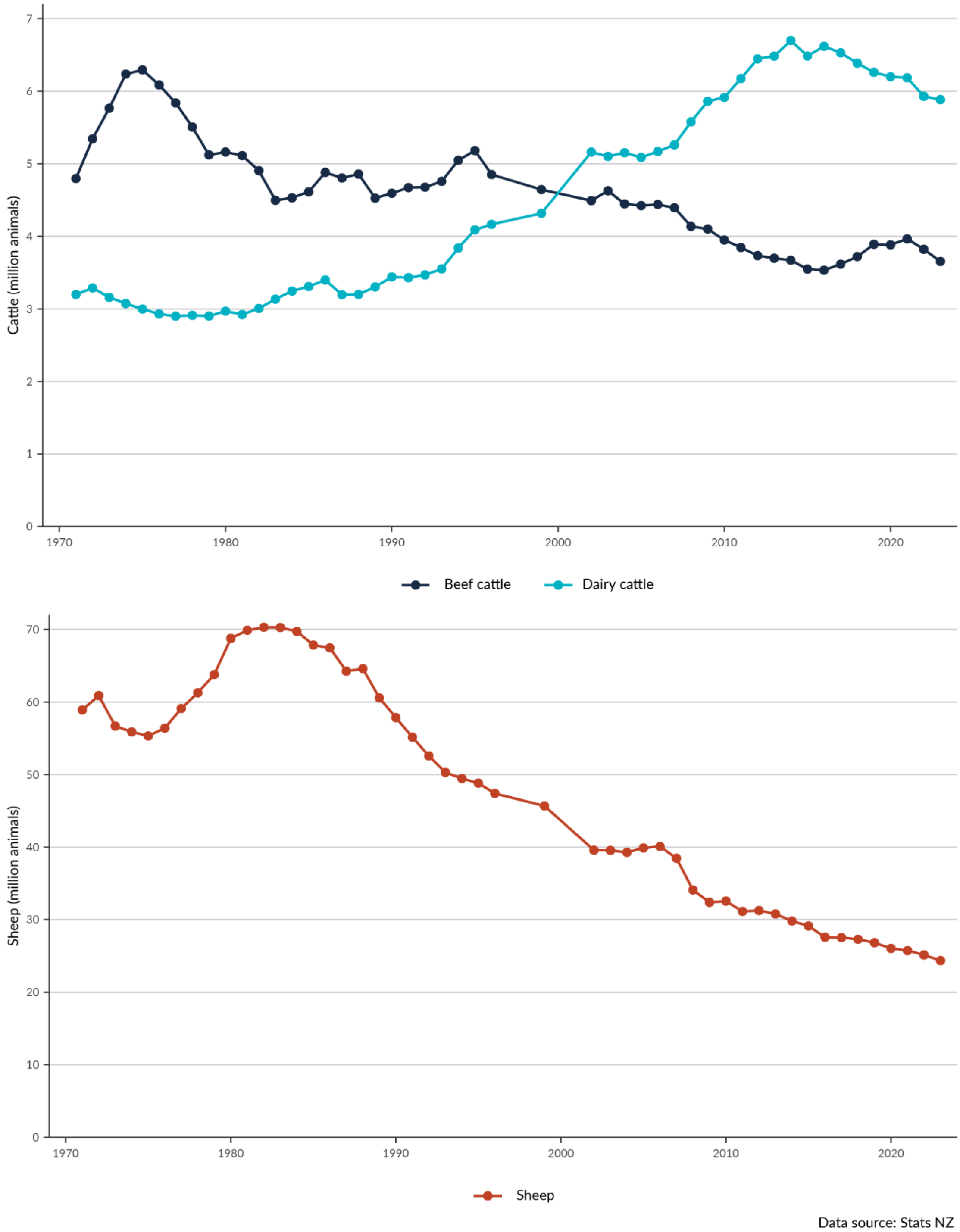
Waste and contaminants pollute soil and water.

- New Zealand consistently generates among the highest rates of municipal waste per person in the developed world, though there are inconsistencies in how different countries report (OECD, 2024). We sent an average of 688 kilograms of waste per person to municipal landfills each year between 2021 and 2023 (MfE, 2023b). From 2012 through 2018, this average increased 32 percent (570.1 to 755.3 kg per person per year). More recently, it has generally stabilised (with some fluctuation). Landfills received 11 percent less waste per capita in 2023 than the peak in 2018 (MfE, 2023b).

[1] Olsen phosphorus findings are not being reported from the Soil quality and land use indicator. This is due to the discovery of an error, which overreports the number of sites tested above target ranges (see indicator: Soil quality and land use).

- Much of our waste ends up in landfills. On average, municipal landfills across the country received a total of 3.9 million tonnes of mixed household, commercial and industrial waste each year between 2021 and 2023. Of this material, 9.8 percent was reused, repurposed or recovered (MfE, 2023b).
- Landfills can leak leachate, or liquid containing contaminants. There are controls to contain leachate, but it can still contaminate nearby soil and water, and harm ecosystems and people (MfE, 2004; Siddiqua et al, 2022).
- Chemical contaminants stem from the use of chemicals, including hazardous substances, in industry, agriculture, horticulture and forestry (MfE, 2021a; PCE, 2022). In the 12 months ended 31 June 2023, councils reported that over 45,000 sites had been used for hazardous activities or industries that might cause contamination (MfE, 2024h).
- There is emerging evidence that some New Zealand soils are contaminated with microplastics, although their distribution and effect are uncertain (de Bhowmick et al, 2021; ESR, 2024). Soils receiving applications of biosolids and composts made from municipal waste have a higher risk of contamination (Ruffell et al, 2025). Internationally, it is estimated that soils could currently store more microplastics than surface water in global oceans (Nizzetto et al, 2016; Tremblay et al, 2019; see section 4: Marine).
- Contaminants from land can be carried to freshwater environments and the ocean directly, via stormwater systems, or in untreated or partially treated wastewater (see section 3: Freshwater). Also, some of our waste does not make it to landfill and ends up as litter. Plastic is the most common type of litter found on beaches (see section 4: Marine).

Figure 1: Livestock numbers (beef cattle, dairy cattle, sheep), 1971–2023



Note: The scale for the number of sheep is 10 times that for cattle (see indicator: Livestock numbers: Data to 2023).

Urban densification places pressure on green spaces, and urban expansion encroaches onto highly productive land

Our cities are densifying and expanding, driven by growing populations, and land-use decisions.

- Population growth has contributed to the outward expansion of towns and cities. The total urban area grew by 15 percent between 1996 and 2018 (see indicator: Urban land cover).

- There is a trend towards densification in cities. The decade to 2021 saw a rise in the construction of higher-density dwelling types, including townhouses and apartments, mostly through low-rise infill in existing urban areas (PCE, 2023; Stats NZ, 2024b; see *Our land 2024*). Meanwhile, towns and cities are also expanding outwards. New subdivisions at the margins are increasingly characterised by larger houses on smaller sections (PCE, 2023).
- Densification helps address the housing supply shortage, can reduce sprawl onto agricultural land and offers opportunities to reduce our transport emissions (PCE, 2023).

Urban development and land fragmentation are decreasing the availability of highly productive land, which can limit options for rural land use.

- Highly productive land is land that is particularly suitable for food production (Curran-Cournane et al, 2021a; see Technical annex). This land type is particularly important for horticulture. It also has cultural and historical value, as Māori gardening and horticulture (māra kai) sites of significance are often on such land near cities (Harmsworth, 2022b).
- About 14 percent (3,830,000 hectares) of the total land area of New Zealand has been classified as highly productive land (NZLRI, 2021; Rutledge et al, 2010).
- Highly productive land is a finite resource. Converting it to housing is effectively irreversible, which means the amount available can only remain stable or decline (Curran-Cournane et al, 2018, 2021b). Conversions reduce how much of this land is available for farming, and could lead to intensification on the remaining land (Curran-Cournane et al, 2021a; Deloitte, 2018).
- In 2002, 69,920 hectares of highly productive land had an urban or residential land use, and so was unavailable for, or restricted from, use as farmland. In 2019, this area had increased to 107,444 hectares (a 54 percent increase) (see indicator: Land fragmentation). This is about 3 percent of New Zealand's highly productive land (NZLRI, 2021; Rutledge et al, 2010).
- During this same period, the remaining highly productive land became slightly more fragmented. There was a 1.9 percent increase in the area occupied by small-sized parcels (parcels of 2 to 8 hectares) and a 1 percent decrease in the area occupied by parcels over 8 hectares (see indicator: Land fragmentation). Smaller blocks, while still productive, are often shifted out of commercial production over time (Curran-Cournane et al, 2021a; Hart et al, 2013).

The quantity and quality of urban green space is declining.

- Urban green spaces provide important cultural connections for many New Zealanders. Other benefits include reducing stormwater run-off, cleaning the air, lowering ambient temperatures and increasing the diversity of plants and animals that can live in our cities (PCE, 2023).
- Loss of green spaces and their biodiversity can cause a disconnection from our natural heritage, and a loss of cultural identity and sense of place (Blaschke et al, 2024; see section 7: Impacts on people, society and the economy).
- Our cities are currently well-endowed with green space, though some suburbs are greener than others. Green space in some cities covers more than 30 percent of their area (PCE, 2023). However, it is under increasing pressure from densification and expansion that does not include planned green areas.

- In some cities, such as Auckland and Hamilton, parks and green belts are not keeping pace with expansion. Private green space is also declining, and this trend is accelerating (PCE, 2023).
- Densification can degrade our existing urban green spaces. It can result in the removal of trees, and the disturbance and compaction of soils. This in turn can lead to urban heat islands and increase the risk of flooding (PCE, 2024). Increases in population density mean more people can enjoy nearby public parks and reserves, but this can increase pressure on these areas (PCE, 2023).

Terrestrial habitats and native species

New Zealand has a high number of endemic species – one of the highest totals worldwide – and many are considered treasured (taonga). Culturally important species, including many threatened terrestrial birds and trees, are vulnerable to diseases like kauri dieback and myrtle rust. Human activities on land, pests, diseases and changes to native ecosystems all combine to threaten iconic species. This subsection explores how these pressures are changing species and habitats.

Many land ecosystems and species are under threat

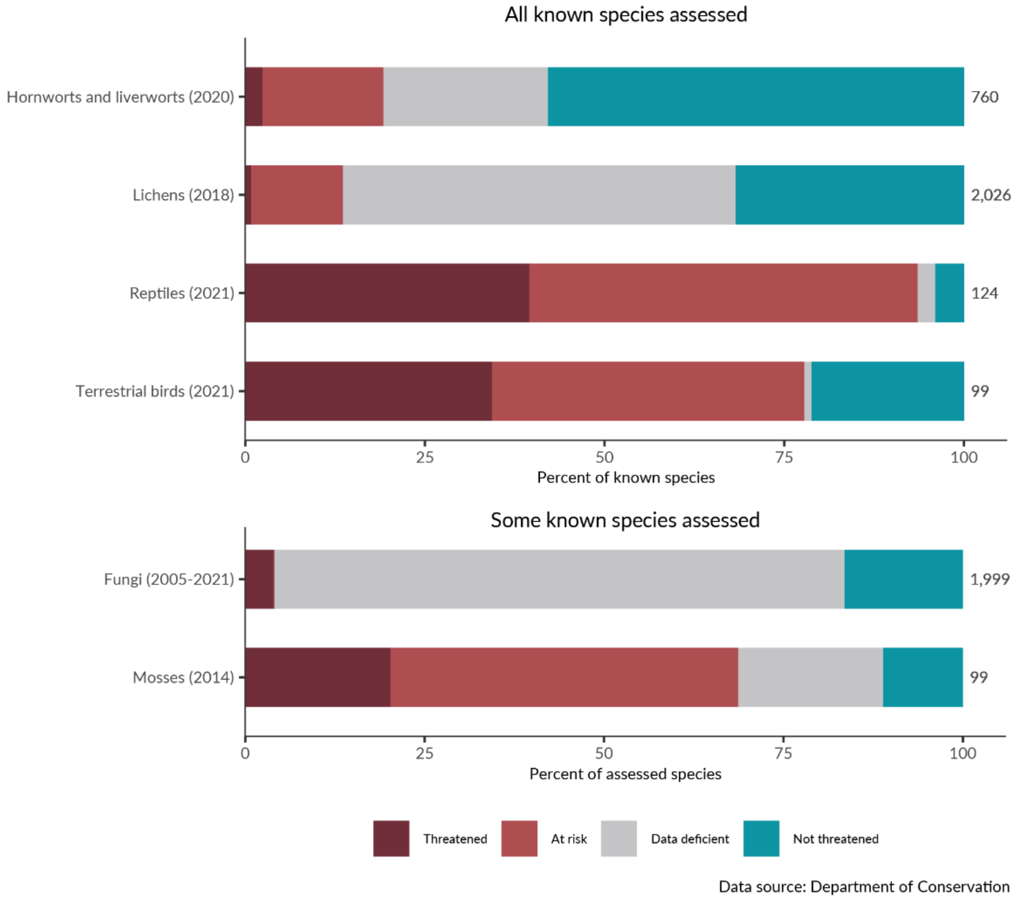
Many indigenous terrestrial species are threatened with extinction or at risk of becoming threatened.

- Pressures on ecosystems from land-use change, pollution, invasive pest species and climate change have individual and cumulative impacts on indigenous species. New Zealand's unique biodiversity has a high proportion of threatened or at-risk species – one of the highest amid the global biodiversity crisis (Bradshaw et al, 2010; IPBES, 2018, 2019; see section 3: Freshwater and section 4: Marine).
- In 2021, 94 percent (116 of 124) of indigenous reptile species were threatened with extinction or at risk of becoming threatened (figure 2). Estimated population trends show 72 percent of species have decreasing populations and 5 percent have increasing populations (see indicator: Extinction threat to indigenous species).
- In 2021, 78 percent (77 of 99) of indigenous terrestrial bird species were threatened with extinction or at risk of becoming threatened (figure 2). Estimated population trends show 22 percent of species have decreasing populations and 21 percent have increasing populations (see indicator: Extinction threat to indigenous species and Technical annex).
- In 2023, 48 percent (1,260 of 2,621) of indigenous terrestrial vascular plant species were threatened with extinction or at risk of becoming threatened. Estimated population trends show 18 percent of species have decreasing populations and 1.4 percent increasing (de Lange et al, 2024).
- In 2022, 80 percent (4 of 5) of indigenous bat species were threatened with extinction or at risk of becoming threatened. Estimated population trends show three species have decreasing populations and one species increasing (O'Donnell et al, 2023).
- In 2024, 93 percent (13 of 14) of indigenous frog species were threatened with extinction or at risk of becoming threatened. Estimated population trends show 12 species have decreasing populations and one stable (Burns et al, 2025).
- In 2022, 36 percent (1,433 of 3,961) of assessed terrestrial invertebrate species were threatened with extinction or at risk of becoming threatened. Estimated population trends

show 0.4 percent of assessed species have decreasing populations, 1 percent stable or increasing, and 26 percent stable; the remaining population trends are unavailable[2] (Andrew et al, 2012; Barker et al, 2021; Buckley et al, 2012; Buckley et al, 2015; Buckley et al, 2016; Heath et al, 2015; Heath et al, 2022; Hoare et al, 2017; Leschen et al, 2012; Mahlfeld et al, 2012; Sirvid et al, 2021; Stringer et al, 2012a; Stringer et al, 2012b; Trewick et al, 2018; Trewick et al, 2022; Walker et al, 2021; Walker et al, 2024a; Ward et al, 2017; Yeates et al, 2012; see Technical annex).

- The decline in the health and area of ecosystems and their biodiversity reduces the environment's ability to recover from disturbances, such as those caused by extreme weather events, long-term environmental changes and climate change (Dasgupta, 2021; Key et al, 2022).

Figure 2: Extinction threat to indigenous terrestrial species[3]



Note: Totals given for species on the right of this figure show the total number of species assessed. Complete assessments are those where all known species in the group have been assessed. Partial assessments are those where not all species in the group have been assessed (see indicator: Extinction threat to indigenous species).

2 Note that only some known species of terrestrial invertebrates have been assessed for extinction threat status and estimated population trends.

3 Note that extinction threat information updated since the Extinction threat to indigenous species indicator update in 2023 has been included in the text and is based on New Zealand Threat Classification System data downloads, as well as older information from the terrestrial invertebrates species group (see Technical annex; NZTCS, 2025). Figure is based only on information available in the indicator (see indicator: Extinction threat to indigenous species).

Remaining indigenous forest, scrub and tussock provide important habitat for indigenous species, but continue to be lost to other land uses.

- Native land cover includes forests, tussock grasslands and shrublands. Land covered with original or regenerating native vegetation ranges from vast areas of conservation land (mainly in higher, more remote areas) to small, isolated stands of regenerating bush on farms and in cities.
- Before the arrival of humans, native forest covered more than 80 percent of the land (see indicator: Predicted pre-human vegetation). It now covers less than 30 percent. The area covered with native ecosystems, including forests, decreased by about 88,000 hectares between 1996 and 2018, mainly through conversion to pasture and exotic plantation forestry (see indicator: Indigenous land cover).
- Lowland native forests are important habitats for a high proportion of threatened native plant species (Walker et al, 2008). Some animals also persist in the remnant native forest in pastoral systems, such as the brown kiwi in the North Island. However, species that need large, connected forest, such as the kōkako, are generally not present in these modified landscapes (Norton et al, 2020).
- Native forest remnants in farmland are vulnerable to exotic plant invasion via creeping edge effects. These effects are increased by spillover of nitrogen and irrigation from agricultural intensification (Brownstein & Monks, 2024). Wetland remnants are also affected by adjacent land use (see section 3: Freshwater).
- Exotic plantation forests can have positive effects on some native species compared with bare or pastoral land, particularly where native habitat is fragmented. It can protect and connect native ecosystem remnants and provide habitat where no alternative exists (Brockerhoff et al, 2017; Pawson et al, 2010). Threatened and at-risk species found in plantation forests include bats, insect-eating birds such as riroriro (grey warbler), pīwakawaka (New Zealand fantail), and kiwi, and a wide variety of invertebrates found in leaf litter layers, soil and wood (Borkin et al, 2011; Marshall et al, 2023; MWLR, 2018; Pawson et al, 2010).

Pests and weeds threaten biodiversity and put vulnerable ecosystems at risk.

- Weeds (plant pests) are introduced exotic plants that are growing in the wild and damaging native ecosystems. Weeds and other pests can reduce biodiversity by outcompeting other species. They can alter habitats, damage ecosystem functions and even increase fire risk (Brandt et al, 2020; Clarkson, 2022; PCE, 2021).
- For some Māori, pests and weeds can disrupt the balance that Papatūānuku (Earth mother) needs to be well, creating a system that no longer provides for life (PCE, 2021).
- There are over 1,800 exotic plant species that can maintain populations in the wild without human assistance (McAlpine & Howell, 2024; PCE, 2021). The number of wild (naturalised) pest plant species is continuing to grow as there are few barriers to naturalisation (Brandt et al, 2020). The North and South islands each have more of these plants than almost any other island in the world, with exotic species making up 44 percent of our vascular plant life (PCE, 2021).
- Weeds pose a threat to endangered ecosystems (Rapson et al, 2023) and are the main hazard to one-third of nationally threatened native plant species (Hulme, 2020; PCE, 2021).

- Wilding conifers are plant pests that spread from plantation forests through natural regeneration or seeding. They are a serious threat to the ecology and biodiversity of many native ecosystems (Edwards et al, 2020; Etherington, 2022; Froude, 2011; MPI, 2023c; Peltzer, 2018). They particularly affect tussock grasslands, rare ecosystems and subalpine habitats, which are all important for supporting biodiversity (MPI, 2014; Peltzer, 2018)
- Around 2 million hectares across the country are thought to be invaded by wilding conifers (Peltzer, 2018), and the area is expanding by around 90,000 hectares a year (MPI, 2023c). Without management, wilding conifers will form dense forests and could invade about 25 percent of land in New Zealand in 30 years (MPI, 2023c).
- Mammalian pests threaten many native birds, reptiles, invertebrates and plants (DOC, 2020). Between 2013 and 2019, possums were the more common pest in woody areas, while for hooved animals (such as deer and goats), mean occupancy (distribution) was around 70 percent in non-woody areas and 85 percent in woody areas (see indicator: Land pests). Possums and hooved animals have a particularly high impact on growth of some native tree species, as native forests have historically lacked herbivorous mammals (Hawcroft et al, 2024). Pest populations in woody areas are harder to harvest or control (Moloney et al, 2021).
- Introduced pathogens (disease-causing microorganisms) threaten native plants and commercial crops. They include kauri dieback disease, myrtle rust and the kiwifruit vine disease, PSA (*Pseudomonas syringae actinidiae*). Pathogens affect species that are culturally important for many Māori (Clarkson, 2022; Diprose et al, 2022; Royal Society Te Apārangi, 2014).

3. Freshwater

Introduction

Aotearoa New Zealand's freshwater environment supports all aspects of our lives, and we share an intimate connection with it. It is central to our quality of life, supporting the economy, recreation and food-gathering. For many Māori, the freshwater environment is central to customs and protocols (tikanga), knowledge (mātauranga) and traditional food-gathering practices (mahinga kai).

Despite this, freshwater is under pressure from activities on the land and in the water, and from a changing climate. Although some freshwater bodies are in a reasonably healthy state, many have been degraded by the effects of these pressures on water quality and freshwater habitats. Further, most indigenous freshwater fish and freshwater bird species, including some iconic treasured (taonga) species, are either threatened with extinction or at risk of becoming threatened.

Rivers and groundwater act as pathways transporting nutrients, sediments and contaminants from the land to the marine environment. Changes in the quality of freshwater can also affect estuaries and coastal waters (see section 4: Marine).

This section looks at two key issues.

First, it reports on the state of **freshwater quality** in our groundwater, rivers and lakes. It also summarises the pressures, including agriculture, wastewater and stormwater, which are responsible for the degraded state of many waterways.

It then presents evidence on how freshwater quality, land conversion, changes to flows and water courses, pests and climate change are all affecting the state of **freshwater habitats and native species**.

For the wider effects of the state of freshwater, see section 7: Impacts on people, society and the economy.

New and updated freshwater indicators and evidence since *Environment Aotearoa 2022*

Updated national groundwater quality assessment

New *Escherichia coli* (*E. coli*) monitoring data show that contamination by faecal pathogens remains the most widespread water quality issue affecting groundwaters. Evidence not previously available from water suppliers shows that *E. coli* levels have failed to meet drinking water standards in some samples from aquifers that supply public drinking water.

An assessment of new nitrate-nitrogen monitoring data has strengthened previous assessments of the scale of nitrate impact in groundwaters. It indicates that a significant proportion of groundwaters have accumulated excess nitrate due to human activities, which can compromise drinking water quality and degrade surface water ecosystems. Groundwaters in most parts of the country continue to comply with drinking water standards, but some aquifers are still not safe for supplying drinking water that has not been treated for nitrate.

New monitoring data for pesticides and per- and polyfluoroalkyl substances (PFAS) indicate that they are not widespread in groundwaters, and rarely occur above drinking water standards.

(See Freshwater quality is mixed. In some water bodies, contaminant levels pose a risk to people and freshwater species, habitats and ecosystems.)

New data and modelled findings for national lake health

A new model for lake water quality affirms previous assessments that almost half of the country's lakes are in poor health due to excess nutrients. However, unlike the previous model, it predicts that most of the remaining lakes are in good health, rather than average. This is due to the new model's improved accuracy for lesser-impacted lakes, and does not reflect a measured change in the state of lake environments between assessment periods.

(See Some river and lake ecosystems are showing signs of degradation from excess nutrient levels.)

Updated extinction threat indicator: indigenous freshwater-dependent birds

The indicator update for indigenous freshwater-dependent birds shows most species remain threatened with extinction, or at risk of becoming threatened.

(See Many indigenous freshwater species are threatened with extinction or at risk of becoming threatened.)

Updated national assessment of extinction risk for indigenous freshwater plants

An updated assessment by the Department of Conservation shows a significant proportion of our indigenous freshwater plant species remain threatened with extinction, or at risk of becoming threatened.

(See Many indigenous freshwater species are threatened with extinction or at risk of becoming threatened.)

Freshwater quality

The quality of our freshwater is affected by different human activities. This impacts the health of ecosystems, and our ability to safely connect with the freshwater environment. This subsection looks at the state of groundwater, lakes and rivers, and what it means for drinking and swimming. It also examines the pressures that can degrade them.

Freshwater quality is widely monitored across groundwater, lakes and rivers, and models are used to predict water quality in unmonitored rivers and lakes. Cultural indicators, such as for traditional food-gathering practices (mahinga kai), can show the overall health of freshwater ecosystems. This subsection uses a selection of these measures to assess the extent of freshwater pollution in New Zealand, focusing on faecal pathogens and nutrients. Elevated nitrogen and faecal contamination can make waters unsafe for drinking, and faecal contamination can make them unsafe for recreation. Excess nutrients can degrade freshwater habitats and ecosystems, and harm freshwater species.

Freshwater quality is mixed. In some water bodies, contaminant levels pose a risk to people and freshwater habitats, species and ecosystems

Some of our groundwater is unsafe for drinking.

- *E. coli* is monitored as an indicator of the presence of pathogens associated with animal or human faeces, especially *Campylobacter*. Consuming faecal pathogens in drinking water can make people ill (see section 7: Impacts on people, society and the economy).
- Forty-six percent of 1,007 groundwater monitoring sites failed to meet the New Zealand drinking water standard for *E. coli* on at least one occasion between 2019 and 2024. This indicates a risk to people if they consume water from these aquifers that has not been adequately treated (Moreau et al, 2025).[4]
- Some of our groundwater drinking water sources have been contaminated with bacteria, including deep aquifers (deeper than 30 metres) and springs. Of the 11,026 (pre-treated) samples from water supply bores that were tested for *E. coli* and reported to Taumata Arowai in 2023, 6 percent failed to meet the drinking water standard. Thirty-three percent of the 326 samples from springs also failed (Taumata Arowai, 2024).
- Twelve percent of 1,173 groundwater monitoring sites failed to meet the New Zealand drinking water standard for nitrate-nitrogen on at least one occasion between 2019 and 2024 (Moreau et al, 2025). Groundwater with concentrations above this standard must be treated for nitrate before it is safe to drink (PMCSA, 2023).
- For the 184 wells sampled in the 2022 national groundwater survey for pesticides, detected concentrations of one compound exceeded New Zealand drinking water standards in six wells. Detected concentrations of two compounds exceeded the standards in two wells, and detected concentrations of three compounds exceeded them in one well (Close & Banasiak, 2023a; Moreau et al, 2025).
- Drinking water standards for other non-natural chemicals were not exceeded in any of the wells sampled in the last national groundwater survey in 2018, or in the first national groundwater survey for per- and polyfluoroalkyl substances (PFAS) in 2022 (Close et al, 2021; Close & Banasiak, 2023b).

Some rivers and lakes are unsuitable for swimming and recreation.

- Exposure to faecal pathogens through recreational activities such as swimming, paddling and water sports can make people ill (see section 7: Impacts on people, society and the economy). Rivers and lakes can be assessed for their suitability for these activities by using measured *E. coli* concentrations to calculate the risk of infection from *Campylobacter* bacteria (see Technical annex).
- Models estimate that 45 percent of the country's total river length was not suitable for activities such as swimming between 2016 and 2020, based on having an average *Campylobacter* infection risk greater than 3 percent (corresponding to National Objectives Framework (NOF) bands D and E for *E. coli*) (see indicator: River water quality: Escherichia coli; MfE, 2024f).

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[4] Moreau et al (2025) update the information in the current version of the Stats NZ Groundwater quality indicator, published in April 2020. The data from Moreau et al will be incorporated into the next indicator update, but the statistics published in the updated web page may differ due to methodological (or other) differences (see Technical annex).

- For *E. coli*, trends at 41 percent of river monitoring sites were worsening and 37 percent were improving between 2001 and 2020 (see indicator: River water quality: Escherichia coli).
- For the period 2017–22, 9 of 92 monitored lake sites had an average *Campylobacter* infection risk of more than 3 percent, making them unsuitable for activities such as swimming (Kuczynski et al, 2024; MfE, 2024f). For the 15 sites where trends could be assessed for *E. coli*, 33 percent were worsening and 20 percent were improving between 2012 and 2022 (Kuczynski et al, 2024; MfE, 2024f).

The quality of our waterways can make them less suitable for food-gathering (mahinga kai) and treasured (taonga) species, which are important cultural indicators of the health of freshwater ecosystems.

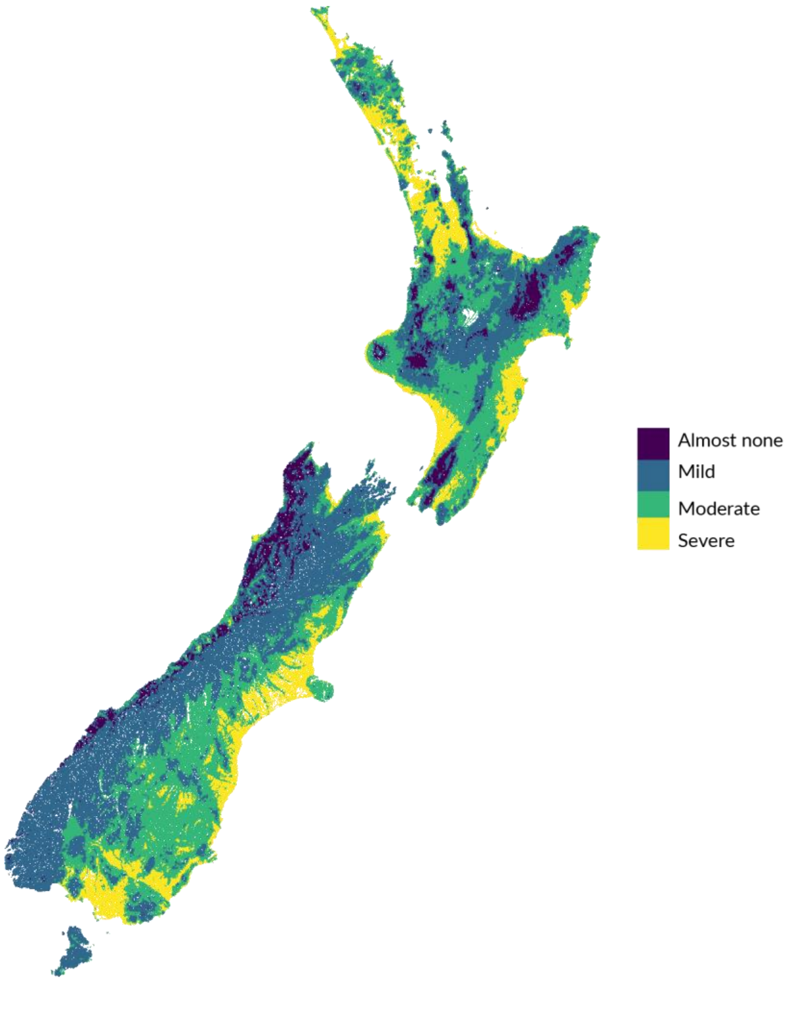
- Mahinga kai is a cultural indicator of a healthy freshwater system (Hikuroa et al, 2018; Tipa, 2009). Sustaining and accessing mahinga kai is closely linked to the state of freshwater, and is important for Māori in understanding the health of an ecosystem (Rainforth & Harmsworth, 2019; Tipa, 2009).
- A survey of five mahinga kai sites in coastal North Canterbury between 2019 and 2021 detected *E. coli* on sampled watercress, and in cockles, at concentrations that exceeded health guidelines for human consumption. Concentrations were significantly higher than in the surrounding water (van Hamelsveld et al, 2023).
- An assessment of the Wairoa and Waiau rivers using mātauranga observations from 2021 to 2023 observed a decline in the health of mahinga kai species: 9 percent of the harvest was unsafe to eat, and 7 percent of the targeted catch was not safe to harvest due to visible injury or sickness. The assessment also observed an accelerating decline in the availability of mahinga kai species that were traditionally or historically available (Galvan et al, 2024).

Some river and lake ecosystems are showing signs of degradation from excess nutrient levels.

- Nutrients, such as nitrogen and phosphorus, occur naturally in the freshwater environment. However, elevated levels can drive eutrophication – an overload of nutrients that can cause algal blooms, depleted oxygen levels and a range of harmful effects on freshwater ecosystems (Snelder et al, 2020; see *Our freshwater 2023*). Freshwater can carry nutrients from land into the marine environment, where they can also cause harm (see section 4: Marine).
- This subsection assesses the flow-on effects of nutrients on freshwater ecosystems using water quality indices that provide a high-level understanding of ecosystem health: macroinvertebrate community index (MCI) for rivers and trophic level index (TLI) for lakes (see *Our freshwater 2023* and Technical annex). For more about nutrients in water, see indicators: River water quality: nitrogen, River water quality: phosphorus, Lake water quality and Coastal and estuarine water quality.
- Between 2016 and 2020, 55 percent of New Zealand's river length had modelled MCI scores that indicate conditions with moderate or severe organic pollution or nutrient enrichment, and 45 percent had scores that indicate no or mild impairment (see indicator: River water quality: macroinvertebrate community index; figure 3).
- For MCI, trends at 56 percent of river monitoring sites were worsening and 25 percent were improving between 2001 and 2020 (see indicator: River water quality: macroinvertebrate community index).

- Forty-six percent of lakes larger than 1 hectare had modelled TLI scores indicating poor or very poor health in terms of nutrient enrichment between 2016 and 2020 (see indicator: Lake water quality). A new TLI model that better represents less-affected lakes predicts that 34 percent of lakes larger than 1 hectare are in good or very good health, based on data from 2018 to 2021 (Wood et al, 2023; see Technical annex).
- For TLI, trends at 45 percent of lake monitoring sites were worsening and 36 percent were improving between 2011 and 2020 (see indicator: Lake water quality).
- For the period 2019–24, groundwater nitrate-nitrogen concentrations were monitored at 1,173 sites. Forty-one percent of sites indicated groundwater in these locations is likely to have accumulated excess nitrate due to human activities. For the 417 sites where trends could be assessed for nitrate-nitrogen, concentrations were increasing at 47 percent of them, and decreasing at 43 percent between 2004 and 2024 (Moreau et al, 2025; see Technical annex).
- The concentration of nitrate that is harmful to groundwater species is unknown (Fenwick et al, 2018), but nitrate-rich groundwaters can contribute to ecosystem degradation in the surface water bodies that they flow into (see *Our freshwater 2023*).

Figure 3: Modelled median macroinvertebrate community index scores indicating organic pollution and nutrient enrichment in rivers, 2016–20



Data source: Regional councils, NIWA

Note: Nutrient enrichment levels from ‘Almost none’ to ‘Severe’ correspond to National Objective Framework bands A to D (see indicator: River water quality: macroinvertebrate community index; MfE, 2024f).

Land use and human activities are major pressures on freshwater quality

Land-based human activities contribute to excess nutrients, sediment and pathogens in fresh waterways.

- Human activities on land, such as agriculture, forest harvesting and urban expansion, can increase erosion rates and the levels of pathogens, nutrients and sediment in freshwater and marine systems (see *Our freshwater 2023* and section 4: Marine). In some parts of New Zealand, increased rainfall and flooding are expected to further increase the amount of eroded sediment reaching downstream environments (see section 2: Land).
- When pathogens, excess sediment and surplus nutrients wash or drain into freshwater environments, they can cause ecological and socio-economic harm. Pathogens such as *Campylobacter*, *Cryptosporidium*, *E. coli* and *Giardia* can make waters unsafe for drinking and recreation (Basher et al, 2011; Devane et al, 2018; Donovan, 2022; Larned et al, 2020; Leonard & Eaton; 2021; see section 7: Impacts on people, society and the economy).

Intensification and other land-use changes have increased pressures on water quality.

- Intensification involves increasing the use of inputs such as fertiliser and irrigation, and draining soils, to increase production. This includes converting land used for less intensive activities such as sheep farming, to more intensive uses such as dairy farming or horticulture (Burge et al, 2023). Agriculture has been intensifying in New Zealand since the 1980s, but the rate has slowed since the mid-2010s (see section 2: Land).
- Analyses of national river water quality monitoring data for 2016–20 show that water quality is more degraded when there is more high-intensity pasture and horticultural land upstream (Whitehead et al, 2022). Models indicate that measured long-term changes in water quality leading up to this period were closely associated with agricultural intensification and, to a lesser extent, better farm management (Monaghan et al, 2021; Snelder et al, 2021; see *Our freshwater 2023*).

Stormwater, wastewater and other waste discharges are also pressures on freshwater quality

Wastewater and stormwater are sources of freshwater contaminants, such as pathogens and heavy metals.

- Sewage and other wastewater from houses, businesses and industrial processes often contains high levels of pathogens and other contaminants. These are significantly reduced by wastewater treatment, but treated discharges can still carry contaminants into the freshwater environment (Ruffell et al, 2021; see *Our freshwater 2020*).
- Some wastewater bypasses treatment entirely. In the 2022 national performance review by Water New Zealand, participating wastewater service suppliers reported that between 2021 and 2022 there were 3,121 reported overflows of untreated wastewater due to wet-weather events, or due to blockages and mechanical failures during dry weather. However, it is likely that this number is under-reported (Water NZ, 2024).
- Stormwater can also carry pollutants from land into freshwater. These pollutants include hydrocarbons and heavy metals from vehicles and industrial yards, and pathogens from animal faeces, wastewater leaks and overflows (see *Our freshwater 2023*).

- River water quality monitoring data for Auckland, Canterbury, Otago and Wellington for 2017–22 indicates that concentrations of the heavy metals copper and zinc were highest at sites with greater proportions of urban land cover in their upstream catchments (see indicator: River water quality – heavy metals: Data to 2022).

Plastics and chemicals that have been produced and used for decades end up in freshwater.

- Plastic waste is a major problem affecting land, freshwater and the marine environments (see section 2: Land and section 4: Marine). Some plastics take centuries to break down, and large quantities are still being produced (PMCSA, 2019).
- In 2021 and 2022, most of the items (68 percent) counted in New Zealand freshwater environments in Litter Intelligence surveys were plastic (Litter Intelligence, nd).
- Microplastics are generally defined as plastic particles less than 5 millimetres in diameter (De Bhowmick et al, 2021). They have been found in urban streams and are often transported via smaller urban streams. A survey across 52 urban streams found microplastics in samples from all sites (Mora-Teddy & Matthaei, 2020).
- Pesticides can stay in the environment for long periods and can enter waterways. They have been used in New Zealand for many decades over large areas of land (Chapman, 2010; Manktelow et al, 2005; Rolando et al, 2016).
- In the 2022 national groundwater survey for pesticides and per- and polyfluoroalkyl substances (PFAS), one or more pesticides were detected in 17 of the 184 wells sampled (9 percent). Pesticides were detected in a smaller proportion of wells, and generally at lower concentrations, than in the last survey in 2018 (Close & Banasiak, 2023a).
- PFAS were included in the national groundwater survey for the first time in in 2022. Of the 131 wells surveyed for PFAS, one or more were detected in 15 wells (11 percent) (Close & Banasiak, 2023b).
- Other non-natural chemical contaminants coming from the manufacture and use of products such as plastics and personal care products have been detected in groundwaters across the country, but mostly at low levels (Close et al, 2021).

Freshwater habitats and native species

New Zealand has many unique native species that depend on freshwater. When freshwater quality declines, these species and their ecosystems become threatened. This subsection looks at how pressures such as invasive species, sediment and contaminants, along with changes to water flows from irrigation and hydropower, are affecting habitats and placing some species at risk of extinction.

The effects of climate change are intensifying many of these pressures. This is discussed in section 6: Atmosphere and climate.

Human activities and exotic species have led to the loss and degradation of habitats, placing significant pressure on native species

Much of our historical wetland has been converted to other uses, and the loss and degradation of these places (considered sacred or wāhi tapu by Māori) have continued. This has reduced habitat for dependent native species and diminished many environmental benefits.

- New Zealand has lost an estimated 90 percent of historical wetland (repo) area, but the small fraction that remains is vital for the survival of many threatened plant and animal species, including several treasured (taonga) bird species (Clarkson et al, 2013; Dymond et al, 2021; see *Our freshwater 2023*).
- Wetlands continue to be lost. Freshwater wetland area decreased by 1,498 hectares (0.6 percent), and saline repo area by 69 hectares (0.1 percent), between 2012 and 2018 (see indicator: Wetland area).
- Wetlands continue to be degraded by drainage and disturbance from adjacent land use, particularly roading and grazing (Burge et al, 2023, 2025).
- Wetlands provide many benefits, such as storing carbon, regulating water flow during storms, and purifying water by filtering out nutrients and sediments (Clarkson et al, 2013; Schallenberg et al, 2013). The extent and condition of these ecosystems affect these important processes.

Freshwater ecosystems can be widely affected by introduced species, some of which degrade freshwater habitats and threaten native species.

- Historically, over 200 species of freshwater animals and plants have been introduced to New Zealand, mostly deliberately. Illegal and accidental introductions still occur (NIWA, 2020), such as the gold clam (*Corbicula fluminea*), which was discovered in the Waikato River in 2023 and has established a breeding population there (DOC, nd-a; MPI, 2023d).
- Many introduced freshwater species, such as trout, koi carp, hornwort and didymo, place pressures on our unique native species and ecosystems. Their spread can destabilise aquatic environments and threaten indigenous biodiversity (Baker et al, 2003; DOC, nd-b; MPI, nd-b; NIWA, 2020; Otago Regional Council, 2024; see *Our freshwater 2023*).

Contaminants from human activities on land can affect freshwater habitats and species.

- Poor water quality, low oxygen levels and warm temperatures can allow toxic concentrations of *Clostridium botulinum* bacteria to build up in freshwater bodies. This has led to botulism outbreaks that have killed hundreds of freshwater fish and birds, including native and threatened species (BirdCare Aotearoa, 2022; Kāpiti Coast District Council, 2024; MPI, 2023e; Waikato Regional Council, 2023).
- Heavy metals in high concentrations can be toxic to aquatic life. They can accumulate in sediments and living organisms (Boehler et al, 2017).
- Kākahi habitat decline has been attributed to river regulation, nutrient enrichment and other types of pollution (Phillips, 2007).

- Microplastics have been found to accumulate in freshwater organisms. These can cause impacts depending on their physical shape and size, age, density and chemical make-up (Ockenden et al, 2021, 2022; Zimmermann et al, 2020).

Excess sediment in waterways can degrade habitats and lead to a decline in native freshwater species

- Soil washed from the land can degrade freshwater both when it is suspended in the water and when it settles as sediment on a streambed (see indicators: Estimated long-term soil erosion: Data to 2022 and Deposited sediment in rivers; and *Our freshwater 2020*).
- Excess suspended sediment makes the water cloudy, blocking light and reducing the native freshwater plants that provide habitat for native species (NIWA, 2019b; Rowe, 2007; Schallenberg et al, 2013). It is directly harmful to freshwater fish, making it more difficult for them to breathe, feed and migrate (Collier et al, 2017).
- Excess deposited sediment smothers natural habitats on the bottom and banks of rivers and lakes – it fills in the spaces between rock and gravel that small fish and invertebrates use to hide and breed. It can also make their food harder to find (Burdon et al, 2013; Clapcott et al, 2011).

The condition of river and lake habitats is generally moderate to good, but some are degraded by contaminants from land, and invasive plants.

- Visual clarity is a measure of underwater visibility in rivers and streams. It indicates how much sediment is suspended in the water. Poorer clarity means there is more sediment, and more risk of harm to species. Clarity is an important indicator of ecosystem health, and of cultural stream health, which includes measures that incorporate Māori values (Galvan et al, 2024; MfE, 2006).
- Seventy-seven percent of the country's river length had modelled visual clarity values that indicated a minimal to moderate impact of suspended sediment on aquatic life (NOF bands A and B) between 2016 and 2020. Twenty-three percent of river length indicated a moderate to high impact (NOF bands C and D) (see indicator: River water quality: clarity and turbidity and Technical annex).
- The overall condition of river and stream habitat can be assessed based on 10 measured parameters including flow and habitat diversity, streambed sedimentation, bank erosion, bank vegetation and shade (Clapcott et al, 2019). Flow and habitat diversity, streambed sedimentation and bank vegetation are also some of the indicators used by some Māori to holistically assess the cultural health of rivers and streams (Galvan et al, 2024; MfE, 2006).
- Of the 459 river and stream monitoring sites assessed for habitat condition across seven regions between 2013/14 and 2018/19, 79 percent were good or excellent and 21 percent were fair (see indicator: Freshwater physical habitat).
- The submerged plant index is a measure of a lake's ecological health. It reflects the diversity and extent of native and invasive plant species that provide habitats and support ecosystem processes. Between 1991 and 2019, 36 percent of 295 monitored lakes were in poor ecological condition based on their plant communities or were entirely without submerged plants, and 34 percent were in excellent or high ecological condition. Eighty-eight percent of lakes with vegetation had some non-indigenous plant species present (see indicator: Lake submerged plant index).

Human changes to flows and water courses put pressure on freshwater habitats and native species

Structures for diverting or controlling water have altered and fragmented river habitats, placing pressure on fish and kōura migrations.

- Structures that divert or control water such as dams, weirs, culverts, fords, stop banks and floodgates alter river channels and flows, and the connections between waterways. These changes can reduce populations or prevent the migration and spawning of some species, affecting the range of species that rivers can support (Brierly et al, 2022; Franklin et al, 2018; Graynoth et al, 2008; Harding et al, 2009; see *Our freshwater 2023*).
- These changes can affect the cultural health of rivers and streams. Barriers and changes to flows place pressure on the migration of mahinga kai species such as whitebait (īnanga), eels (tuna) and freshwater crayfish (kōura) (McDowall, 2000). The re-routing of flows in the Tarawera River has greatly reduced environmental and cultural wellbeing (Hikuroa et al, 2018).
- A national assessment of river barriers estimates that a minimum of 48 percent of the river network is at least partially inaccessible to migratory fish, though a further 36 percent has not yet been assessed for barriers and could be inaccessible (Franklin et al, 2022).
- Confining waterways to well-defined channels sometimes concentrates flows, which can increase the erosion of riverbanks and the amount of sediment deposited downstream (Fuller et al, 2011; Maddock, 1999; see *Our freshwater 2020*).

Using water for hydropower and irrigation can change the timing and volume of freshwater flows.

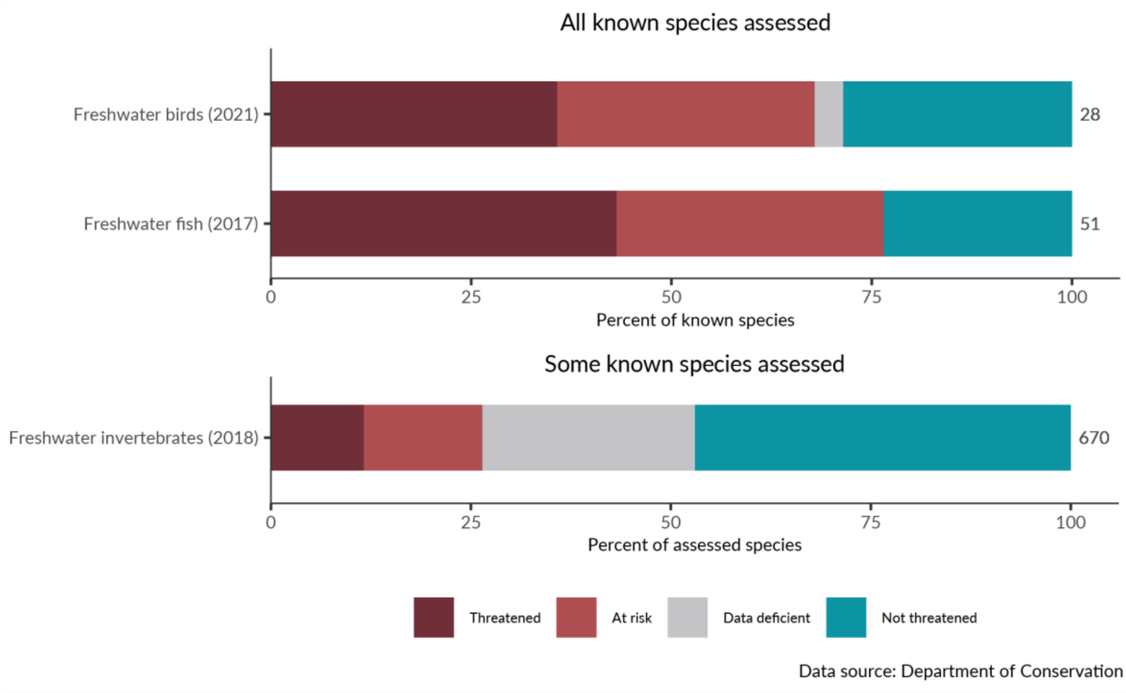
- Using and storing water for human activities can affect the natural variability of a river's flow – the volume of water, how fast it flows, how the flows vary seasonally and in response to precipitation, and the connections between waterways. Diverted or altered flows in one area can affect or alter the flows in connected water bodies, and the health of freshwater ecosystems (see *Our freshwater 2020*).
- About 440 billion cubic metres of freshwater flows in our rivers and streams every year (Collins et al, 2015). In the year ended June 2020, about 752 billion cubic metres were held in aquifers as groundwater (Stats NZ, 2021b).
- For the 2017/18 water reporting year, 13 billion cubic metres of surface water and groundwater was allocated for irrigation, drinking, industrial and other uses across the country. The largest share (58 percent) was allocated to irrigation (see indicator: Consented freshwater takes).
- Even when it only temporarily stores water, hydroelectric generation can affect the timing and volume of flows downstream of dams and diversions. Some hydro schemes divert flows from one river to another, or to the ocean, and are considered consumptive uses of water. The amount of water used by these consumptive schemes is significant in some regions (see *Our freshwater 2020*).

Indigenous freshwater species are under threat

Many indigenous freshwater species are threatened with extinction or at risk of becoming threatened.

- In 2017, 76 percent of indigenous freshwater fish species (39 of 51) were threatened with extinction or at risk of becoming threatened, including seven identified as treasured (taonga) (figure 4). Estimated population trends show 63 percent of species have decreasing populations and 2 percent have increasing populations (see indicator: Extinction threat to indigenous species).
- In 2021, 68 percent of indigenous freshwater-dependent bird species (19 of 28) were threatened with extinction or at risk of becoming threatened (figure 4). A number of these are also considered to be taonga species (Keane-Tuala, 2015; Taura et al, 2017; Te Manahuna Aoraki Project, 2022; see *Our freshwater 2023*). Estimated population trends show 29 percent of species have increasing populations and 25 percent decreasing (see indicator: Extinction threat to indigenous species).
- In 2017, 39 percent of indigenous freshwater plant species (71 of 180) were threatened with extinction or at risk of becoming threatened (figure 4). Estimated population trends show 20 percent of species have decreasing populations and 77 percent have stable populations (see indicator: Extinction threat to indigenous species).
- In 2018, 26 percent of assessed indigenous freshwater invertebrates (177 of 670) were threatened with extinction or at risk of becoming threatened, including three identified as taonga (figure 4). Estimated population trends show 3 percent of assessed species have decreasing populations and no species has an increasing population (see indicator: Extinction threat to indigenous species and Technical annex).
- In 2023, 43 percent of indigenous freshwater plant species (77 of 180) were threatened with extinction or at risk of becoming threatened. Estimated population trends show 21 percent of species have decreasing populations and 77 percent have stable populations (de Lange et al, 2024; see Technical annex).

Figure 4: Extinction threat status of indigenous freshwater species[5]



Note: Totals given for species on the right of this figure show the total number of species assessed. Complete assessments are those where all known species in the group have been assessed. Partial assessments are those where not all species in the group have been assessed (see indicator: Extinction threat to indigenous species).

5 Note that extinction threat information updated since the Extinction threat to indigenous species indicator update in 2023 has been included in the text and is based on New Zealand Threat Classification System data downloads (see Technical annex; NZTCS, 2025). Figure is based only on information available in the indicator (see indicator: Extinction threat to indigenous species).

4. Marine

Introduction

Aotearoa New Zealand's marine environment plays a key role in our national identity. It supports unique habitats and species, and contributes to our quality of life and economy. For many Māori, the ability to gather seafood (kai moana) is an important indicator of the health of the ocean and enables traditional food-gathering practices (mahinga kai) (see *Environment Aotearoa 2022*).

The marine environment faces significant pressures from human activities, both on land and at sea, and from climate change. Land management practices that affect freshwater through sediment and nutrient run-off also affect our coasts and oceans. Fishing adds to these pressures, and climate change is altering the ocean in different ways. Although some pressures have decreased in recent years, others are increasing. Many marine species are still threatened with extinction, in part because their habitats are shrinking or being damaged.

This section looks at three interconnected issues affecting **coastal and marine ecosystem health**: the effects of land-based activities on water quality and marine ecosystems, the impacts of fishing practices, and the consequences of climate change for the oceans.

It then examines the impacts on **indigenous marine species and habitats**.

For the wider effects, see section 7: Impacts on people, society and the economy.

New and updated marine indicators and evidence since *Environment Aotearoa 2022*

Updates to coastal and estuarine water quality and primary productivity indicators

More coastal and estuarine water quality monitoring sites reported improving trends than worsening ones between 2006 and 2020. This included all nutrient forms (nitrogen and phosphorus) and some sedimentation measures (suspended solids, turbidity).

Most coastal regions saw increasing primary productivity trends between 1998 and 2022, while oceanic regions showed mixed trends, with both increases and decreases in primary productivity.

(See Land-based activities affect water quality and primary productivity.)

New data for fish stocks, bycatch of protected species, and bottom trawling

Most of the fish stocks in the 2023 update to the Fisheries New Zealand Quota Management System were assessed to be fished within safe limits, while 12 percent were assessed to be overfished or depleted. The latest national survey of recreational fishers reported a decrease in recreational fisheries between 2017/18 and 2022/23, particularly in the north of New Zealand.

The latest update to bycatch data shows that it continues to place pressure on marine protected species.

Two new assessments from the Ministry for Primary Industries on the extent and intensity of bottom trawling showed a decline over time for deepwater and inshore fisheries. Most seamounts and high-productivity areas are either closed to trawling or have never been trawled, while 13 percent of seamounts were trawled at least once in recent decades.

(See Commercial activity in the marine environment affects ecosystems and biodiversity.)

Updates to sea-surface temperature indicator and new data for marine heatwaves

Average sea-surface temperatures have risen across New Zealand's four oceanic regions between 1982 and 2023, with their warmest years recorded in either 2022 or 2023.

New evidence shows that marine heatwaves have become more frequent, more intense and longer lasting in some parts of the ocean around the country. These trends are expected to continue.

The 2022 update to national sea-level rise projections from the NZ SeaRise Programme indicated that areas in New Zealand experiencing ongoing downward land movement, may face faster relative sea-level rise than previously reported.

(See Climate change and our marine environment.)

Updated national assessment of extinction risk for indigenous marine invertebrates

An updated assessment by the Department of Conservation shows more than half of our indigenous marine invertebrate species remain threatened with extinction, or at risk of becoming threatened.

(See Marine habitats and native species.)

Coastal and marine ecosystem health

This part looks at three interconnected issues affecting the health of our coasts and oceans: water quality, fishing and climate change.

Certain land-use and management practices accelerate sediment build-up and nutrient run-off, affecting water quality in marine environments. Although water quality has improved in terms of nutrients in some estuarine and coastal areas, sedimentation is worsening in many places. Plastic waste, which can end up as litter (see section 2: Land), is accumulating in the ocean and along the coasts. Although fishing pressures have decreased, overfishing, bycatch and trawling continue to deplete some fish stocks, harm protected species and damage the seabed. Climate change exacerbates these issues by driving ocean warming, acidification and sea-level rise. These changes disrupt marine species and ecosystems, and increase their vulnerability to invasive species and human disturbance.

Land-based activities affect water quality and primary productivity

Changing sediment levels in coastal and estuarine areas can cause ecological effects.

- New Zealand has naturally high rates of soil loss, with the amount of sediment entering waterways varying regionally. Land use, including agriculture and forestry, can increase the sediment in rivers, as well as downstream in estuaries and coastal waters (Marden et al, 2022, 2023; Phillips et al, 2017; PMCSA, 2021). Increased frequency and severity of extreme weather events are likely to exacerbate soil loss and downstream sediment (see section 2: Land and section 3: Freshwater).
- Between 2006 and 2020, more coastal and estuarine sites had improving trends than worsening for suspended solids (66 of 84) and turbidity, a measure of how cloudy the water is (54 of 87). Monitoring sites were not distributed evenly around the coastline, and were often clustered around urban centres (see indicator: Coastal and estuarine water quality and Technical annex).
- Sediment accumulation rates in estuaries increased by orders of magnitude after European settlement. Sedimentation has continued in some estuaries over the last 20 years, at variable rates due to factors such as the structure of each estuary, and past catchment disturbances (Jones et al, 2022).
- Excess suspended and deposited sediment in estuaries and coastal areas can reduce and alter habitats, smother sensitive species and affect the gills of some species. Fine suspended sediment can clog the gills of filter feeders such as cockles, pipi and scallops (Booth, 2020; Lowe et al, 2015; Morrison et al, 2009; O’Meara et al, 2017; PMCSA, 2021; Thrush et al, 2021).

Excess nutrients from dairy farming and horticulture can affect coastal and estuarine ecosystems.

- Nutrients such as nitrogen and phosphorus occur naturally in estuaries and coastal waters. However, land activities such as dairy farming and horticulture can lead to elevated nutrient levels (see section 2: Land). Excess nutrients that reach estuaries often have delayed effects, which can vary between different parts of an estuary (Lohrer et al, 2023).
- Excess nutrients in estuaries can cause eutrophication, which is an overload of nutrients that produces algal blooms and depletes oxygen levels. This can be harmful to plants, animals and people (Dudley et al, 2020; Plew et al, 2020; Salmond & Wing, 2022; Snelder et al, 2020).
- For nitrogen and phosphorus, more coastal and estuarine sites had improving trends than worsening between 2006 and 2020 (see indicator: Coastal and estuarine water quality).
- Land activities also cause pathogens such as faecal bacteria to enter rivers, lakes, estuaries and coastal waters. These bacteria come from animal excrement, wastewater discharges and contaminated soil run-off, and can harm ecosystems and people (LAWA, 2021; see section 3: Freshwater and section 7: Impacts on people, society and the economy).
- Faecal coliforms are monitored as an indicator of the presence of disease-causing bacteria in waters. Between 2006 and 2020, faecal coliform levels were improving at 50 percent of coastal and estuarine monitoring sites (25 of 50) and worsening at 24 percent (12 of 50) (see indicator: Coastal and estuarine water quality).

Primary productivity is increasing in coastal regions.

- Marine primary productivity describes the growth of phytoplankton in coastal and ocean waters, which provides the energy that supports most marine food webs. It is affected by nutrients, water temperature and the availability of light (see indicator: Marine primary productivity: Data to 2023).
- Areas of high primary productivity support productive marine ecosystems, including various commercial shellfish and finfish fisheries (MPI, 2021a). However, high primary productivity in estuarine and coastal waters can indicate the presence of harmful algal blooms due to excess nutrients from land (Gall & Pinkerton, 2024; Pinkerton et al, 2023; Roberts & Hendriks, 2022).
- Primary productivity is monitored by measuring chlorophyll-a, an indicator of phytoplankton abundance. Phytoplankton monitoring between 1998 and 2022 indicates that primary productivity very likely increased in most coastal regions, at average rates ranging from 5 to 13 percent per decade.
- The oceanic regions showed increasing and decreasing trends in chlorophyll-a concentrations (see indicator: Marine primary productivity: Data to 2023 and Technical annex).

Plastics continue to accumulate throughout the marine environment and affect marine species, including seabirds.

- Plastic waste can stay in the environment for centuries, and is a major problem affecting the land, freshwater and marine environments (PMCSA, 2019; see section 2: Land and section 3: Freshwater).
- In 2023, most of the items (67 percent) counted on beaches in Litter Intelligence surveys were plastic (Litter Intelligence, nd). Some hazardous additives in plastic have also been detected in plastic debris on our beaches (Bridson et al, 2024).
- Marine species and seabirds are at risk from eating or getting tangled in plastics, which can cause injury or death (Buxton et al, 2013; Clark et al, 2023; PMCSA, 2019).
- Microplastics (less than 5 millimetres long), which result from the breakdown of larger plastics, are widespread throughout the marine environment (Asher, 2023; De Bhowmick et al, 2021; Li et al, 2024; PMCSA, 2019). They typically occur in greater quantities near urban centres (Munsterman et al, 2024).
- Microplastics and the chemicals they release accumulate in animals as they move up food chains, harming marine species, and could pose risks to human health (PMCSA, 2019). They have been found in many of New Zealand's fish species that are eaten by humans, and in green-lipped mussels (Clere et al, 2022; Mazlan et al, 2022). Understanding the effects of microplastics on ecosystems and human health is a growing area of research (Asher, 2023; De Bhowmick et al, 2021; Li et al, 2024; PMCSA, 2019).

Commercial activity in the marine environment affects ecosystems and biodiversity

- While pressures from commercial and recreational fishing have reduced and most is within safe limits, some fish stocks continue to be overfished. Commercial fishing methods in New Zealand include bottom trawling, dredging, longlining and set netting. Bottom trawling is the most common (MPI, 2023f; see *Our marine environment 2022*).

- In 2023, 88 percent of fish stocks in the New Zealand Fish Quota Management System (133 of 152 stocks) were assessed to be fished within safe limits, with 82 percent at or above their management goals (MPI, 2024b).
- However, 12 percent of stocks (19 of 152) were overfished or depleted in 2023, including some stock of black cardinalfish, orange roughy and scallops. Five stocks had collapsed, indicating fishery closures should be considered to rebuild the stock quickly (MPI, 2024b).
- The total estimated catch from recreational fishing in 2022/23 was 3.7 million fish and 1.6 million shellfish. Snapper, kahawai, blue cod and red gurnard together made up 80 percent of all fish harvested by recreational fishers (MPI, 2024c).
- Recreational fisheries declined between 2017/18 and 2022/23, particularly in the north of New Zealand. Contributing factors include extreme weather events in 2023, prolonged La Niña conditions and changes in fishing habits (MPI, 2024c).

Bycatch continues to contribute to population decline and extinction risk of some protected species.

- Bycatch is the unintended capture during fishing of non-target species, including protected ones. Removing or killing important species through bycatch threatens biodiversity and puts pressure on marine ecosystems (MPI, 2021b, 2024c).
- Since 2019/20, Hector's dolphin deaths due to commercial bycatch have ranged from 0 to 5 per year, except in 2023/24, when 15 deaths were reported. All 15 deaths in 2023/24 were reported on the east coast of the South Island, where an estimated 9,728 (61 percent) of the total estimated 15,847 Hector's dolphins reside (DOC, 2024a; MPI, 2019a).
- Other marine mammals, large numbers of seabirds and some protected corals are also caught as commercial bycatch. For example, models estimated 3,613 seabirds and 476 fur seals were bycaught in trawling and longline fisheries in 2020/21 (Protected species bycatch, nd). In the 2021/22 fishing year, 2,073 kilograms of protected coral were reported as bycaught (McGovern, 2024).
- Between 2 and 34 captures of protected sea turtles were reported each year between 2007/08 and 2019/20, and 58 were reported in 2020/21 (including 50 leatherback turtles). This reporting includes reports by fishery observers and self-reporting by commercial fishers (Dunn et al, 2022).

The area trawled each year has been declining, but trawling still affects the seafloor and the animals that live there.

- Commercial fish trawling and dredging have lasting impacts on the seabed and its habitats. These include altering seabed structure, damaging habitats, re-suspending sediment, removing species from food webs and disrupting marine populations (Clark et al, 2019, 2022a; MPI, 2023f).
- Between 1990 and 2021, about 11 percent of the exclusive economic zone and territorial seas were trawled. The area trawled each year has been declining over time and was 74,500 square kilometres in 2021 (MPI, 2023f). Methods have also improved in recent years to reduce contact with the seabed, in both deepwater and inshore fisheries (MacGibbon et al, 2024).

- Seamounts, knolls and hills are underwater areas of high productivity and biodiversity that are targeted by some deepwater fisheries (Clark et al, 2019, 2022b). Seamount recovery from trawling is slow: it took about two decades for the first signs of potential benthic (seafloor) community recovery to appear after trawling ceased on the Graveyard Knolls of the Chatham Rise (Clark et al, 2022a).
- Thirteen percent of seamounts, knolls and hills in New Zealand's exclusive economic zone and territorial seas were trawled at least once between 1989 and 2019 (Clark et al, 2022b).

Aquaculture is a growing sector with positive and negative effects on marine ecosystems.

- The growing aquaculture industry, which includes species like green-lipped mussels, Chinook salmon and Pacific oysters, can have both positive and negative impacts on marine ecosystems (Howarth & Major, 2023; MPI, 2013).
- Mussel farming, for example, can support seafloor communities and some wild fish. However, it can lead to local enrichment of the seabed, and alters the composition of sediments (Howarth & Major, 2023; Underwood et al, 2023). Farm infrastructure can disrupt currents, damage the seabed, shade the seafloor and pose entanglement risks to wildlife (Howarth & Major, 2023; MPI, 2013).

Climate change and our marine environment

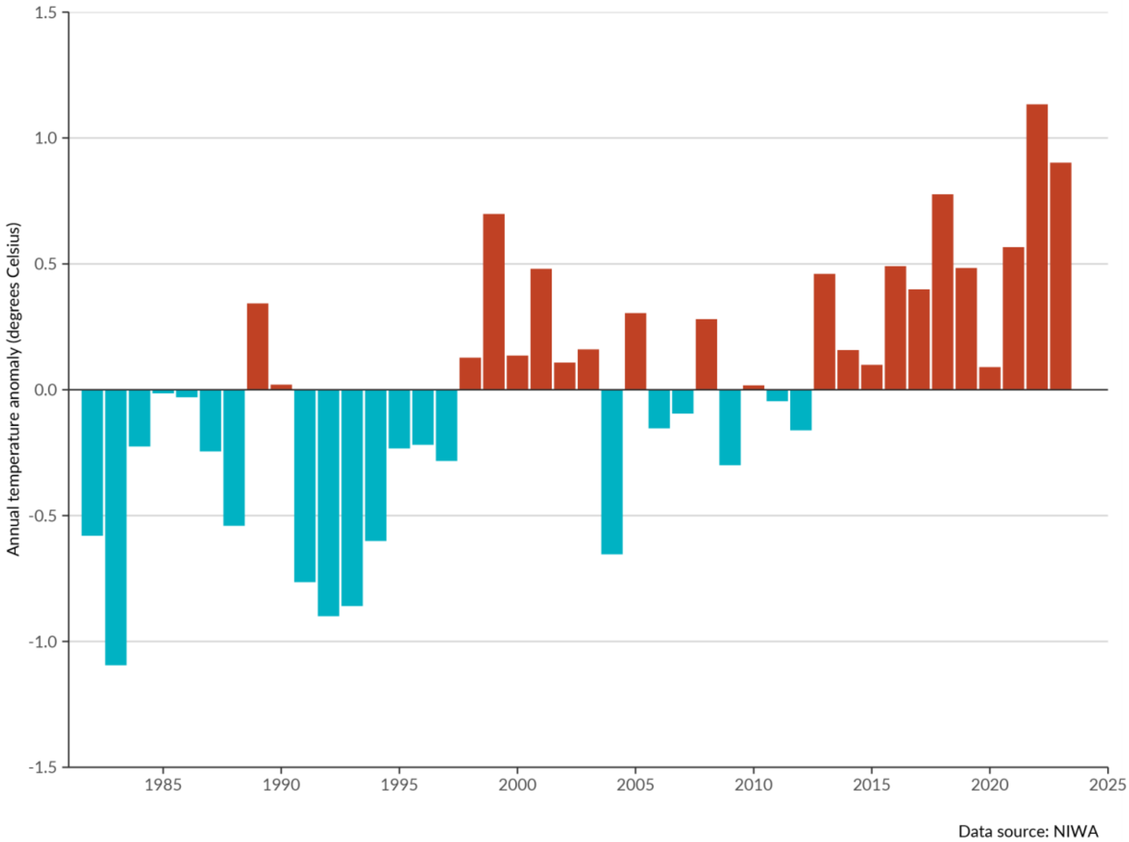
The ocean is becoming warmer and more acidic due to climate change, with impacts on marine ecosystems.

- Global oceans have captured nearly 25 percent of total human carbon emissions since industrialisation (Friedlingstein et al, 2020). This is making the ocean more acidic. Surface ocean acidity is estimated to have increased by almost 30 percent from 1750 to 2000 (Jiang et al, 2023). Acidity increased 8.6 percent in subantarctic surface water off the coast of Otago between 1998 and 2020 (see indicator: Ocean acidification).
- Oceans have also captured 90 percent of the excess heat from greenhouse gas emissions, increasing the ocean temperatures (Venegas et al, 2023).
- Between 1982 and 2023, sea-surface temperature in the country's oceanic regions increased an average of 0.16 to 0.26 degrees Celsius per decade, and in coastal regions an average of 0.19 to 0.34 degrees per decade (figure 5) (see indicator: Sea-surface temperature: Data to 2023).
- Marine heatwaves have become more frequent, intense and longer-lasting, including in New Zealand (Montie et al, 2024; Sun et al, 2023). In 2022, New Zealand experienced a record number of marine heatwave days, and the two longest and most intense marine heatwaves on record in some locations (Salinger et al, 2023; Shears et al, 2024). These trends are expected to continue (Behrens et al, 2022; Bodeker et al, 2022; Sun et al, 2023).
- Marine heatwaves have caused declines and local extinctions of some populations of ocean species. Warmer sea-surface temperatures and ocean acidification alter habitats, and affect the food supply and the growth and life cycles of native marine species, including treasured (taonga) species. This intensifies other pressures such as invasive species and human disturbances (see section 6: Atmosphere and climate).

Warmer seas are accelerating sea-level rise.

- Increasing ocean temperatures cause the water to expand (Venegas et al, 2023). Combined with melting glaciers and ice sheets, this contributes to sea-level rise (Lindsey & Dahlman, 2023; Venegas et al, 2023). Global mean sea level has risen 21–24 centimetres since 1880, and is projected to rise to 0.3–1.0 metres above 2000 levels by 2100 under a low emissions scenario (Grandey et al, 2024; Lindsey, 2023).
- Annual mean coastal sea levels rose faster (relative to land) at four longer-term monitoring sites around New Zealand between 1961 and 2020 when compared with 1901–60. This rate is accelerating – the mean rate of rise between 1961 and 2020 was double that between 1901 and 1960 at three of the four sites (see indicator: Coastal sea-level rise).
- In New Zealand, sea levels relative to land are rising faster in some areas due to downwards land movement. Sea level in those areas is expected to rise 20 to 30 centimetres by 2050 compared with 2005 levels. For many parts of the country, a 30-centimetre rise is a threshold for extreme flooding, above which a 100-year coastal storm becomes an annual event (MfE, 2024g; NZ SeaRise, nd) (see section 7: Impacts on people, society and the economy).

Figure 5: Coastal sea-surface temperature annual average anomaly, 1982–2023



Note: The baseline for anomalies is the average sea-surface temperature from 1991 to 2020, following World Meteorological Organization guidelines (WMO, 2017). This national average is aggregated from nine regional measurements (see indicator: Sea-surface temperature: Data to 2023).

Marine habitats and native species

Our marine environment is made up of diverse habitats. These include estuaries, rocky reefs and shores, fiords and seamounts, and open and deep-water habitats. Knowledge of marine habitats and their distribution is limited in New Zealand (Anderson et al, 2019; Lundquist et al, 2024).

These habitats support a large number of native animals and plants, many of them threatened or at risk of becoming threatened with extinction. The spread of non-native species can also contribute to the decline of native species and changes to habitats.

The effects of climate change are intensifying many of the pressures on marine ecosystems; these are discussed in section 6: Atmosphere and climate.

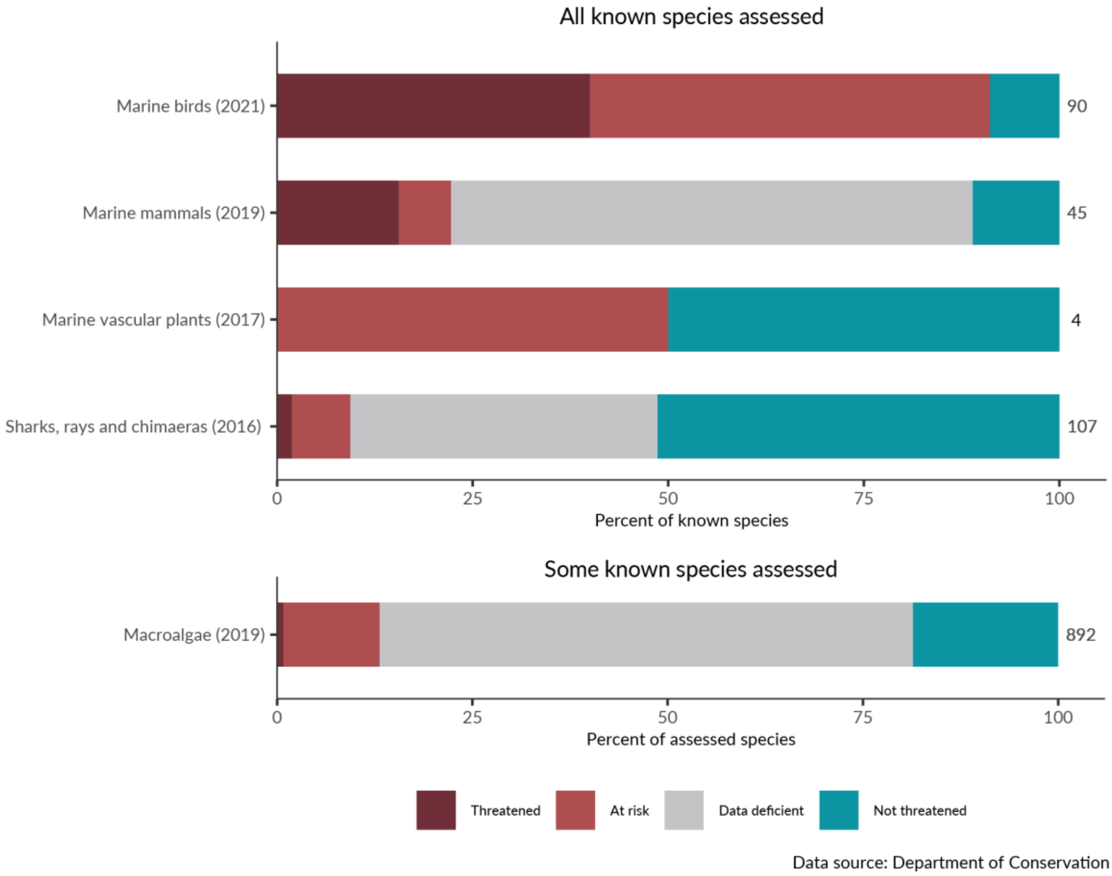
Our indigenous marine species and habitats are under threat

Most indigenous marine bird species are threatened with extinction or at risk of becoming threatened; however, most are estimated to have stable or increasing populations

- In 2021, 91 percent of indigenous marine bird species (82 of 90) were threatened with extinction or at risk of becoming threatened, including 16 species identified as treasured (taonga) (figure 6). Estimated population trends show 27 percent of species have decreasing populations, 18 percent increasing, 12 percent stable or increasing, and 43 percent stable (see indicator: Extinction threat to indigenous species).
- In 2019, 22 percent of indigenous marine mammal species (10 of 49) were threatened with extinction or at risk of becoming threatened, including seven species identified as taonga (figure 6). Estimated population trends show 13 percent of species have decreasing populations and 2 percent have increasing populations (see indicator: Extinction threat to indigenous species).
- In 2016, 9 percent of shark, ray and chimaera species (10 of 107) were threatened with extinction or at risk of becoming threatened, including one species identified as taonga (figure 6). Estimated population trends show 2 percent of species have increasing populations and 1 percent have decreasing populations (see indicator: Extinction threat to indigenous species and Technical annex).
- In 2021, 56 percent of assessed indigenous marine invertebrate species (443 of 786) were threatened with extinction or at risk of becoming threatened. Estimated population trends show 5 percent of assessed species have decreasing populations, 66 percent stable, and one species increasing[6] (Funnel et al, 2024; see Technical annex).

[6] Note that only some known species of marine invertebrates have been assessed for extinction threat status and estimated population trends.

Figure 6: Extinction threat to indigenous marine species[7]



Note: Totals given on the right of this figure show the total number of species assessed. Complete assessments are those where all known species in the group have been assessed. Partial assessments are those where not all species in the group have been assessed.

More non-native species are in our marine waters and are spreading to new locations.

- Non-native marine species are being introduced continually, usually carried by ballast water or on the hulls of shipping and recreational vessels (see indicator: Marine non-indigenous species: Data to 2022; Davis & Hepburn, 2020). Several biosecurity measures are in place to prevent non-native species from entering New Zealand and to detect, remove or control these species early (Marine Biosecurity Porthole, nd; MPI, nd-c).
- Non-native marine species can spread quickly and compete with native species. This can result in the decline of native species and changes to habitat. There is also a risk that pathogens could be introduced that may threaten native species, aquaculture or human health (Lane et al, 2022; see *Our marine environment 2022*).
- As of 2022, a total of 428 non-native marine species had been found in marine waters around New Zealand; 266 (62 percent) have established populations here. Seventy-three new non-native species were found between 2010 and 2022, 44 of which have become established (see indicator: Marine non-indigenous species: Data to 2022).

[7] Note that extinction threat information updated since the Extinction threat to indigenous species indicator update in 2023 has been included in the text and is based on New Zealand Threat Classification System data downloads (see Technical annex; NZTCS, 2025). Figure is based only on information available in the indicator (see indicator: Extinction threat to indigenous species).

- In 2021, two exotic sea mustard species, *Caulerpa brachypus* and *Caulerpa parvifolia*, were discovered on Aotea Great Barrier Island (see indicator: Marine non-indigenous species: Data to 2022). By August 2024 they had spread to over 1,500 hectares of the upper North Island seabed, competing with other species, disrupting local ecosystems and posing risks to recreational, cultural and commercial marine activities (MPI, 2024d).

Few biogenic and coastal ecosystems are monitored, but data suggest they are experiencing loss or damage.

- Biogenic habitats are those formed by plants and animals. They support biodiversity, stabilise sediments, recycle nutrients, and have cultural, recreational and economic value. Examples include kelp forests, seagrass meadows and sponge gardens (Anderson et al, 2019).
- Few biogenic habitats are monitored in New Zealand, but most that are have experienced loss or damage (Anderson et al, 2019; Bennion et al, 2024; Morrison et al, 2014).
- Mangrove forests are one of the few biogenic habitats that have increased in extent (Anderson et al, 2019; Jones et al, 2022; Morrison et al, 2014). Seagrass meadows are also showing sign of recovery in some locations in recent decades (Lundquist et al, 2018).
- Native vegetation, wetlands and dunes on and near the coast help protect coastal ecosystems from excess sedimentation, nutrient pollution and sea-level rise, among other benefits (Allan et al, 2023; Thompson, 2022).
- Between 1950 and 2008, active sand dune extent decreased 80 percent (see indicator: Active sand dune extent). Remaining active dunes are increasingly threatened by introduced marram grass (*Ammophila arenaria*). This, coupled with grazing, land development and erosion, degrades the integrity and function of dune ecosystems (Thompson, 2022; see *Our land 2024*).

5. Air

Introduction

The air we breathe plays an important role in our health and our quality of life. Although we cannot see the air, we can see its impacts on people and the environment.

Air and light link all components of Earth, and reflect cultural connections to the environment (te taiao). In the Māori language (te reo Māori), the word hau can mean air or wind, and can also refer to the vital essence or vitality of a person, place or object. The origins of these words recognise that our health (hauora) and the health of the air (hau takiwā) are interlinked. The clarity of the air and visibility of the night sky are important for many Māori cultural practices.

This section looks at two key issues. The first relates to **air quality** and the sources of air pollution. In Aotearoa New Zealand, air quality is generally good compared with many other countries, largely due to prevailing winds. However, increasing urbanisation can mean that more people are at risk of exposure to polluted air.

The second key issue in this section is **artificial light** and its effects on the environment. Artificial light at night is increasing in both extent and brightness, with potential impacts on native species.

Air pollution and artificial light also have wider consequences – see section 7: Impacts on people, society and the economy.

New and updated air indicators and evidence since *Environment Aotearoa 2022*

Updates to air quality indicators

Concentrations of the air pollutants particulate matter (PM_{10} and $PM_{2.5}$), nitrogen dioxide, and sulphur dioxide continue to decrease at most monitoring sites. However, many sites still exceed World Health Organization (WHO) guidelines at times.

No monitoring sites exceeded WHO guidelines for the air pollutants ground-level ozone and carbon monoxide.

(See Air quality is improving, but pollutant levels in some areas could pose risks to human health.)

Updated data for road vehicles and reductions in transport emissions

Although the air pollutant emission factor has not been updated, new evidence shows that motor vehicle engine and fuel improvements continue to reduce air pollutant emissions from transport. This is despite increases in the total number of kilometres travelled in a year, the size of our vehicle fleet, and the proportion of our vehicles with diesel engines (which has been growing steadily). However, the number of electric vehicles (battery electric and plug-in hybrid) has grown, nearly doubling from 2022 to 2024.

(See Transport is a major source of air pollutants, including sulphur dioxide, carbon monoxide and nitrogen oxides.)

Updates to home heating data

New data show that burning wood and coal for home heating (which is a major source of particulate matter emissions) continues to decline in favour of heat pumps and electric heaters. However, although coal burning is now very rare, about one-third of homes still rely on burning wood or pellets.

(See Burning wood for home heating is a major source of $PM_{2.5}$.)

Air quality

Air quality standards in New Zealand require monitoring of four gas pollutants: nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO) and ground-level ozone (O_3) (LAWA, 2023b).

Particulate matter (PM) is another form of monitored air pollution. PM is tiny solid particles and liquid droplets suspended in the air. It can include substances such as heavy metals and microplastics (Fan et al, 2022; Semadeni-Davies et al, 2021).

This subsection compares air quality measures to national standards (NESAQ) and international guidelines (WHO), to understand the risks to human health (for details on standards, see Technical annex).

Most of the monitoring network is in urban areas where we expect pollution to be highest and where people are more exposed. As a result, we know little about air pollution in less populated areas, or its effects on native species and ecosystems.

This subsection also reports on air pollutants that have direct impacts on human health. It does not cover greenhouse gas emissions (for this information, see section 6: Atmosphere and climate).

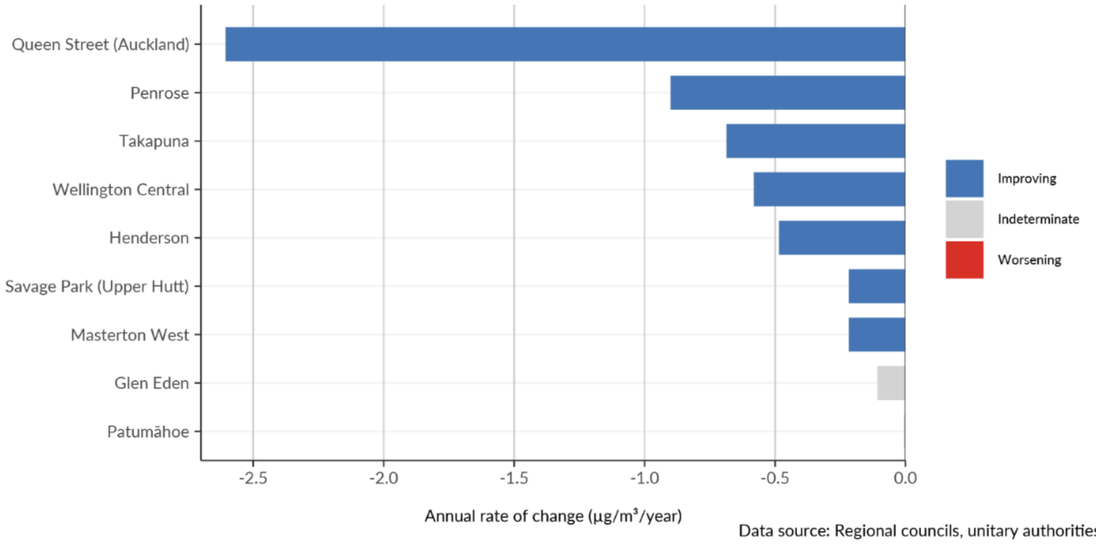
Air quality is improving, but pollutant levels in some areas could pose risks to human health

Gas pollutants are decreasing in most places where they are monitored, but NO_2 and SO_2 concentrations exceed guidelines in some areas.

- Trends in annual average NO_2 concentrations were improving at 99 of 114 sites (87 percent) in the New Zealand Transport Agency | Waka Kotahi monitoring network between 2014 and 2023. No sites showed worsening. Trends in NO_2 concentrations were improving at seven of the nine regional council and unitary authority sites between 2016 and 2023, and no trend was detected at the other two (figure 7).
- Concentrations of NO_2 were above the 24-hour WHO guideline at 6 of 10 sites (60 percent) between 2020 and 2023. Five of 10 sites were above the annual WHO guideline at least once during the same period and one site was above the one-hour NESAQ standard (see indicator: Nitrogen dioxide concentrations: Data to 2023 and Technical annex).
- Between 2016 and 2023, trends in annual average SO_2 concentrations were improving at three of four sites, and no trend was detected for the other site.

- Concentrations of SO_2 were above the 24-hour WHO guideline at two sites between 2020 and 2023. No sites exceeded the one-hour NESAQ standard (see indicator: Sulphur dioxide concentrations: Data to 2023).
- Between 2016 and 2023, trends in annual average ground-level ozone concentrations were improving at Patumāhoe (Auckland) and worsening at Wellington Central. Both sites were within WHO guidelines between 2020 and 2023 (see indicator: Ground-level ozone concentrations: Data to 2023).
- Between 2016 and 2023, trends in annual average CO concentrations were improving at one of the three sites in the Greater Wellington region where trends could be assessed, and no trends were detected for the other two. All four sites across the Auckland and Greater Wellington regions were within the WHO guidelines between 2020 and 2023 (see indicator: Carbon monoxide concentrations: Data to 2023).

Figure 7: Nitrogen dioxide trends by monitoring site, 2016–23



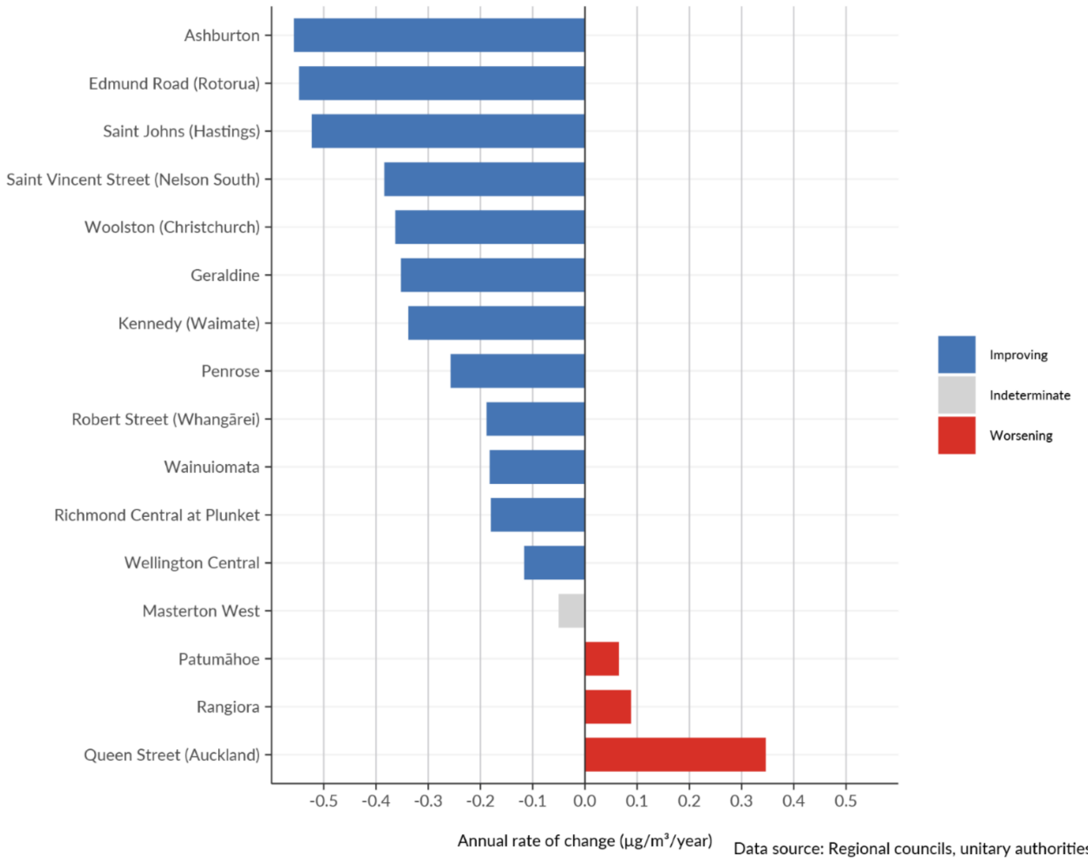
Data source: Regional councils, unitary authorities

Particulate matter is decreasing in most places where it is monitored, but concentrations exceed health guidelines in some areas.

- Air quality monitoring in New Zealand focuses on two categories of PM. PM_{10} refers to airborne particles that are less than 10 micrometres in diameter. $PM_{2.5}$ is fine particulate matter, a subset of PM_{10}, referring to airborne particles less than 2.5 micrometres in diameter (LAWA, 2023b).
- Between 2016 and 2023, trends in annual average PM_{10} concentrations were improving at 30 of 41 sites where trends could be assessed (73 percent) and worsening at 4 (10 percent).
- Concentrations of PM_{10} exceeded the 24-hour NESAQ standard at 19 of 58 assessed sites (33 percent) on two or more days between 2020 and 2023. Thirty-eight sites (66 percent) were above the 24-hour WHO guideline on at least one day per year during the same period. Twenty-seven sites (47 percent) were above the annual WHO guideline in at least one of those years (see indicator: PM_{10} concentrations (air quality): Data to 2023).
- Between 2016 and 2023, trends in annual average $PM_{2.5}$ concentrations were improving at 12 of 16 sites where trends could be assessed (75 percent) and worsening at 3 (19 percent) (figure 8).

- Concentrations of $PM_{2.5}$ were above the 24-hour WHO guideline at all 31 assessed sites at least once per year between 2020 and 2023. Twenty-eight sites (90 percent) were above the annual WHO guideline for at least one year during the same period, and 18 were above it every year from 2020 to 2023 (see indicator: $PM_{2.5}$ concentrations (air quality): Data to 2023).

Figure 8: $PM_{2.5}$ trends by monitoring site, 2016–23



Data source: Regional councils, unitary authorities

Air pollution emissions are reducing, but transport and home heating are still the main contributors

Transport is a major source of air pollutants, including sulphur dioxide, carbon monoxide and nitrogen oxides.

- Air pollutant emissions from transport (including road, aviation, shipping and rail) were lower in 2019 than in 2012 for all monitored pollutants except SO_2. Emissions of CO were down 47 percent (over 85,000 tonnes). Nitrogen oxides (NO_2 and nitric oxide [NO]) were down 12 percent (over 8,000 tonnes) (see indicator: Air pollutant emissions).
- Road vehicles were the largest source of nitrogen oxides (39 percent) in 2019, with the greatest contribution coming from diesel vehicles (see indicator: Air pollutant emissions). Vehicle fuel combustion, particularly diesel, is also a significant source of $PM_{2.5}$. Wear of brake pads and tyres, and road surface dust, are major sources of PM_{10} (LAWA, 2023b; Semadeni-Davies et al, 2021).
- Vehicle ownership per person in New Zealand is among the highest in the world. In 2022, we reached the largest fleet size to date, and the largest percentage of diesel vehicles (21 percent) (EHINZ, 2023; MOT, nd-a). The total number of vehicle kilometres travelled in a year has also increased over recent decades (MOT, nd-a, 2022).

- However, emissions of air pollutants from motor vehicle exhaust are reducing due to stronger vehicle emissions standards, increased uptake of lower-emissions vehicles and improvements in engine technology and fuel quality. This trend is expected to continue (Boamponsem et al, 2024; Metcalfe & Kuschel, 2022; NZTA, 2023).
- Domestic shipping is a significant source of SO_2 (contributing 16 percent of all SO_2 emissions in 2019), although an international treaty now limits the level of sulphur in ship fuel (MOT, nd-b; see indicator: Air pollutant emissions).

Burning wood for home heating is a major source of $PM_{2.5}$

- The residential energy sector accounted for 30 percent of $PM_{2.5}$ and 41 percent of CO emissions in 2019, mainly from wood burning for home heating (see indicator: Air pollutant emissions).
- Heat pumps and electric heaters were the most common types of heating used in houses in 2023. Over time, a smaller proportion of homes have been burning wood and coal, but almost one-third relied on wood or pellet burners in 2023. Less than 1 percent of houses used coal burners (EHINZ, 2020; Stats NZ, nd).

Air pollution comes from various human activities, as well as natural sources and climatic conditions

Other contributors to air pollution emissions include agriculture, construction, industry and other human activities.

- Agricultural activities emit PM, including through tillage, burning vegetation, crop harvesting, applying fertiliser and livestock waste (Metcalfe et al, 2022; Parfitt et al, 2012; see *Our air 2018*).
- Construction also emits air pollutants, including PM and nitrogen oxides (Cheriyan & Choi, 2020; Kunak, 2023; Yan et al, 2023).
- Dust from unsealed roads was the largest source of PM_{10} (28 percent) in 2019. Less than 10 percent of this was $PM_{2.5}$ (see indicator: Air pollutant emissions).
- Burning coal was a major source of SO_2 emissions in 2019 (41 percent), mainly from manufacturing, construction, and public electricity generation and heat production. Aluminium production was another significant source (13 percent) (see indicator: Air pollutant emissions).
- Air pollutant emissions from public electricity generation and heat production were lower in 2019 than in 2012 for all pollutants. Sulphur dioxide emissions were down 40 percent, due to lower emissions from coal burning (see indicator: Air pollutant emissions).

Particulate matter can come from natural sources and is influenced by climate, including wind patterns.

- Particulate matter can come from natural sources, including the oceans and volcanoes. Sea salt is the largest natural source of particulate matter in urban areas of New Zealand (Boamponsem et al, 2024; Davy et al, 2024; Revell et al, 2024).
- Climate conditions influence the amount and types of PM and gases in the air. Stable weather allows pollutants to accumulate, while wind and rain can disperse them (Talbot, 2019; UCAR Center for Science Education, nd; Waikato Regional Council, nd). The weather and climate can also be directly influenced by PM (see section 6: Atmosphere and climate).

- As wind and rain patterns alter with climate change, they will affect the extent to which particulate matter disperses and is removed from the air. Areas with drier conditions and more frequent drought could experience worsening air quality due to lower rainfall, higher fire risks and more windblown dust (Bodeker et al, 2022).

Artificial light

Artificial light at night influences the broader quality of the air we experience. Light pollution affects health and cultural practices, and has economic consequences (see section 7: Impacts on people, society and the economy).

Artificial light at night is becoming brighter and more widespread

Light pollution affects much of the population and may affect native species.

- In 2014, 97 percent of New Zealand's population lived under light-polluted skies (Cieraad & Farnworth, 2023).
- Between 2012 and 2021, the lit surface area of the country increased by 37.4 percent (from 3.0 percent to 4.2 percent), primarily in rural areas (Cieraad & Farnworth, 2023).
- Brightness intensity increased across 4,694 square kilometres during the same period, and decreased across 886 square kilometres. Most of the decreases were observed in urban centres, but their brightness levels remained high relative to rural areas (Cieraad & Farnworth, 2023).
- Evidence of the negative impact of light pollution on species in New Zealand is limited. However, growing evidence indicates that it affects and disrupts the habits, interactions and navigation of some native species, such as bats, wētā and seabirds (Cieraad & Farnworth, 2023; Falcón et al, 2020; McNaughton et al, 2022; Meeuwen-Dijkgraaf, 2021; Schofield, 2021; Sterup, 2024).

6. Atmosphere and climate

Introduction

Human activities have driven rapid increases in atmospheric greenhouse gas concentrations, causing Earth to warm. The global mean surface temperature was estimated to be 1.1 degrees Celsius above pre-industrial levels in 2011–20. Projections suggest it will exceed 1.5 degrees by 2030 (IPCC, 2023; WMO, 2024). While this may seem like a small increase, even slight rises can drive increasingly significant changes to the natural environment (see *Our atmosphere and climate 2023*). The 10 warmest years on record have all been in the past decade (2015–24), with 2024 the warmest (WMO, 2025).

In Aotearoa New Zealand, we see rising air and sea temperatures, changing rainfall, more frequent droughts, accelerating sea-level rise, glacial retreat and more frequent or severe extreme weather events. These trends are expected to continue with further warming.

Climate change intensifies pressures and accelerates changes in land, freshwater, marine and air ecosystems. It exacerbates threats such as land degradation, invasive species, resource extraction and pollution. Biodiversity is under pressure from climate change. We see this through changes in where species live, their habitats, their interactions, and in life cycles and seasonal timing. Extreme weather events have direct and damaging impacts on species and ecosystems.

Biodiverse and resilient ecosystems can shield us from the worst impacts, as they absorb some emissions and can provide buffers against extreme weather events and rising seas. Conversely, the continuing loss of biodiversity and degradation of ecosystems weaken their ability to provide these benefits (see *Our land 2024)*.

This section looks at **our emissions** and how our activities are contributing to an increase in concentrations of greenhouse gases in the atmosphere. It then focuses on **our changing climate** and how this is affecting the environment.

For the wider consequences, see section 7: Impacts on people, society and the economy.

New and updated atmosphere and climate indicators and evidence since *Environment Aotearoa 2022*

Update to greenhouse gas concentrations indicator

The 2023 indicator update confirms that atmospheric concentrations of carbon dioxide, methane and nitrous oxide, measured in the Wellington area, increased in the decade up to 2022.

(See Atmospheric concentrations of greenhouse gases in New Zealand have increased substantially since pre-industrial times, and have continued to increase in recent years.)

New data on greenhouse gas emissions from human activities

The 2024 update of New Zealand's greenhouse gas inventory shows that in 2022 our total gross emissions were at their lowest since 1999, but still higher than in 1990. All sectors (except Tokelau) saw reductions in emissions between 2021 and 2022.

Carbon sequestered by land use, land-use change and forestry offset a quarter of our emissions in 2022, compared with 1990 when sequestration by this sector offset about a third of our emissions.

(See Our greenhouse gas concentrations and emissions profile.)

Updated climate indicators and new evidence

Indicator updates show New Zealand's average air temperature continues to rise, and most monitored areas are experiencing more warm days and higher growing degree days (indicating longer growing seasons). The frequency of medium-term (agricultural) drought is increasing in many places.

The updates also show that the south of New Zealand is becoming wetter, and the north and east are becoming drier. Maximum daily rainfall is likely increasing across more areas of the South Island, and likely decreasing across more areas of the North Island, and extreme wind is likely decreasing across most of New Zealand. These findings are supported by additional new evidence indicating that extreme weather events are becoming more frequent and severe due to climate change from human activities.

The 2024 update to the national climate projections for New Zealand provides insight into the future state of several climate variables, including temperatures, rainfall, drought and extreme winds.

(See New Zealand's climate is changing.)

More evidence for climate impacts on species and ecosystems

Evidence continues to grow that climate change intensifies pressures on land, freshwater and marine ecosystems, exacerbating threats such as land degradation, invasive species, resource extraction and pollution.

Evidence continues to grow that climate change affects where species live, their habitats, interactions, life cycles and seasonal timing across terrestrial, freshwater and marine ecosystems.

(See Many impacts of climate change affect biodiversity and ecosystems.)

Our emissions

Greenhouse gas emissions from human activities are accumulating in the atmosphere. They are the most significant driver of climate change since pre-industrial times.

Natural influences, such as climate oscillations, can also lead to shorter-term changes over years and decades. However, by increasing the amount of greenhouse gases in the atmosphere, humans are having a significant impact on our climate.

Our greenhouse gas concentrations and emissions profile

Atmospheric concentrations of greenhouse gases in New Zealand have increased substantially since pre-industrial times, and have continued to increase in recent years.

- In 2023, global atmospheric carbon dioxide (CO_2) concentrations were 419.3 parts per million (ppm), higher than at any time in at least 2 million years (IPCC, 2023).
- The highest atmospheric CO_2 concentration observed in New Zealand between 1972 and 2022 (415.5 ppm) was in August 2022. This was up 6 percent since 2012, and around 48 percent higher than pre-industrial levels of 280 ppm (Ciais et al, 2013; see indicator: Greenhouse gas concentrations).
- The highest observed atmospheric methane (NH_4) concentration in New Zealand between 1989 and 2022 (1881.4 parts per billion [ppb]) was in October 2022, around 169 percent higher than pre-industrial levels of 720 ppb (Ciais et al, 2013; see indicator: Greenhouse gas concentrations).
- The highest atmospheric nitrous oxide (NO_2) concentration observed in New Zealand between 1996 and 2022 (335.5 ppb) was in December 2022, around 24 percent higher than pre-industrial levels of 270 ppb (Ciais et al, 2013; see indicator: Greenhouse gas concentrations).

New Zealand has a unique greenhouse gas emissions profile.

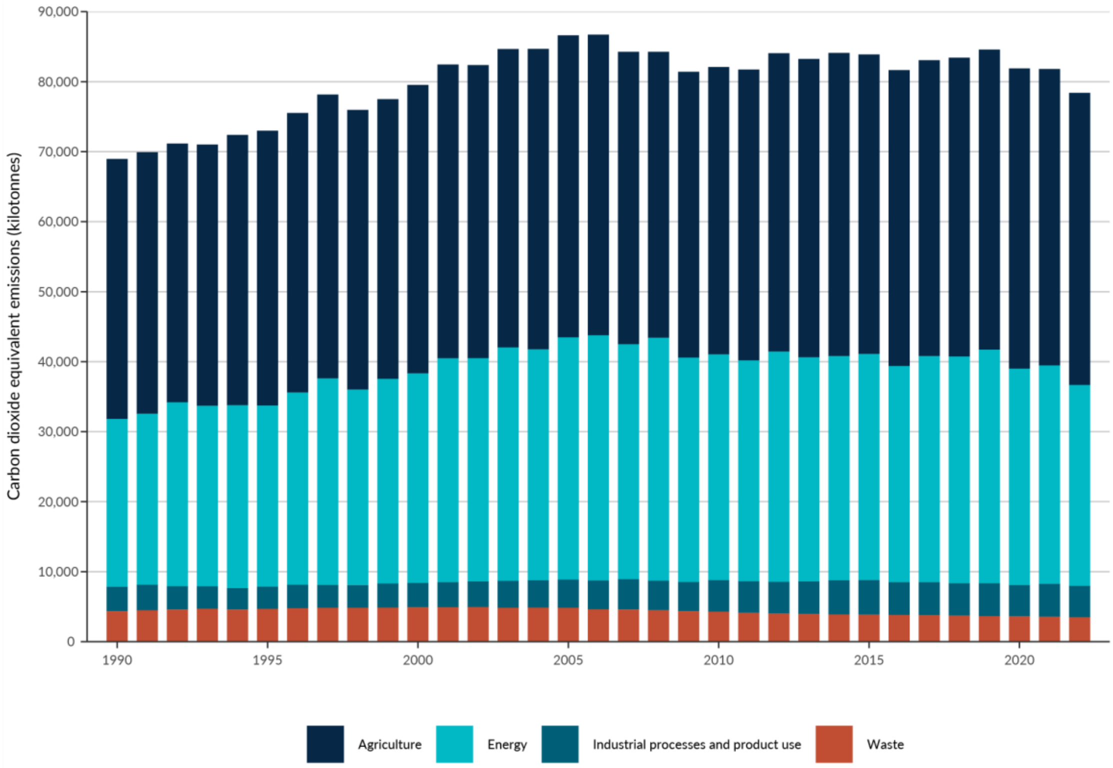
- Our share of global greenhouse gases emissions is small, but gross emissions per person are high compared with other developed countries (MfE, 2024d).
- Most developed countries emit more CO_2 than NH_4 and NO_2, but for New Zealand it is the opposite. This is mainly due to the scale of the agriculture sector proportional to population, a relatively small energy sector and a high proportion of renewable electricity (MfE, 2024d); (figure 9).
- Methane and NO_2 emissions from agriculture made up 52 percent of gross emissions in 2022. Livestock emitted 90 percent of NH_4, and agricultural soils emitted 92 percent of NO_2, mainly due to effects of livestock waste and fertiliser use (MfE, 2024c).
- Carbon dioxide emissions made up 40 percent of the country's gross emissions in 2022. Emissions from road transport (part of the energy sector) accounted for 39 percent of gross CO_2 emissions in 2022 (MfE, 2024c). This is driven by a high rate of road vehicle use – per capita rates of CO_2 emissions from road transport are some of the highest in the world (MfE, 2024d; see section 5: Air).

Gross emissions peaked in 2006 and have been declining since 2019.

- In 2022, our gross greenhouse gas emissions were 14 percent higher than in 1990, and 7 percent lower than in 2019. After peaking in 2006, they stayed relatively stable through to 2019, after which they declined year on year (MfE, 2024c).
- The effects of the COVID-19 pandemic were a factor in lower emissions between 2020 and 2021, but did not influence their continued decrease between 2021 and 2022. This most recent reduction has seen emissions at their lowest since 1999, with reductions across all sectors, except Tokelau (MfE, 2024c).

- Methane emissions increased by 2 percent between 1990 and 2022. Since peaking in 2006, they have declined slightly (MfE, 2024c). Carbon dioxide emissions increased 24 percent between 1990 and 2022. They increased between 1990 and 2008, before plateauing and beginning to decline in 2019 (MfE, 2024c).
- Nitrous oxide emissions increased 35 percent between 1990 and 2022, and combined fluorinated gases increased 87 percent (MfE, 2024c).
- Our net emissions are projected to decrease in the future. Based on the economic conditions and policies in late 2024, net target accounting emissions (which include all gross emissions and a subset of emissions and removals from the land use, land-use change and forestry sector) are projected to decrease 20 percent between 2020 and 2030, and 35 percent between 2020 and 2050 (MfE, 2024j).

Figure 9: Annual gross greenhouse gas emissions by sector, 1990–2022



Data source: Ministry for the Environment

Note: Emissions presented here exclude those from Tokelau. Gross emissions do not include reductions from the land use, land-use change and forestry sector (MfE, 2024c). The energy sector includes transport.

Greenhouse gas emissions from most sectors decreased in 2022.

- Agriculture: Emissions have been declining slowly since peaking in 2014, and decreased 1.4 percent between 2021 and 2022. This reduction is mainly due to long-term decreases in beef cattle and sheep populations, and lower synthetic fertiliser use (MfE, 2024c; see section 2: Land).
- Energy: Emissions decreased 8 percent between 2021 and 2022. This included a 39 percent reduction in public electricity generation and heat production emissions due to high rainfall increasing the proportion of power generated by hydropower. Petroleum-refining emissions also dropped 76 percent following the closure of the country's only oil refinery (Marsden Point) in March 2022 (MfE, 2024c).

- Road transport: Emissions decreased 1.6 percent between 2021 and 2022, to levels 5 percent lower than before the COVID-19 pandemic (MfE, 2024c). This reduction may be due to a combination of factors, such as changes in driving patterns or the increased use of more fuel-efficient cars (MfE,2024d).
- Industrial processes and product use: Emissions decreased 5 percent between 2021 and 2022, mainly due to the closure of the Marsden Point Oil Refinery, and the effects of the COVID-19 pandemic (MfE, 2024c).
- Waste: Emissions decreased 1.5 percent between 2021 and 2022, to levels 4 percent lower than 2019. Waste emissions have been declining since 2002 due to ongoing improvements in landfill management and wastewater treatment (MfE, 2024c).

Carbon dioxide is removed from the atmosphere when plants grow and store carbon, which offsets some, but a decreasing percentage, of our emissions.

- The land use, land-use change and forestry sector offset 25 percent of New Zealand's gross greenhouse gas emissions in 2022, a decrease from 1990, when it offset 35 percent. Net removals from this sector are variable because of the influence of forest planting and harvesting cycles (MfE, 2024c).
- New Zealand is experiencing historically high rates of afforestation, and low deforestation rates, mostly affecting exotic forests, which help absorb carbon (MfE, 2024c). Up to the latest measurement in 2018, native vegetation cover was decreasing, reducing the ability of native forests and other native vegetation to absorb carbon (see section 2: Land).
- Healthy peatlands and wetlands offer vast, long-term carbon storage potential (Ausseil et al, 2015). However, their ongoing degradation and drainage for agriculture (see section 3: Freshwater) results in releases of stored organic carbon into the atmosphere (Clarkson et al, 2013). More than 600,000 tonnes of carbon were lost to the atmosphere from peatland fires at Kaimaumau-Motutangi and Awarua wetlands in 2022 (Pronger et al, 2024).

Other emissions also affect the climate and atmosphere

Global efforts to reduce the use of ozone-depleting substances have reduced the hole in the ozone layer, but some substitutes are potent greenhouse gases.

- New Zealand has phased out the use and manufacture of the ozone-depleting substances, controlled under the Montreal Protocol to protect the stratospheric ozone layer, which took effect in 1992 (MfE, 2021b).
- The size of the ozone hole naturally varies from year to year, but is on track to recover. Global ozone levels are projected to return to pre-1980 levels by the mid-2060s (NASA, 2024; WMO, 2022).
- The annual average thickness of the ozone column at Lauder, Otago decreased between 1979 and 2022 but was slightly thicker than the global average over the same period (see indicator: Atmospheric ozone).
- Hydrofluorocarbons are potent greenhouse gases often used as substitutes for ozone-depleting substances. From 2019, hydrofluorocarbons and related compounds have been phased down under the Kigali Amendment to the Montreal Protocol (MfE, 2019).
- New Zealand's hydrofluorocarbon emissions were 14 percent higher in 2022 than in 2019, and accounted for 34 percent of emissions from the industrial processes and product use sector (MfE, 2024c).

Particles in the atmosphere can have heating and cooling effects on the climate.

- Aerosols are small solid or liquid particles in the atmosphere that are formed by human and natural sources. They affect the weather and climate in many ways, including by influencing cloud formation and solar radiation (Hamilton, 2015; Ruiz-Arias, 2021; Sakai et al, 2016; Shi et al, 2022; Spada et al, 2015; Su et al, 2024).
- Understanding of how these particles interact with clouds remains limited, and is a large source of uncertainty in understanding Earth's climate and future changes (Boucher et al, 2013; Su et al, 2024).
- Black carbon absorbs sunlight due to its dark colour, and has localised warming effects in New Zealand (see *Our atmosphere and climate 2023*). It mostly comes from vehicles, domestic fires and wildfires (Bond et al, 2013; Lee et al, 2022). No inventory exists for black carbon emissions in New Zealand, though nitrogen dioxide emissions can be used as a proxy for these (see section 5: Air and *Our atmosphere and climate 2023*).
- Wildfires and dust storms in Australia produce dust that can be carried to New Zealand. They have the potential to influence our climate (Brahney et al, 2019; Nguyen et al, 2019).

Our changing climate

Climate change is causing warmer temperatures, shifting rainfall patterns, more frequent droughts and stronger winds. These changes affect how and when we can grow food, store water or build infrastructure.

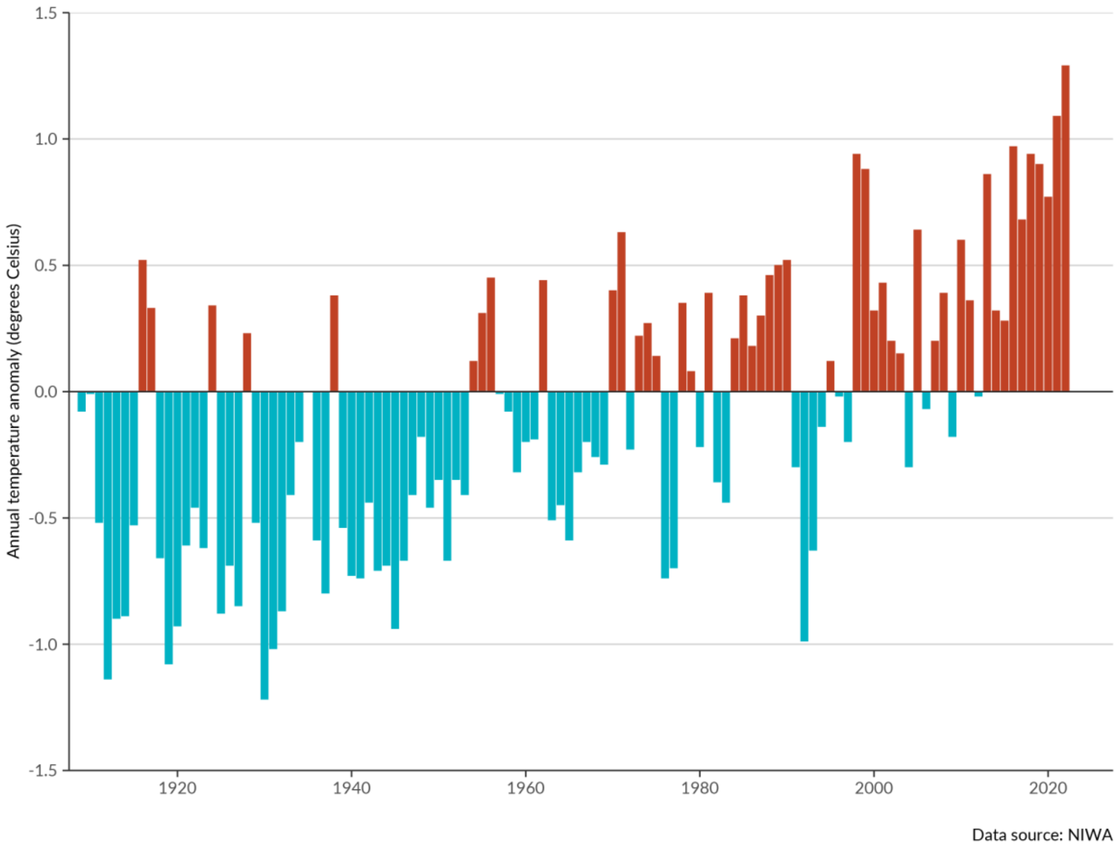
The changing climate is also altering natural climate phenomena such as El Niño and La Niña, making extreme weather events more intense. This puts additional pressure on habitats and species, leading to biodiversity loss and ecosystem disruption.

New Zealand's climate is changing

Long-term annual average temperatures are rising, with fewer frost days and increasing growing degree days (indicating longer growing seasons).

- The annual average temperature in New Zealand has increased 1.26 (± 0.27) degrees Celsius between 1909 and 2022, and 8 of the 10 warmest years on record occurred between 2013 and 2022 (see indicator: Temperature and figure 10). The annual average temperature is projected to increase 1.9 degrees Celsius by 2090, compared with the 1995–2014 period under the Shared Socio-economic Pathway 2-4.5 scenario (MfE, 2024b; see Technical annex).
- The number of warm days (when the maximum temperature is above 25 degrees Celsius) increased at 25 of 30 monitoring sites across New Zealand between 1972 and 2022, and decreased at three (see indicator: Temperature). More warm days are projected for most of the country, especially the north and east of the North Island (MfE, 2024b).
- The number of frost days (when the minimum air temperature is below zero degrees Celsius at 1.2 metres above the ground) decreased at 20 of 27 sites between 1972 and 2022, and increased at five (see indicator: Frost and growing degree days). Fewer frost days are projected for the west and south of the South Island (MfE, 2024b).
- Growing degree days (the amount of warmth available for plant and insect growth during a growing season) increased at 29 of 30 sites between 1972 and 2022 (see indicator: Frost and growing degree days).

Figure 10: New Zealand annual average temperature anomaly, 1909–2022



Note: The baseline for temperature anomalies is the average annual temperature for the 30 years from 1961 to 1990 (see indicator: Temperature).

Rainfall patterns are changing, with the south becoming wetter and the north and east becoming drier.

- Annual rainfall increased at 15 of 30 monitoring sites between 1960 and 2022, and decreased at eight. There were increases at many sites in the southern South Island, and decreases at many sites in the northern half of the North Island (see indicator: Rainfall). By 2090, the west and south of the South Island are projected to have higher annual rainfall. The North Island is projected to have lower annual rainfall, particularly in the north and the east (MfE, 2024b).
- Most sites with increasing rainfall trends also had increases in their annual maximum one-day rainfall amounts. Annual maximum one-day rainfall increased at 12 of 30 sites, and decreased at 10 (see indicator: Extreme rainfall).

Frequency of medium-term agricultural drought is increasing in many places.

- The frequency of medium-term agricultural drought events (a marked shortage of moisture compared with what is expected across a six-month period) increased at 15 of 30 monitoring sites between 1972 and 2022, and decreased at six (see indicator: Drought). By 2090, drought is projected to increase in the east of New Zealand and decrease in the west (MfE, 2024b).

Extreme winds are decreasing at most sites.

- Annual averages of the daily maximum wind gust decreased at 14 of 17 sites between 1980 and 2022, and increased at three (see indicator: Extreme wind).
- Fewer windy days (with maximum wind speed more than 10 metres per second) per year are projected for much of the North Island, and more are projected for most of the South Island by 2090 (MfE, 2024b).

Extreme weather events are becoming more frequent and/or more intense.

- New Zealand has recently seen multiple severe weather events happening at the same time or in the same place, or both. One example is the atmospheric river that delivered an unprecedented amount of rainfall to Auckland in January 2023, closely followed by the effect of Cyclone Gabrielle across much of the North Island in February 2023 (Harrington et al, 2023; Stone et al, 2024).
- In 2021, extreme rainfall events that caused flooding in Canterbury were 10 to 15 percent more intense because of climate change. Similarly, extreme weather and associated flooding on the West Coast in 2021 were nearly 10 percent more intense due to climate change (MfE, 2023a; Stone et al, 2022).
- Floods are among the most frequent and damaging natural hazards in New Zealand (Frame et al, 2020; Royal Society Te Apārangi, 2016). They are mostly caused by heavy and/or prolonged rainfall but can be mitigated or exacerbated by other factors such as land use and infrastructure (Auliagisni et al, 2022). As the climate changes, flooding caused by higher rainfall and rising sea levels is expected to increase (Bodeker et al, 2022; Pourzand et al, 2023; Thomas et al, 2024)
- The frequency of tropical cyclones is slightly decreasing over the South Pacific basin (Roberts et al, 2020), but the cyclones that do form are more severe (Bodeker et al, 2022; Chand et al, 2022).
- The frequency of extreme temperature events in New Zealand has increased two to threefold due to human influence since pre-industrial times (Thomas et al, 2023; see Technical annex).
- The wildfire risk is changing. The number of days with very high and extreme fire danger increased at 12 of 28 sites between 1997 and 2019, and decreased at eight (see indicator: Wildfire risk). Comparison of fire risk is complicated due to the difference in fuel type used for analysis between sites (see Technical annex and *Our atmosphere and climate 2023*).
- In the 2021/22 wildfire season, 4,417 fires burnt an area of 4,864 hectares. This area was smaller than in the wildfire seasons in 2020/21 (4,586 fires burnt an area of 13,348 hectares) and 2019/20 (5,735 fires burnt an area of 10,415 hectares) (FENZ, 2021, 2022, 2023).
- The wildfire risk is expected to increase across many regions of New Zealand through the rest of the century, compared with its first two decades (Langer et al, 2021; Melia et al, 2022).

Climate varies naturally but natural variation might be changing too

El Niño Southern Oscillation and Southern Annular Mode influence natural climate variability.

- Natural patterns of change (oscillations) influence the weather and climate in New Zealand, including the El Niño Southern Oscillation (ENSO), Interdecadal Pacific Oscillation (IPO) and

Southern Annular Mode (SAM) (see indicators: El Niño Southern Oscillation, Interdecadal Pacific Oscillation and Southern Annular Mode).

- ENSO has three phases: neutral, El Niño and La Niña (NIWA, nd-a). New Zealand may experience more northeasterly winds and wetter conditions in the north and east, and warmer-than-average air and sea temperatures during La Niña. During an El Niño phase in summer, increased westerly winds, more rain in the west and dryness in the east occur. In winter, El Niño can lead to more frequent, cooler southerly winds (see indicator: El Niño Southern Oscillation; Ummenhofer et al, 2009). However, understanding of how ENSO modulates the climate remains limited.
- The most recent El Niño phase was from July 2015 to April 2016. This was one of the two strongest El Niño phases between 1990 and 2022, the other occurring during 1997 to 1998. The most recent La Niña phase was from April 2022 to December 2022 (see indicator: El Niño Southern Oscillation).
- Climate models indicate that ENSO variations have increased in size by up to 10 percent since 1960, partly due to rising greenhouse gas concentrations in the atmosphere (Cai et al, 2023). One result is that El Niño and La Niña events are becoming stronger and more frequent (Cai et al, 2023).
- SAM is associated with the strength and position of westerly winds and storm tracks. The recent declines in extreme wind magnitude and frequency in New Zealand are likely related to SAM more often being in a 'positive' phase, which moves storm tracks further south (NIWA, nd-b; Thompson et al, 2011).
- Evidence indicates the positive trend of SAM over recent decades is an indirect response to stratospheric ozone depletion and climate change (Goyal et al, 2021; King et al, 2023; Morgenstern, 2021).

Complex atmospheric phenomena influence rainfall and flooding.

- Varying atmospheric circulation affects the transport of moisture and has a complex connection to precipitation in New Zealand (Bennet & Kingston, 2022; Thomas et al, 2024).
- New Zealand is exposed to extreme precipitation events caused by fronts, atmospheric rivers, cyclones and other atmospheric phenomena. In particular, we are in a region of high atmospheric river activity (Reid et al, 2021). Longer extreme precipitation events generally lead to higher rainfall accumulation and more widespread flooding (Vishwanathan et al, 2024).
- Extreme precipitation events often occur when multiple atmospheric phenomena interact. For example, prolonged heavy rain can occur when atmospheric blocking (high-pressure systems that halt normal weather movement) interacts with atmospheric rivers (Prein et al, 2023; Vishwanathan et al, 2024).
- Notable examples include the July 2021 Westport flood, caused by an atmospheric river stalling over the Buller River catchment (Stone et al, 2022), and the February 2023 northeastern flood, linked to Cyclone Gabrielle stalling off the north coast (Harrington et al, 2023).

Many impacts of climate change affect biodiversity and ecosystems

Climate change intensifies pressures from human activities on ecosystems, amplifying threats such as land degradation, invasive species, resource extraction and pollution.

- Increased frequency and intensity of heavy rainfall events exacerbate land degradation through landslides and soil erosion, especially in areas with exposed soils or non-native vegetation. This can reduce the productivity of the land, and increase the amount of sediment that washes into downstream environments (see section 2: Land, section 3: Freshwater, section 4: Marine and section 7: Impacts on people, society and the economy).
- Climate change creates more favourable conditions for exotic pests and diseases to invade, establish and spread (Keegan et al, 2022; Meurisse et al, 2023; Mouton et al, 2022). This poses a growing threat to the natural environment and primary sectors (Meurisse et al, 2023; see section 3: Land, section 4: Marine and section 7: Impacts on people, society and the economy).
- Total glacier ice volumes in New Zealand decreased 35 percent, and the rate of annual loss increased between 1978 and 2020 (see indicator: Annual glacier ice volumes). Receding glaciers and changes to snow cover are expected to affect flows in glacier- and snow-fed rivers, altering downstream water supply for ecosystems, irrigation and hydropower (Keegan et al, 2022; Purdie, 2022; Queen et al, 2023). This also increases risks of natural hazards arising from higher run-offs and lake outburst (IPBES, 2018).
- Streamflow patterns have changed across the country as the climate has changed. Between 1969 and 2019, winter streamflow increased in the western South Island and decreased in the northern North Island. Summer streamflow decreased across the northern regions of the North Island (Queen et al, 2023). This has compounded the effects of water take and land use on river flows in some areas (Booker & Snelder 2023; see section 3: Freshwater).
- More frequent floods and droughts can exacerbate many forms of water pollution, from sediments to pathogens and pesticides (IPCC, 2022). Increasing freshwater temperatures are expected to increase the risk of cyanobacteria blooms, degrading water quality and potentially rendering some freshwater unsafe for consumption (Puddick et al, 2022).
- Rising sea-surface temperatures, marine heatwaves and ocean acidification can exacerbate fishing pressure by affecting the lifecycle and reproduction of marine species such as kōura (crayfish) and tāmure (snapper), which are already declining due to overfishing and other human activities (Cummings et al, 2021; Gee, 2021; Heeringa, 2021; Shears et al, 2024).

Climate change is directly affecting land, freshwater and marine habitats and species already under pressure from other human activities.

- Wildfires pose a growing risk to forests, as well as to wetlands and tussock grassland, which are already in decline (Case et al, 2023; Melia et al, 2022; Pronger et al, 2024; see section 2: Land and section 3: Freshwater). Recovery from fire events is slow, and fires can disrupt the natural succession of ecosystems and favour non-native species over native ones (Case et al, 2023; Perry et al, 2014; Richardson et al, 2018).
- Changes in precipitation and rising temperatures alter the timing of seasonal events such as flowering, growth and migration, and species interactions. The impacts are felt across entire terrestrial ecosystems. For example, rising temperatures contribute to the increased frequency of beech mast (a period during which beech trees produce a large

amount of seeds). This can lead to outbreaks of pests (rats, mice and stoats) that threaten native forest birds and long-tailed bats (King, 1983; O'Donnell et al, 2017).

- Some alpine species of lizards, insects and birds may face habitat loss as warming is expected to shift snowlines (Jarvie et al, 2022; Koot et al, 2022; Lorrey et al, 2022; Weinhäupl & Devenish-Nelson, 2024).
- Droughts can alter soil properties and carbon cycling (Macinnis-Ng & Schwendenmann, 2015) and cause changes to forest diversity as more drought-resistant species survive (Wyse et al, 2013). Droughts can harden soils, making it difficult for species such as kiwi to extract food (Boffa Miskell, 2020).
- Changes in freshwater temperatures, and in drought and flood frequency, are predicted to influence the life cycles and successful migrations of some native freshwater fish species (Awatere et al, 2021; Egan et al, 2020; Keegan et al, 2022). Increased rainfall and flooding can degrade habitats for freshwater fish, freshwater-dependent birds and other freshwater species (Awatere et al, 2021; Goodman, 2018; Keegan et al, 2022).
- Rising sea-surface temperatures can reduce food availability for seabirds in some areas (Mills et al, 2008; Salinger et al, 2023). Ocean acidification and warmer temperatures are expected to make it harder for species such as molluscs and corals to grow and maintain their shells and skeletons (Anderson et al, 2022; Law et al, 2018).
- Primary productivity (see section 4: Marine) is expected to decrease around the North Island and west coast of the South Island in response to increasing sea temperatures, but may increase in water off southern New Zealand (Roberts & Hendriks, 2022).
- Marine heatwaves have caused unusual fish migrations, severe bleaching and necrosis of sponges, large losses of farmed salmon and southern bull kelp (rimurapa), and likely contributed to the mass mortality of blue penguins (kororā) in the Bay of Plenty (Salinger et al, 2019, 2020, 2023). In some areas where the bull kelp was completely lost during the 2017/18 heatwave, an invasive, non-native kelp established. This coincided with a sharp decrease in green-lipped mussels (kākahi), an important traditional food-gathering (mahinga kai) species (Awatere et al, 2021; Thomsen et al, 2019).
- Sea-level rise and storm surges threaten coastal ecosystems and freshwater species by moving saltwater farther into coastal freshwater environments, altering their salinity (Cañedo-Argüelles et al, 2013; IPCC, 2022; Neubauer et al, 2013; Schallenberg et al, 2003). Rising sea levels have also led to a loss of nesting sites for various shorebirds (Keegan et al, 2022).
- Seawalls and coastal hardening protect our homes and communities from rising sea levels. However, they also limit the ability of coastal habitats, such as sandy beaches, dunes and wetlands, to retreat inland. This may cause further loss of these important habitats (Allan et al 2023; Douglas et al, 2022; MfE, 2024g; Stewart et al, 2020).

7. Impacts on people, society and the economy

This section examines how changes in the environment are impacting our lives, in three areas.

The first part of this section looks at how our **health and quality of life** are deeply rooted in the environment. A healthy environment provides clean air, water, food and spaces for recreation, all of which support physical and mental well-being. Conversely, environmental degradation – such as pollution, biodiversity loss and climate change – can harm health. It contributes to respiratory illnesses, heat-related conditions, waterborne diseases, and mental health challenges stemming from the loss of natural spaces or increased environmental stresses.

The second part looks at **people's connection to place**, which is also intertwined with nature. The environment shapes cultural values, traditions and a sense of identity. It fosters strong bonds between communities and the landscapes they inhabit. Healthy ecosystems sustain these connections, supporting cultural practices and community resilience.

The third part looks at how our **homes and livelihoods** depend on the services provided by nature. Ecosystems play a critical role in food production, water availability and energy generation, creating the foundation for social and economic stability. However, challenges such as biodiversity loss and climate change (including severe weather events) pose risks to our homes and jobs and to the broader natural and built environment that supports them.

Addressing these interconnected challenges is vital for our lives and the resilience of the environment.

Health and quality of life

Access to nutritious food, fresh air and safe drinking water is fundamental to our health and quality of life. These essential needs depend on a healthy environment, including fertile soil, clean air and unpolluted water. Degradation of the environment, climate change and extreme weather events pose significant threats to human health, increasing risks such as food insecurity, poor air quality and contaminated water.

In contrast, a healthy environment enhances the resilience of food systems, supports natural air filtration and ensures water infrastructure can withstand the challenges of climate change and extreme weather.

Our health and vulnerability are also shaped by who we are and where we live. Urban areas, where many of us live, benefit from well-functioning ecosystems that can provide critical services. However, environmental drivers and pressures increasingly threaten these ecosystems. Emerging contaminants, such as microplastics, add another layer of risk to human health, infiltrating food, air and water, though their full impact remains poorly understood.

This subsection focuses on two aspects of human health: access to healthy food and clean air; and how climate change amplifies health risks. Both aspects highlight the profound connection between environmental health and overall quality of life.

Our food, water and air are impacted by the state of the environment, with consequences for our health

Access to affordable and nutritious food is vulnerable to global disruptions and extreme events.

- Access to affordable and nutritionally dense food relies on a resilient and stable food system. This includes, among other things, access to reliable sources of water, and stable supply chains and distribution infrastructure. These are at risk from disruptors such as pandemics, international wars, climate change, sea-level rise, drought and other extreme weather events that can cause instability and price fluctuations. Changes in food prices can influence people's choices towards buying less healthy but more affordable products. This affects our health, particularly in lower socio-economic communities, rural communities and children (Resilience to Nature's Challenges, 2024; Strom et al, 2024; Vatsa & Renwick, 2024).
- Outdoor horticulture, including fruit and vegetable growing, relies on a finite supply of highly productive land that is becoming less available due to urban development (see section 2: Land). This constrains this sector's ability to adapt to other pressures, threatening diverse supply of vegetables for domestic use and access to healthy diets (Curran-Cournane & Rush, 2021; Curran-Cournane et al, 2021a; Davis et al, 2023; Greenhalgh et al, 2017; MPI, 2019b).

The water we drink can carry diseases.

- Since 1980, at least 49 drinking water illness outbreaks have been reported in New Zealand (DPMC, 2024). This includes the 2016 campylobacteriosis outbreak in Havelock North, which made an estimated 6,000 to 8,000 people ill, led to 42 hospitalisations and contributed to at least four deaths (Gilpin et al, 2020).
- A cryptosporidiosis outbreak occurred in Queenstown in September 2023, causing illness in at least 72 people and requiring three hospitalisations. Human faecal contamination was considered the most likely cause of the outbreak (Baker et al, 2023; Grout et al, 2024).
- Rural communities face a higher risk of waterborne disease. Compared with the urban population, the proportion of the rural population reporting cryptosporidiosis is four to six times larger, and for reporting campylobacteriosis, two to four times larger. Young children and people living in deprived areas are also at greater risk of waterborne disease (EHINZ, 2024a).

Contaminated water in lakes, waterways and coastal waters used for recreation and food gathering can lead to disease and illness.

- Regional councils monitor popular swimming sites to assess their health risk for swimming and food gathering. Faecal contamination from humans and animals is a common reason why exposure to water can become unhealthy, as it can cause infections and gastroenteritis (LAWA, 2022). Some sites are under harvest bans because food harvested is not safe to eat (Clough, 2013; Morrison et al, 2023; van Hamelsveld et al, 2023).
- In 2023 there were 388 notifiable illness cases of campylobacteriosis, 135 of giardiasis, 106 of cryptosporidiosis, 102 of salmonellosis and 138 of *Escherichia coli* infection, for cases where people reported contact with recreational water (river, lake or sea) (ESR, 2025).

- Exposure to freshwater with high levels of toxic algae can cause illnesses in humans, including nausea, diarrhoea and, in extreme cases, liver damage, and can also kill dogs (LAWA, 2023a). Toxic algae are generally only present at low levels in New Zealand's freshwater environments, but blooms occur more frequently in nutrient-rich waters and during summer when there are higher temperatures, more sunlight and lower rainfall (BPAC, 2020; LAWA, 2023a; Puddick et al, 2022).

Breathing polluted air can cause serious health issues for thousands of people each year and lead to high social costs.

- The health impacts and social costs from human-made air pollution are higher than previously thought, based on our growing understanding of the extensive health and social damage caused by motor vehicle pollution (Kuschel et al, 2022).
- In 2019, it is estimated that human-made air pollution in the form of fine particulate matter $PM_{2.5}$ (airborne particles less than 2.5 micrometres in diameter) and nitrous oxide (NO_2) was a factor in 3,239 premature deaths, 13,237 hospitalisations, 12,653 cases of childhood asthma and over 1.771 million restricted activity days. It is estimated that air pollution from motor vehicles was associated with 71 percent of these hospitalisations and 69 percent of premature deaths. Social costs resulting from the health impacts associated with air pollution were estimated at $15.3 billion for the year 2019, with 69 percent of these costs associated with air pollution from motor vehicles (Metcalfe & Kuschel, 2023; see *Our air 2024*).
- The estimated health impacts associated with human-made air pollution ($PM_{2.5}$ and NO_2) increased between 2006 and 2016 due to population growth and rising NO_2 exposure. Premature deaths associated with NO_2 exposure from motor vehicle emissions increased 28 percent, and hospitalisations increased 39 percent. However, health impacts from $PM_{2.5}$ exposure decreased during this period, likely due to reduced emissions from domestic fires (see indicator: Human health impacts of $PM_{2.5}$ and NO_2 and Technical annex).
- The health risks from air pollution are higher for some people and communities than for others. Children, the elderly, pregnant people, and those with pre-existing cardiovascular or respiratory disease are more vulnerable (Peled, 2011). People in the most socio-economically deprived areas are exposed to more air pollution, and suffer greater health impacts as a result, than those in the least deprived areas (Telfar-Barnard & Zhang, 2021; Wickham et al, 2023).
- Plants in urban green spaces can filter pollution from the air, but these spaces are under pressure from development. It is estimated that each year, trees in Auckland alone remove 1,230 tonnes of NO_2, 1,990 tonnes of ground-level ozone and 1,320 tonnes of particulate matter (PCE, 2023).

A changing climate can pose risks to our physical and mental health

Climate change could further jeopardise access to healthy food and water.

- Food production in New Zealand often concentrates specific industries in certain regions, making the food system more vulnerable to climate change and extreme weather events in those areas (Renwick, 2023; Resilience to Nature's Challenges, 2024). For example, Cyclone Gabrielle and the Auckland floods in 2023 disrupted road access, and damaged infrastructure and crops (eg, vegetables and orchards), in key production areas in the North Island (The Treasury, 2023; Vatsa & Renwick, 2024). This led to shortages of specific foods and a temporary increase in prices for some goods and services, adding to the rising cost of living (MFAT, 2023b; The Treasury, 2023).

- Climate change will have a negative impact on crop productivity around the world, making it more difficult to access a variety of food – a fundamental need, especially for children (Binns et al, 2021).
- Drinking water supply is at risk from climate change. Effects will be localised, with drought posing a risk to reservoir and catchment yield for drinking water supply, and increasing water demand from other uses (Kamish et al, 2020; MfE, 2020).
- There are existing health risks for rural communities and marae who rely on water from untreated systems, such as tank water and groundwater wells in intensively farmed areas. This risk can increase with extreme rainfall events and higher temperatures through contaminated drinking water (Awatere et al, 2021; Teen, 2024).

Higher temperatures and heatwaves could lead to growing health impacts.

- Higher temperatures and heat waves can cause illness and worsen chronic health conditions. Some people, including babies, infants, older people and people working outside, are more at risk than others. Higher temperatures have also been associated with an increased incidence of assaults (EHINZ, 2022; Lai et al, 2024; Royal Society Te Apārangi, 2017; Stevens et al, 2019).
- International evidence shows that extreme heat poses an increasing risk of mortality and morbidity with climate change, particularly for the elderly and those with cardiovascular disease. There is currently a lack of data for this connection in New Zealand (Chaseling et al, 2023).
- Our growing urban areas produce, absorb and retain more heat than rural and natural areas. This will make them even hotter as temperatures rise (IPCC, 2021). Urban heat can stress infrastructure and ecosystems and may exacerbate the health impacts of heat in cities. Urban forests and green space help to lower temperatures through transpiration and providing shade, reducing this urban heat island effect (PCE, 2023; Toi Te Ora Public Health, 2024).

Climate change could amplify the risk of disease.

- Allergic rhinitis, or hay fever, is commonly caused by windborne pollen. While data are limited, one study estimated that it affects 35 to 40 percent of those aged 20–44 years in New Zealand, and this number is increasing (Newnham, 2017, 2021). Warmer temperatures and higher carbon dioxide concentrations could increase the suitable growing areas of major pollen-producing species, so that they produce more pollen for longer (Damialis et al, 2021; Newnham, 2021). Recent monitoring and research indicate that our high pollen count days have increased by 75 percent over the last three decades (RNZ, 2024).
- Thunderstorm asthma occurs when a thunderstorm coincides with a significant amount of pollen in the air, causing immediate asthma flare-ups. Emerging evidence indicates that these events are likely to increase because of climate change (D'Amato et al, 2021) and could possibly occur in New Zealand (Asthma Foundation NZ, 2021; Sabih et al, 2020; Stewart et al, 2022).
- Smoke from wildfires has adverse physical and mental health effects, which children and people with asthma are particularly vulnerable to (Aguilera et al, 2021; McDonald et al, 2023).

- As our climate becomes increasingly suitable for insects such as mosquitos, there is an increasing risk that insect-spread viruses like the Zika virus and dengue fever will be introduced from overseas and locally transmitted (Ammar et al, 2021).
- Extreme weather events such as heavy rainfall and flooding are linked to a higher chance of waterborne disease outbreaks, which could become more frequent with climate change (Grout et al, 2022, 2024; Pourzand et al, 2023). Regions experiencing increased extreme rainfall may face greater risks of waterborne diseases, particularly through contaminated water supplies (Hales, 2019; Lai et al, 2020).

Climate change and extreme weather could harm mental health, affecting some groups more than others.

- Some population groups will be more affected by climate change health impacts than others, and existing health and social system inequities will be exacerbated by climate change. The already disadvantaged, including young, elderly, disabled and lower-income communities, people living in poverty, and Māori and Pasifika communities, will be disproportionately affected (Bennett et al, 2014; EHINZ, nd-b; EHINZ, 2024; Jones et al, 2014; Masters-Awatere et al, 2023).
- With an increasing number of extreme events, a rise in related health and wellbeing effects is expected, including injuries and deaths, displacement, and significant damage to community infrastructure. Vulnerable groups including children, elderly and disabled will be particularly at risk (Grout et al, 2022; Mason et al, 2021).
- Climate anxiety, including feelings of hopelessness and frustration, particularly affects some groups. Young people face an uncertain future, and Pacific communities have connections to small island countries susceptible to climate-induced displacement (Burkett, 2011; Campbell, 2010; Fritze et al, 2008; Health Navigator New Zealand, 2022; McBride, 2022; Tiatia-Seath et al, 2020).
- Emerging evidence indicates that children and young people are showing increasing levels of mental distress due to climate change, and research suggests they will be disproportionately burdened by the impacts of climate change (Gislason et al, 2021; Ma et al, 2022).
- Severe weather events such as extreme rainfall, drought, wildfires and floods have been linked to elevated levels of anxiety, depression and post-traumatic stress disorder (Ministerial Inquiry into Land Use in Tairāwhiti and Wairoa, 2023). People with pre-existing mental health conditions are at higher risk, as exposure to these events can worsen mental health and lead to higher mortality, with increased psychiatric hospitalisations and suicide rates (Charlson et al, 2021).
- Extreme weather events have long-term health and wellbeing implications for individuals and entire communities. Increased frequency of severe events can lead to exhaustion and emotional tolls on individuals and communities (Grout et al, 2022; Jones et al, 2023; Ministerial Inquiry into Land Use in Tairāwhiti and Wairoa, 2023).

People and their connection to place

The natural beauty of our environment, including mountains, rivers and coasts, is central to our culture and national identity.

As individuals, we each connect to the environment in our own way and for different reasons – including walking, swimming and gathering food. As communities, we also have different ways of enjoying our local environment – spending time in city parks, along rivers or at beaches. As the environment changes, these connections change, whether those changes are sudden and we notice them, or are more gradual and not immediately obvious.

These changes require knowledge adaptation, and affect mātauranga Māori and associated practices such as traditional food-gathering (mahinga kai) and using plant medicines (rongoā rākau). We also have intergenerational connections to the environment. Just as the way that those before us lived with the landscape influences the current state of the environment and how it affects society today, so will future generations be affected by the way that we live with the environment today.

Access to a healthy environment is important for maintaining our ties with nature

Access to urban greenspaces is important to stay connected to nature.

- Spending time in urban green spaces, and in or near rivers and lakes can support good mental health – reducing fatigue and stress, improving immune system function, lowering blood pressure and providing space for physical activities (Gascon et al, 2017; MfE, 2022; Nutsford et al, 2013; Pasanen et al, 2019; Tzoulas et al, 2007; White et al, 2020).
- Lower-income communities have less access to urban green spaces and their benefits, which can reduce the positive impact of green spaces on human health (Blaschke et al, 2024; Regional Public Health, 2010; Zhang et al, 2024).
- The accessibility of urban green spaces for adolescents is associated with reductions in stress, substance problems and depressive symptoms, as well as with improvements in mental health, behaviour and cognitive development (Hobbs et al, 2023; Mavoa et al, 2019; McCormick, 2017; Tzoulas et al, 2007). This association is important as one-third of New Zealand's adolescents aged 15 to 17 years have reported difficulties in everyday activities such as communicating and social interaction, due to mental illness (HPA, 2020).

Environmental degradation is affecting people's ability to connect with nature.

- Many New Zealanders engage in outdoor recreation, and we get important cultural and health benefits from activities such as walking, swimming, waka ama, surfing, kayaking, fishing and gathering shellfish. It can impair our communities' engagement and connection with the environment if these activities cannot be enjoyed safely (see *Environment Aotearoa 2022*).
- Our native ecosystems and unique wildlife provide opportunities for recreation. For many New Zealanders, having access to nature is a major advantage of living here, with around one in two visiting protected areas such as parks and beaches each month over the 2023/24 summer (DOC, 2021a, 2024b).
- A degraded environment affects connection to the land (whenua) for some Māori, and the foundation of tūrangawaewae (the land base, a place of belonging, standing and identity). This poses a risk to their cultural functioning capacity, and impacts quality of life (Awatere

et al, 2021; Harmsworth & Awatere, 2013; Hond et al, 2019; Reihana et al, 2023; Stewart-Harawira, 2020). For example, air pollution, including odour, at Whareroa Marae in Mount Maunganui is lowering the quality of life of those living near the marae, and community members are concerned about its effects on their cultural practices (Bay of Plenty Regional Council, nd; ESR, 2023).

- Changes in land cover and biodiversity loss have reduced people's connection to their local environment over several generations. Loss of connection is particularly pronounced in urban spaces, where the loss of native vegetation can cause disconnection from natural heritage, and a loss of identity and sense of place. Making natural heritage visible in urban areas, where most people live, can help restore our connection to nature (Hall et al, 2021; Rodgers et al, 2023; Walker et al, 2024b).

Changes to the environment impact our culture, identity and connections to place

Many important sites and infrastructure for culture and recreation are at risk from flooding, erosion and extreme weather events.

- Many sites of ecological, archaeological and recreational importance are in low-lying coastal areas at risk from coastal inundation as sea levels rise. This includes 420 archaeological sites on public conservation land (Tait, 2019).
- Severe weather has extensively damaged recreational infrastructure and tracks in recent years. For instance, the Queen Charlotte Track in the Marlborough Sounds was temporarily closed to walkers and mountain bikers for a few months in 2021. The Okura Bush walkway also remains closed following severe weather in 2023 (DOC, 2021b, 2024c).
- Culturally important sites and infrastructure, such as marae, burial grounds (urupā) and settlements (kainga), are vulnerable to damage from flooding, erosion, wildfires and other extreme weather events. Damage to these sites can affect the knowledge (mātauranga Māori) associated with them (Awatere et al, 2021; King et al, 2007). Around the country, 191 marae are within 1 kilometre of the coast, and, in the Bay of Plenty alone, 41 urupā are within 1 kilometre (Bailey-Winiata, 2021).
- Coastal erosion is a particularly serious threat to archaeological sites because it permanently removes them, erasing any evidence they could provide for archaeological investigation. Mapping indicates that the most at-risk areas are in the North Island around Taranaki, Auckland, Coromandel and northern Hawke's Bay, and in the South Island around Tasman and parts of Otago and Canterbury (Jones et al, 2023).

The ability to practise and access food-gathering (mahinga kai) and traditional plant medicine (rongoā rākau) is affected by changes to the environment.

- Changes to our terrestrial, freshwater and marine environments due to land-use change, invasive species, pollution and climate change can have direct impacts on treasured (taonga) species and the ability to carry out mahinga kai and rongoā rākau. This affects the transmission, retention and development of customs and protocols (tikanga), knowledge (mātauranga) and Māori language (te reo Māori), highlighting the importance of protecting these species and safeguarding the embedded knowledge within these practices (Awatere et al, 2021; Collier et al, 2017; Glavinovic et al, 2022; Harmsworth & Awatere, 2013; Herse et al, 2021; Noble et al, 2016; Parsons et al, 2021; Paul-Burke et al, 2020; Phillips et al, 2016; Rainforth & Harmsworth, 2019; Tipa, 2009).

- More than simply allowing for gathering kai, the ability to collect customary resources affects the authority (mana) of an iwi or hapū. These resources contribute to their capacity for manaakitanga – offering food from their land (whenua) and water (wai) to invited guests is an important part of hospitality (Rainforth & Harmsworth, 2019; Smith & Hutchings, 2024).
- Mahinga kai connects tangata with whenua (people with land), is intergenerational and is a holistic and integrated value. Mahinga kai includes the ability to access food resources, food-gathering sites, the gathering and use of food, and the abundance and health of species used for food (Awatere et al, 2018; Herse et al, 2021; Rainforth & Harmsworth, 2019; Ruru et al, 2022).
- Decreased or altered river flows, accumulation of sediment and sewage contamination in rivers, and the effects of excess nutrients in estuaries and the ocean can affect the cultural health of mahinga kai sites. These changes prevent safe access and reduce the availability of mahinga kai species (Collier et al, 2017; Hikuroa et al, 2018; Mika, 2021; Stewart-Harawira, 2020; PCE, 2020; Tipa, 2009; see *Our marine environment 2022*).
- Plant medicine (rongoā rākau) is integral to traditional Māori healing practices, and the plants necessary for these practices are vulnerable to changes in the landscape. Adverse effects on these plants can reduce rongoā practitioners' ability to connect with and harvest them (Awatere et al, 2021; Mark et al, 2022; Marques et al, 2023).

Changes to the environment affect traditional ways of monitoring the environment.

- Through observing the environment closely over time, Māori developed a deep knowledge of location-specific environmental indicators, or tohu. These help to monitor and forecast trends in the environment (te taiao) (Harcourt & Awatere, 2022; King et al, 2005; Matthews, 2023; Pomare et al, 2023, Wilcox et al, 2024).
- Many Māori cultural practices are based on astronomical knowledge, including those related to growing crops and fishing. Reduced visibility of the night sky forces changes to these practices (Hikuroa, 2017; Matamua, 2017; see *Environment Aotearoa 2022*).
- Climate change threatens the loss of treasured (taonga) species and resources. This poses risks to the maintenance and transfer of traditional skills, expertise and values relating to practices such as observing the maramataka (Awatere et al, 2021; NZAEE, 2021). Maramataka is the traditional Māori way by which time is marked by observing the phases of the moon. Mātauranga Māori, including maramataka, holds centuries of observations to understand causal effects (Hikuroa, 2017).
- Changes in local climates are causing tohu to change, which is affecting planting, daily decisions and activities such as resource gathering and hunting (Skipper, 2018). Understanding and monitoring changes to tohu can help to manage and adapt climate-sensitive activities like these (Benson et al, 2020; King et al, 2005; Nursey-Bray et al, 2022; Warbrick et al, 2023). However, the pace of climate change risks the severing of connections with taonga species and tohu, if knowledge adaptation cannot keep up with changes (Awatere et al, 2021; Bond et al, 2019; King et al, 2010; Paul et al, 2016; Penny et al, 2007a, 2007b; Warmenhoven et al, 2014).
- Taonga species are important for maintaining values such as authority (mana), knowledge (mātauranga), and passing knowledge to the next generation (whakaheke korero). The deterioration of some of these species risks disrupting the maintenance and transmission of tohu (Collier et al, 2017; Harmsworth, 2022b; Harmsworth & Awatere, 2013; Lyver et al, 2017a, 2017b, 2021; Mark et al, 2022; Taura et al, 2021).

Homes and livelihoods

The environment provides the foundation for our homes, infrastructure and livelihoods. It offers the resources and stability needed for a thriving society. However, environmental change, and in particular climate change, poses serious threats to homes, infrastructure and livelihoods. Extreme weather events, such as heavy rainfall, storms and wildfires, damage housing and infrastructure, particularly in flood-prone and drought-affected areas. Rising sea levels also threaten coastal communities through erosion and inundation, demanding costly repairs and long-term adaptation. Hydropower, which generates about 60 percent of New Zealand's electricity, is vulnerable to changing rainfall patterns and reduced snowmelt, reducing energy reliability (MBIE, 2023; MfE, 2024g).

Although some parts of New Zealand's economy, such as agriculture and forestry, are more visibly dependent on the environment, every sector relies on natural resources and ecosystems to some extent (see *Our land 2024*). In the year ended June 2024, primary industries contributed $53.3 billion to exports (MPI, 2024a). In the year ended March 2024, international tourism's contribution to total exports was $16.9 billion (Stats NZ, 2025).

Many industries – including agriculture, horticulture, forestry, tourism and fisheries – face risks from climate change (Lawrence et al, 2020). Short-term shocks, such as disrupted crop yields and damage to marine ecosystems, can require timely interventions to stabilise food production and protect vulnerable livelihoods. However, addressing the broader long-term impacts of climate change calls for more adaptive and sustainable strategies. The cumulative stress on ecosystems and decline of iconic landscapes necessitate a range of responses, including nature-based solutions. Restoring and enhancing wetlands, for instance, can provide resilient and cost-effective protection for homes, livelihoods and ecosystems. These approaches build adaptive capacity, ensuring ecosystems and communities can better withstand future climate challenges (Hobbie & Grimm, 2020).

Homes, infrastructure and energy supply

The impacts of climate change are being felt on our homes and infrastructure.

- Climate change, including more frequent and intense extreme weather, is increasingly causing daily impacts on our homes and infrastructure. Costs are rising due to disrupted supply chains, power cuts caused by extreme weather, and the need to evacuate homes due to fires or flooding (Grout et al, 2022).
- Flooding from rainfall and overflowing rivers can damage critical infrastructure including housing and transport, energy, stormwater and wastewater systems. Cyclone Gabrielle is an example of extreme weather that damaged vulnerable infrastructure, including water, transport, power and communication (Ministerial Inquiry into Land Use in Tairāwhiti and Wairoa, 2023). The wastewater treatment plant in Napier was seriously damaged and unable to operate, so that untreated sewage was released into the sea (Jones et al, 2023).
- Hydropower has provided an average of 57 percent of our electricity each year between 2010 and 2021, but this varies with rainfall. (Deep South, 2021; EECA, nd).
- In 2023, low rainfall in the South Island led to the lowest inflows to lakes Manapōuri and Te Anau since 1953. Heavy rainfall in the North Island took Lake Taupō storage to its limit, which, despite controlled release, led to minor flooding. This extreme rainfall is partially linked to La Niña and affects hydroelectricity storage and generation across the country. It may become more frequent with climate change (Deep South, 2021; Electricity Authority, 2023; see section 6: Atmosphere and climate).

Building in at-risk areas and facing more extreme weather makes us more vulnerable to climate change.

- Ongoing rural development and urban expansion expose more people to wildfire threats in some areas, due to the increasing proximity of homes to highly flammable vegetation such as ungrazed pastures or forestry plots (Huggins et al, 2020; Langer & Wegner, 2018; Langer et al, 2022). During the 2016/17 fire season, more homes were destroyed than in each of the previous 100 years, and this record was then surpassed in 2020/21 (Langer et al, 2021).
- Development near rivers restricts their natural flow, increasing flood risks to homes and infrastructure, while reducing the flexibility needed to adapt to climate change (Brierley et al, 2023; Hicks et al, 2021). Around 750,000 people and 500,000 buildings, worth more than $145 billion, are near rivers and in coastal areas already exposed to extreme flooding in New Zealand (Awatere et al, 2021; Paulik et al, 2023; see *Our atmosphere and climate 2023*).
- Coastal development has increased our vulnerability to extreme wave and storm events, and to the accelerating coastal erosion, inundation and flooding caused by sea-level rise (Awatere et al, 2021; Lawrence et al, 2020; Thompson, 2022). In 2019, 2,273 kilometres of roads, 5,572 kilometres of water pipes, 2,457 square kilometres of land, and buildings with a replacement value of $26.18 billion (2016) were assessed as vulnerable if sea levels rise by 0.6 metres (NIWA, 2019a).
- Sea-level rise will increasingly affect infrastructure in low-lying and coastal communities. This includes stormwater and wastewater services critical for health and sanitation that are also affected by extreme weather (Feng et al, 2021; Kool et al, 2020; PCE, 2015, 2023, 2024). Impacts from compromised wastewater services include odour, leaks and uncontrolled discharges that contaminate the environment, and will have a range of social, economic, health and cultural consequences (Hughes et al, 2021; Kool et al, 2020; Lawrence et al, 2020; see section 3: Freshwater).

Our livelihoods – including from primary industries and tourism – are at risk from a changing environment and climate

Climate change and extreme weather are making primary industries more vulnerable.

- Extreme weather events such as droughts and floods have cost New Zealand billions of dollars in the last five years (ICNZ, 2021), and the frequency and severity of these events are increasing (see section 6: Atmosphere and climate). Estimated damage to the food and fibre sector alone from Cyclone Gabrielle may total between $700 million and $1.1 billion in recovery costs (MPI, 2023g). In the lower South Island, during the flood event of February 2020, farmland and infrastructure were damaged and revenue was lost where milk tanker access was not possible (Griffin et al, 2023).
- The Māori economy is particularly vulnerable to climate change because Māori own a large share of assets in the primary sector (Awatere et al, 2021; BNZ, 2024; Haemata Limited, 2023; King et al, 2010; MFAT, 2019).
- Primary industries (eg, agriculture, horticulture, forestry, fisheries) rely on natural resources such as soil and freshwater. They are therefore expected to be highly affected by climate change. Changes in temperature, rainfall patterns and extreme weather events will affect freshwater and soil, with impacts for agriculture and horticulture (Ausseil et al, 2021; Case et al, 2023; Mourot et al, 2022; Salinger et al, 2019, 2020).

- Droughts reduce the availability of water for farming, which can negatively affect the economy. This also reduces employment and income (Bell et al, 2021; Nguyen et al, 2022). Snow and rainfall patterns are projected to shift due to climate change, with regional and seasonal variability that will affect patterns in the need and availability of water for irrigation (Mourot et al, 2022; Purdie, 2022; Queen et al, 2023).
- Forestry plantations are vulnerable to extreme weather events such as wildfires (Villamor et al, 2023; Watt et al, 2019). High-intensity fires incur high economic costs for forests and long recovery times. However, more frequent medium-intensity fires tend to cause the most economic damage (Blanc & Noy, 2024).
- The changing climate is also having a slow-burning effect by affecting the suitability of regions for producing different crops (Ausseil et al, 2021; Clothier et al, 2012; Lilburne et al, 2024; MPI, nd-a; Rajan et al, 2024; Salinger et al, 2019, 2020). Fruit production will be affected and needing changes to cultivation practices. Impacts include changes in fruit quality and quantity, changes in flowering and fruiting periods (Ausseil et al, 2021), and increasing risk of insufficient winter chilling (Rajan et al, 2024).
- Pests and diseases are compromising productivity in land-based industries, as they become more susceptible to new invasions (Keegan et al, 2022). Intensified production systems may be more vulnerable to disruption (Meurisse et al, 2023). The total costs of pests were estimated at $9.2 billion in 2019/20 (2.9 percent of gross domestic product), with about $4.3 billion attributed to losses in primary production (MPI, 2021c).
- Sea-level rise is expected to impact coastal agricultural land, increasing flooding and salinisation, particularly in areas below mean sea level (Craig et al, 2023).

Fisheries and aquaculture are affected by warming seas and marine heatwaves.

- Climate change, sedimentation, diseases and invasive species pose risks for aquaculture and fishing. Commercial fishing species such as snapper, hoki, pāua and kōura are among the many at-risk species (Awatere et al, 2021; King et al, 2010; Johnson et al, 2024; PMCSA, 2021). Warming sea temperatures and ocean acidification may affect some species and ecosystems that are important for aquaculture and wild-caught fisheries. For example, they may reduce the growth rate of shellfish (including flat oysters, green-lipped mussels and pāua) and of snapper and other fish (Cummings et al, 2021; Lundquist et al, 2023). However, ocean warming could increase the catch of flatfish, trevally and jack mackerel (Mediodia et al, 2024).
- Changes in the distribution of fish stocks due to changing ocean temperatures will affect fishery interests. Quotas are tied to specific areas or zones, posing a challenge for quota management if the related fish stocks relocate. Māori commercial fisheries hold about a third of the interests in New Zealand, so would be affected as part of this (Hudson, 2022).
- Commercial fisheries are also vulnerable to increased frequency and intensity of marine heatwaves. Moderate events are associated with increased fish catches, but higher-intensity events are associated with substantially lower catches (Lacheheb et al, 2024).

Tourism is at risk from changes in the environment and climate.

- New Zealand is renowned for its beautiful landscapes, which are important for attracting tourists (DOC, 2024; PwC, nd, 2023). Climate change, biodiversity loss, coastal erosion, shorter snow seasons and melting glaciers put the tourism industry at risk (Aotearoa Circle, 2023; PwC, nd).

- The decreasing volumes of ice in glaciers affect tourism, with challenges such as alpine access and tourist safety (Purdie et al, 2020; Wang and Zhou, 2019). At the Tasman Glacier, the effects of climate change have also resulted in opportunities to adapt to changing conditions. The rapidly expanding lake means visitors take boat tours to get close to the calving ice at the glacier edge, and shorter winter freezing allows a longer tourist season (Carver & Tweed, 2021; Purdie et al, 2020).
- Engaging with the night sky is important for cultural practices, astrotourism and astronomical research, but light pollution degrades these values. The creation of dark sky reserves is helping to protect areas from light pollution. They are popular tourist destinations and foster economic, social and cultural growth by preserving night-sky views and providing educational opportunities (Patterson, 2023; South Wairarapa District Council, nd; Tapada et al, 2021; Zielinska-Dabkowska & Xavia, 2021).

8. Knowledge gaps

In previous environmental reports, the ‘Knowledge gaps’ section identified specific gaps in each domain. This report takes a broader approach, identifying gaps that prevent us from understanding environmental change as a whole, and its impacts on people and their quality of life.

This recognises the interrelated nature of the drivers and pressures of environmental change, and their cumulative impacts on individuals, communities and ecosystems.

This section explores five themes to describe critical knowledge gaps that are holding us back – not only in understanding the drivers and consequences of environmental change, but also in effective actions and responses. These gaps echo challenges faced globally, highlighted by international initiatives such as the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Knowledge Taskforce, which emphasises the need for robust, interdisciplinary insights to address shared environmental issues (see IPBES Knowledge gaps).

Learning from both local experiences and international research can better address these gaps and equip Aotearoa New Zealand to tackle the complexities of environmental change.

Theme 1: Decoding drivers of change

Environmental change is driven by many complex factors, such as international influences, human population growth, individual consumer choices, and technological and climate change (see section 1: Drivers).

These drivers create environmental pressures that are interconnected, shaped by feedback loops and evolving over time. Understanding the dynamics is further complicated by spatial variations in drivers and pressures. A key knowledge gap about drivers, therefore, is disentangling these intricate relationships to determine which factors drive specific pressures across different times and places.

Addressing this gap requires advances in modelling techniques. The models must analyse data to identify patterns and feedback processes, isolate pressures and drivers, and predict how various factors (eg, economic policies, climate conditions, technological advancements and population growth) interact over time.

However, improving predictions for issues such as global warming and biodiversity loss highlights another critical gap: understanding how societies, economies and institutions are likely to respond. This requires further research in social sciences, including psychology, political science, economics, complexity science and socio-technical transitions.

Another gap lies in the development of robust scenario-based models to explore possible futures. These models enable the testing of ‘what-if’ scenarios, each with distinct assumptions or conditions. This illustrates a range of possibilities rather than a single forecast. For example, they are used to examine how future urbanisation in a specific area might interact with changing climate patterns, or to predict localised effects of policy changes such as urban green design. Advancing research in predictive scenario modelling will be essential to decode environmental change and support effective decisions.

Theme 2: Harnessing data to track change

Data gaps across all the domains in this report prevent deeper understanding of environmental patterns, processes and feedback loops. These data are critical for our understanding, and for informing modelling and decision making.

Since it is not possible to collect on-the ground observations for every location in New Zealand, modelling techniques can be used to fill gaps in unmeasured areas, using patterns across time and space. Investing in new technologies such as satellite imagery or eDNA can improve the scale and coverage of environmental data. However, it is essential to establish clear monitoring standards and methods for consistency, and to ground truth these new technologies. This is especially important as new technologies and service providers are advancing at pace.

Research on emerging pollutants and their impacts is another gap. The number of studies of microplastics, waste byproducts and liquid chemical pollutants in air, soils, and freshwater and marine environments is growing. However, we still need to quantify how widespread these are, understand their ecological impacts, and assess their role in climate change.

Monitoring and evaluating the effectiveness of policies and management interventions is another area where data are either poor or lacking. Reliable evaluation requires environmental baselines, targeted monitoring design, and robust data management. Standardising data collected at local or regional scales to measure the impact of interventions (eg, good land management practices) helps make clear links between action and response. Advances in artificial intelligence could support this by mining historical data and speeding up data cleaning and processing.

Data monitoring networks often rely on regional or local information, which may not represent national trends. Monitoring must allow for national representation, to understand the scale and extent of a problem. Global-scale models can also be used through downscaling to fit to our context. Clear data management (eg, standardisation, consistent terminology) and detailed metadata are essential to avoid misinterpretation and to facilitate greater reuse of data (eg, land use or ecosystem classification systems; Law et al, 2024; Sprague & Wiser, 2024). Many foundational datasets are curated by public organisations such as Crown research institutes or universities. Balancing open access to shared data with privacy and sovereignty protection is key to ensuring informed decisions that benefit everyone.

Theme 3: Understanding interactions and cumulative impacts

The environmental domains we report on (land, freshwater, marine, air, and atmosphere and climate) are interconnected. Ecological and social processes frequently interact, often leading to cumulative effects on ecosystems and people. For example, pollution, climate change, invasive species and land-use change combine with and amplify each other’s impacts.

Understanding these dynamics requires an integrated ecosystem-level approach. This would bring together diverse data sources to reveal cause-and-effect relationships, as well as tipping points (where a small change or event causes a significant and permanent change in environmental state), and to identify opportunities for action.

There are three knowledge gaps here to overcome:

- the limited availability of data
- difficulties in integrating data as well as linking techniques, for example linking land use with water quality to identify cause and effect, and overcome complicating factors such as lag times and legacy effects
- research and models that can link this environmental change to impacts on people. For example, the development of adaptation strategies would benefit from better understanding of the interdependencies among climate, urban infrastructure (including services), financial services (including banking and insurance) and governance systems.

A similar set of challenges must be overcome to visualise interactions between climate, water, food, biodiversity and people (IPBES, 2024b). Changes to land use, for example, often affect freshwater and marine ecosystems and their services (eg, food production, and water for irrigation).

Advanced models, decision tools and even 'digital twins' are critical to bridging these gaps. They can help simulate the interactions across systems, understand chain reactions and evaluate the impacts and co-benefits of interventions. An integrated understanding of the processes by which one part of a social-ecological system has flow-on effects to another is vital to address both current risks and future uncertainties.

Theme 4: Mātauranga Māori and place-based knowledge

Mātauranga Māori (Māori knowledge) provides a rich and unique record of changes in the environment, and the impact on people and their quality of life. Mātauranga Māori does not separate the environment into domains, nor people from it. It therefore helps us understand the cumulative effects of environmental change on individuals, communities and ecosystems more holistically.

Despite the significance of mātauranga Māori, gaps remain in bringing it into environmental reporting and how it affects the Māori worldview (te ao Māori). The following are some of the areas that remain to be addressed.

- Systematically collect, manage and make available environmental indicators (ngā tohu o te taiao) and place-based knowledge – while respecting Māori data sovereignty.
- Interweave mātauranga Māori with conventional scientific methods. Frameworks that respect and integrate both knowledge systems can provide a more comprehensive understanding of environmental state and trends. Environmental reporting often lacks the storytelling and cultural narratives central to mātauranga Māori. Incorporating these can provide richer, more meaningful insights into environmental change and impact on the environment (te taiao), people and their quality of life.
- Actively value mātauranga Māori as a knowledge system. This creates a foundation for collaboration and mutual respect. This partnership is more likely to promote environmental stewardship.
- Acknowledge the growing economic benefits of Māori involvement in primary industries such as agriculture, forestry, aquaculture and fisheries. This provides another avenue to address gaps in the way we utilise mātauranga Māori, as well as generate new knowledge. By leveraging cultural wisdom and sustainable practices, we can enhance economic outcomes while ensuring environmental sustainability.

Addressing these gaps will not only enhance environmental reporting, but also uphold the principles of te Tiriti o Waitangi (the Treaty of Waitangi). This will foster a more inclusive and effective approach to environmental stewardship.

Theme 5: Connecting environmental change to quality of life

There is limited understanding of how environmental change affects people's quality of life. This makes it challenging to determine whether the changes have positive or negative effects. For example, ecosystems provide essential services – such as clean air, water and food – which support economic stability, health and community resilience. However, quantifying these contributions is complex, particularly with intangible benefits such as mental health support from green spaces, or cultural ties to landscapes.

Our relationships with nature vary between people and communities, and also shift over time due to social changes. This makes it difficult to assign consistent values to these benefits, and highlights a significant knowledge gap – developing robust, reliable and adaptive valuation methods for ecosystem services, especially for non-market benefits (Ausseil et al, 2021; Maechler & Boisvert, 2024). To more inclusively capture the full spectrum of effects on people's relationships with nature, these methods must account for social and cultural differences, and variations across different locations and over time.

Equally important is understanding risks and resilience in the face of environmental challenges. Predicting health impacts, such as from air pollution, requires advanced modelling to anticipate exposure levels and outcomes. Similarly, identifying the communities most at risk, whether from rising sea levels, extreme weather or resource scarcity, is vital for targeted interventions and ensuring certainty for development in lower-risk areas. To create lasting solutions, we need new methods to measure adaptation progress and resilience. With improved assessment, we can better understand trade-offs and develop strategies that not only protect ecosystems and vulnerable populations, but also enhance quality of life in a rapidly changing world.

Additional information

Environmental indicators

Below are the indicators incorporated in this report.

- Active sand dune extent
- Air pollutant emissions
- Annual glacier ice volumes
- Atmospheric ozone
- Carbon monoxide concentrations: Data to 2023
- Coastal and estuarine water quality
- Coastal sea-level rise
- Consented freshwater takes
- Deposited sediment in rivers
- Drought
- El Niño Southern Oscillation
- Estimated long-term soil erosion: Data to 2022
- Exotic land cover
- Extinction threat to indigenous species
- Extreme rainfall
- Extreme wind
- Fertilisers – nitrogen and phosphorus
- Freshwater physical habitat
- Frost and growing degree days
- Greenhouse gas concentrations
- Ground-level ozone concentrations: Data to 2023
- Highly erodible land: Data to 2022
- Human health impacts of $PM_{2.5}$ and NO_2
- Indigenous land cover
- Interdecadal Pacific Oscillation
- Irrigated land: Data to 2022
- Lake submerged plant index
- Lake water quality
- Land fragmentation
- Land pests
- Livestock numbers: Data to 2023
- Marine non-indigenous species: Data to 2022

- Marine primary productivity: Data to 2023
- Nitrogen dioxide concentrations: Data to 2023
- Ocean acidification
- PM_{10} concentrations (air quality): Data to 2023
- $PM_{2.5}$ concentrations (air quality): Data to 2023
- Predicted pre-human vegetation
- Rainfall
- River water quality – heavy metals: Data to 2022
- River water quality: clarity and turbidity
- River water quality: Escherichia coli
- River water quality: macroinvertebrate community index
- River water quality: nitrogen
- River water quality: phosphorus
- Sea-surface temperature: Data to 2023
- Soil quality and land use
- Southern Annular Mode
- Sulphur dioxide concentrations: Data to 2023
- Temperature
- Urban land cover
- Wetland area
- Wildfire risk

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Infographics

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