Our environment 2025
Tō tātou taiao
Technical annex
Āpitihanga hangarau

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

Ministry for the Environment
Manatū Mō Te Taiao

Stats NZ
Tatauranga Aotearoa

Contents

Tables

This technical annex provides more detailed context for the use of evidence from Stats NZ indicators and other sources in *Our environment 2025*. The sources cited within this document are fully referenced in *Our environment 2025* (see References).

Trend certainty and reporting terminology

See indicators and references for more information.

- In Stats NZ indicators, trends describe how the data is changing over time. Trend likelihoods are reported using categories describing the certainty of trends adapted from the Intergovernmental Panel on Climate Change (Mastrandrea et al, 2010). Stats NZ classify trends as 'likely' when the probability of an increasing or decreasing trend is above 66 percent, and as 'very likely' when the probability is above 90 percent.

- In *Our environment 2025*, the proportion of sites with 'likely' and 'very likely' increasing trends for a given variable are reported together as a single statistic, described as 'increasing' (or 'improving' or 'worsening' – see following bullets). Similarly, the proportion of sites with 'likely' and 'very likely' decreasing trends are reported together as a single statistic, described as 'decreasing' (or 'improving' or 'worsening' – see following bullets).

- For measured variables where a detected trend does not necessarily indicate a worsening or improving state or an increasing or decreasing pressure on the environment (including people), the trend is reported as 'increasing' if the measurement is increasing, or 'decreasing' if the measurement is decreasing.

- For measured variables where a detected trend (whether increasing or decreasing) indicates a worsening state or an increasing pressure on the environment (including people), the trend is reported as 'worsening'. For variables where a trend indicates an improving state or a decreasing pressure, the trend is reported as 'improving'.

- The trend that describes the largest proportion of analysed sites for a given variable is reported first, and the trend that describes the smaller proportion of sites is reported second. For brevity, the proportion of sites with no detectable trend is not reported.

- Exceptions to these methods apply in some cases, and these are noted in-text, in the following headings for the individual chapters, or both.

Extinction threat to indigenous species

Extinction threat to indigenous species indicator

See indicator: Extinction threat to indigenous species.

- **Conservation status:** The indicator reports the extinction threat categories and estimated population trend of indigenous, resident, living species in Aotearoa New Zealand, as assessed by expert panels under the New Zealand Threat Classification System (NZTCS) developed by the Department of Conservation (DOC). Experts assign a conservation status based on criteria of abundance, distribution and population trends over time. The NZTCS provides a national process to assess the conservation status of plants, animals and fungi. It complements the International Union for Conservation of Nature's Red list of Threatened Species.

- **Extinction threat:** Species are given an extinction threat category: threatened, at risk, not threatened, or data deficient. Threatened is a higher extinction threat than at risk. The threatened category includes nationally critical, nationally endangered, nationally vulnerable, and nationally increasing – in order of decreasing risk.

  Our environment 2025 reports the proportion of species in each species category that are threatened or at risk, but for brevity, does not report the proportion that are not threated or data deficient in-text.

- **Species assessed:** Not all species within a species group are known or described. Findings are only reported for species groups where all known species have been assessed, that is, bats; birds; freshwater fish; frogs; hornworts and liverworts; lichens; marine mammals; reptiles; sharks, rays, and chimaeras; and vascular plants. For brevity, *Our environment 2025* does not report in-text on species with only some known species assessed, but these are shown figures 2, 4, and 6. Marine and freshwater taonga species are reported regardless of whether they are from a group that has been fully assessed.

- **Data deficient:** A species is classified as 'data deficient' when it has been assessed but there is insufficient information available to categorise its conservation status. Conclusions on groups with all known species assessed but with high proportions of data deficient species should be made with care. The data deficient category may include threatened species.

- **Population trend:** Population trend is estimated over the longest of 10 years or 3 generations. Generation length is the average age of breeding females. Estimates are standardised from historic, current and predicted trends, and known impacts of threats and management to express the current status of a species. When there is insufficient information available to estimate a population trend, the trend is classified as 'not available'. Conclusions should be made with care where population trends, for a group of species, are partially estimated.

  Our environment 2025 generally reports the changing trend (increasing or decreasing) that applies to the largest proportion of species first, followed by the changing trend that applies to the lesser proportion of species. It generally does not report the proportion with a stable population trend, unless this is specifically required for context.

- **Marine and freshwater taonga species:** The indicator web page lists the 29 marine and 18 freshwater taonga species included in this report, along with the approach used to identify these species.

  Our environment 2025 also refers to 12 of 19 native freshwater-dependent bird species identified as taonga through a separate approach used in *Our freshwater 2023*, some of which were also identified for the indicator and are described on the indicator page as marine taonga species.

- **Assigning species groups to environmental domains for *Our environment 2025*:** Species were assigned to marine, freshwater or terrestrial domains based on the environment classification within New Zealand Threat Classification System data. (See indicator: Extinction threat to indigenous species for data download.)

Extinction threat statuses and estimated population trends from New Zealand Threat Classification System status reports

See nztcs.org.nz/content/home_about for more information on the New Zealand Threat Classification System.

- *Our environment 2025* reports the proportion of species in each species category that are threatened or at risk, but for brevity, does not report the proportion that are not threated or data deficient in-text.

- *Our environment 2025* generally reports the changing trend (increasing or decreasing) that applies to the largest proportion of species first, followed by the changing trend that applies to the lesser proportion of species. It generally does not report the proportion with a stable population trend, unless this is specifically required for context.

For indigenous species groupings that have had one or more species or groups assessed since the *Extinction threat to indigenous species* indicator was published, *Our environment 2025* uses data directly from Department of Conservation Threat Classification System status reports.

- **Bats** were previously assessed in 2017. *Our environment 2025* uses data from the most recent assessment in 2022, reported in 2023 (O'Donnell et al, 2023). All known indigenous bat species were assessed by DOC.

- **Frogs** were previously assessed in 2017. *Our environment 2025* uses data from the most recent assessment in 2024, reported in 2025 (Burns et al, 2025). All known indigenous frog species were assessed by DOC.

- **Marine invertebrates** were previously assessed in 2013. *Our environment 2025* uses data from the most recent assessment in 2021, reported in 2024 (Funnell et al, 2023). Only a portion of known marine invertebrate species were assessed by DOC. Also note that three nematode species were duplicated in the NZTCS dataset – in all cases we report the latest assessment of their information and removed the old assessment.

- **Terrestrial invertebrates** were previously assessed between 2005 and 2021, depending on the species group. *Our environment 2025* uses data from the most recent assessments in 2022, reported in 2022 and 2024 (Trewick et al, 2022; Walker et al, 2024a), which updated older data, so the new assessments were assessed between 2010 and 2024. Only a portion of known terrestrial invertebrate species were assessed by DOC. Since two reports (Terrestrial Gastropoda: 3. Rhytididae (carnivorous snails), 2022 (Walker et al, 2024a);

Orthoptera 2022 (Trewick et al, 2022)) that make up this group in the indicator were updated, all 19 datasets for this group were sourced from the NZTCS.

- **Vascular plants** were previously assessed in 2017. *Our environment 2025* uses data from the most recent assessment in 2023, reported in 2024 (de Lange et al, 2024). All known indigenous vascular plant species were assessed by DOC.

Land

Highly erodible land

See indicator: Highly erodible land: Data to 2022.

- This indicator uses the Highly Erodible Land (HEL) model to identify land at risk to the main forms of mass-movement soil erosion in Aotearoa New Zealand (landslide, earthflow and gully) if it does not have protective woody vegetation. The HEL model identifies where highly erodible land is located, but not the amount of sediment moved.

- The model categorises erosion risk into five classes:

  1. high landslide risk / delivery to stream

  2. high landslide risk / non-delivery to steam

  3. moderate earthflow risk

  4. severe earthflow risk

  5. gully risk.

  These classes are not ranked in severity, except for earthflow risk, which has severe and moderate classes of risk. Landslide erosion is the sudden failure of soil slopes during storm rainfall. Earthflow erosion is the slow downward movement of wet soil slopes towards waterways. Gully erosion is massive soil erosion that begins at gully heads and expands up hillsides over decadal time scales.

- Soil erosion is modelled using three factors: slope, land cover and erosion terrain. The HEL model uses a digital elevation model to identify slopes, incorporates different erosion terrains and erosion thresholds, and uses land-cover mapping from the national Land Cover Database (LCDB) or a 'Woody layer' to describe vegetation, built environments, water bodies, and bare natural surfaces.

- The model used to identify areas at risk of soil erosion does not consider whether an area has space-planted trees (an erosion mitigation activity) because this information is not available nationwide. Slope failure from earthquakes is also not considered in the model.

Land fragmentation

See indicator: Land fragmentation.

- This indicator measures changes in total highly productive land (HPL) area and the distribution of this land area across different land parcel size classes, since 2002.

- HPL is defined by land-use capability (LUC), and includes classes 1, 2 and 3 (land highly suitable for growing a range of crops). The LUC system is the most common system councils use to classify highly productive land and considers physical factors (rock type, soil, slope, severity of erosion, and vegetation) as well as inventory factors (climate, the effects of past land use, and potential for erosion). Under the LUC system, land is categorised into eight classes according to its long-term capability to sustain one or more productive uses. Land that is classified as Class 1 under the LUC system is the most versatile and has the fewest limitations for use, while Class 8 is the least versatile with the highest limitations for use.

- Land fragmentation is assessed against two potential impacts: land that cannot be used or is restricted from use as farmland because of its new residential or urban land use ('land restricted from use as farmland') and land which may still be able to be used for growing/production ('land potentially available for use as farmland').

Freshwater

Trend periods

See indicators: River water quality: clarity and turbidity, River water quality: macroinvertebrate community index, and Lake water quality; Kuczynski et al, 2024 and Moreau et al, 2025.

- Where multiple trend periods were available, a single trend period has been reported for simplicity of communication.

- Twenty-year trends (2001 to 2020) are presented for rivers because of the strong influence of natural climate variation on shorter trend periods for rivers and lakes (Snelder et al, 2021). Ten- and 30-year trends are available for river water quality indicators and are reported on the indicator web pages.

- Ten-year trends are presented for lakes because monitoring data to broadly support reporting 20-year trends was limited. Trends for trophic level index are reported for 2011 to 2020, based on the Lake water quality indicator. Trends for *Escherichia coli* (*E. coli*) are reported for 2012 to 2022 from Kuczynski et al, 2024 instead of the indicator, because *E. coli* trends were not calculated for the indicator. Twenty-year trends are available for several lakes and can be viewed in Kuczynski et al, 2024.

- Twenty-year trends are reported for groundwater quality, to align with the 20-year trend period used for rivers. Ten- and 30-year trends are available for groundwater quality and can be viewed in Moreau et al, 2025.

National groundwater quality statistics for *Escherichia coli* and nitrate–nitrogen from Moreau et al, 2025

See Moreau et al, 2025; Taumata Arowai, 2024.

- The national groundwater quality findings reported from Moreau et al, 2025 update the *E. coli* and nitrate-nitrogen findings reported in the Stats NZ Groundwater quality indicator published in April 2020. (See indicator: Groundwater quality.) Moreau et al, 2025 reports statistics for 1994 to 2023, and the indicator reports statistics for 1999 to 2018.

- Moreau et al, 2025 used groundwater data from territorial authorities across Aotearoa New Zealand, and from the National Groundwater Monitoring Programme (NGMP), to provide as comprehensive a representation of monitored groundwater quality in New Zealand as data availability allows.

- Data harvesting and processing, and statistical methods and interpretations, for Moreau et al, 2025, were intentionally harmonised to the maximum-extent-practicable with those used for Stats NZ's water quality indicators. This is to enable a standard approach to reporting water quality in the Environmental Reporting Series reports. This approach, and reported findings, are likely to be similar to those included in the next update to the Groundwater quality indicator, but may differ due to methodological, or other, differences.

- Nitrate-nitrogen and *E. coli* monitoring data for all monitored wells are compared to the maximum allowable values set in the New Zealand Drinking Water Standards (NZ-DWS) for these contaminants. This is to understand the extent to which these contaminants are present in New Zealand groundwaters at levels that pose known health risks to people if they drink this water untreated. This is different than the monitoring of drinking water sources and supplied water that is undertaken by water suppliers, which is done to ensure supplied drinking water is adequately treated to ensure it is safe to drink (Taumata Arowai, 2024).

Measured and modelled water quality for rivers and lakes

See indicators: River water quality: clarity and turbidity, River water quality: macroinvertebrate community index, and Lake water quality; Wood et al, 2023.

- Modelled data are used to report water quality state for rivers and lakes where they are available, because they are nationally representative. The models estimate water quality for all river segments in New Zealand, and for all of New Zealand's lakes larger than 1 hectare. Models are based on measured data, and a suite of predictor variables like land cover and elevation.

- For simplicity of communication, measured data are not reported for state if models are available. Summary statistics for measured data can be viewed on the indicator web pages and in Wood et al, 2023.

- Trends are reported for measured data only, as it would not be appropriate to assess trends using modelled data.

Selection of river and lake water quality indicators and variables for reporting ecosystem health

See indicators: River water quality: clarity and turbidity, River water quality: macroinvertebrate community index, and Lake water quality.

- For simplicity of communication, *Our environment 2025* exclusively uses macroinvertebrate community index (MCI) scores to report river degradation from excess nutrients. It does not cite or refer to findings from the nutrient indicators River water quality: nitrogen or River water quality: phosphorus, which can be viewed on the web pages for those indicators. As a biotic index that measures the response of species communities to organic pollution and enrichment from multiple forms nutrients, MCI provides the best high-level indication of the extent of nutrient impacts on the health of river ecosystems.

- *Our environment 2025* uses water clarity from the River water quality: clarity and turbidity and Lake water quality indicators to report on habitat degradation, because sediment pollution is a focal pressure on habitats and reduces clarity. Turbidity, which provides a similar measure of degradation from suspended material, is omitted in favour of clarity because clarity has ecosystem health reference values in the National Policy Statement for Freshwater Management 2020 (NPS-FM 2020, Table 8) (MfE, 2024f). Turbidity findings can be viewed on the River water quality: clarity and turbidity indicator web page.

- MCI and clarity data are compared to the National Objectives Framework (NOF) ecosystem health bands (reference values) in the NPS-FM 2020 (Tables 9, 14 and 15) to understand the extent of ecosystem impacts that could be occurring because of water quality (MfE, 2024f). For simplicity of communication, *Our environment 2025* reports the proportion of river length in bands A or B (indicating minimal to moderate impact) and compares this to the proportion in bands C or D (indicating moderate to high impact).

- For simplicity of communication, *Our environment 2025* exclusively uses trophic level index (TLI) scores to report degradation of lakes from excess nutrients. It does not cite or summarise findings from the individual indicators of nutrient enrichment (chlorophyll-a (algae), total phosphorus, total nitrogen, ammoniacal nitrogen, nitrate-nitrogen, and clarity), which can be viewed on the Lake water quality indicator web page. As an index of several of these individual indicators (chlorophyll-a, total phosphorus and total nitrogen) TLI provides the best high-level indication of the extent of nutrient impacts on the health of lake ecosystems.

Modelled trophic level index (TLI) scores for lakes

See indicator: Lake water quality; Wood et al, 2023.

- Models of TLI scores are used to predict the ecosystem health state of all New Zealand's lakes larger than one hectare. Lakes are classified into one of five trophic levels: microtrophic (very good), oligotrophic (good), mesotrophic (average), eutrophic (poor) and supertrophic (very poor).

- *Our environment 2025* intentionally cites findings from two TLI models to report lake ecosystem health:

  - a random forest model to report the proportion of lakes in poor and very poor health (per Snelder et al, 2022; for 2016 to 2020, see indicator: Lake water quality),

  - an extreme boosting model to report the proportion of lakes in good or very good health (per Wood et al, 2023; for 2018 to 2021).

  Using this updated model, Wood et al, 2023 found that predictions for poor and very poor lakes were well-aligned with those reported in the indicator, so *Our environment 2025* has not overwritten these. However, it found that the random forest model used for the indicator significantly underestimated the proportion of lakes that are likely in good or very good health, so *Our environment 2025* has deferred to the Wood et al, 2023 findings for these lakes.

Suitability of rivers and lakes for activities like swimming

See indicators: River water quality: Escherichia coli and Lake water quality.

- The NPS-FM 2020 bases suitability for contact recreation on the risk of infection from the faecal pathogen *Campylobacter*, which is estimated using *E. coli* concentrations. Risk categories are defined in Table 9 of the NPS-FM as NOF attribute bands A through E, with band A carrying the lowest risk and band E the highest (MfE, 2024f).

- Stats NZ used models to predict *E. coli* concentrations (or counts) for all of New Zealand's rivers, and all of its lakes larger than 1 hectare. *Our environment 2025* compares these concentrations to the NOF attribute bands for *E. coli* to understand the general suitability of New Zealand's water bodies for 'contact' recreation (swimming, or other activity where contact with water can lead to its accidental ingestion). The NOF band for each river section and lake was determined based on its modelled *E. coli* concentrations for 2016 to 2020. River sections and lakes with a predicted average *Campylobacter* infection risk greater than 3 percent were classified into bands D (Orange) or E (Red) and assessed as being unsuitable for contact recreation based on this risk.

- This reporting is different than the information published by Land Air Water Aotearoa, which uses recent, site-specific *E. coli* and toxic algae monitoring results from swimming sites to inform the public whether these locations are safe for swimming (see lawa.org.nz/explore-data/swimming).

Marine

Coastal and estuarine water quality measures

See indicator: Coastal and estuarine water quality.

- The coastal and estuarine water quality measures in Aotearoa New Zealand between 2006 and 2020 are reported based on 15 key indicators. These indicators are grouped into four categories:

  - nutrient (ammoniacal nitrogen, nitrate-nitrite nitrogen, total nitrogen (unfiltered)

  - dissolved reactive phosphorus, and total phosphorus (unfiltered)), microbiological (faecal coliforms, Enterococci, and chlorophyll-a)

  - optical (visual clarity, turbidity, and suspended solids)

  - physico-chemical measures (dissolved oxygen, pH, salinity, and temperature).

- The state of each measure was assessed for the period from 2016 to 2020. Trends were analysed for the period from 2006 to 2020.

- The trend analysis included data from six regional councils and unitary authorities: Northland, Auckland, Bay of Plenty, Hawke's Bay, Canterbury and Southland. However, there were gaps in coverage in other regions such as Waikato, Gisborne, Taranaki, Horizons, Greater Wellington, Tasman, Marlborough, Nelson City, West Coast and Otago.

- Monitoring sites were not distributed randomly or evenly around the coastline of New Zealand but were instead clustered around urban centres. Caution must be exercised, therefore, when drawing inferences from these analyses about their representativeness of (a) all of New Zealand's coastline; and (b) the influences of all of New Zealand's land uses on estuarine and coastal water quality.

Marine primary productivity

See indicator: Marine primary productivity.

- This indicator estimates the concentration of phytoplankton in ocean water by estimating chlorophyll-a (chl-a) concentrations (in milligrams per cubic metre, mg/m³) in the coastal (territorial) and oceanic waters around New Zealand. Higher near-surface concentrations of chl-a are generally indicative of higher primary productivity – the amount of energy going into the base of most marine food webs.

- Satellite measurements of chl-a in surface waters over time are used as a proxy for phytoplankton primary production. Chl-a average concentrations (by season, year and over the whole time series) and anomalies (changes from long-term average concentrations) are reported for coastal regions around New Zealand (up to 12 nautical miles offshore) between 1998 and 2022, as well as four oceanic regions: Chatham Rise, Subtropical Water, Subantarctic Water and Tasman Sea between 1998 and 2023. Note that the angle of the sun is too low to reliably measure chl-a concentrations in southern regions during winter.

- Two datasets are used: one for coastal chl-a (from the Copernicus Marine Environment Monitoring Service, which generates chl-a estimates at 4km resolution) and another for oceanic chl-a (combining data from two ocean colour satellite sensors SeaWiFS and MODIS-Aqua at 9km resolution). Differences in spatial resolution, data processing, and length of time series mean that caution should be applied when comparing the datasets

- Average annual trends in chl-a concentrations are calculated using the Theil-Sen slope estimator. Trend direction and likelihood are estimated using an adjusted Mann-Kendall to account for autocorrelation. Trends are calculated over the whole year for northern regions, but chl-a concentrations cannot be measured reliably in southern regions during winter, so trends in Subantarctic waters are indicative only.

Air

NESAQ and WHO guidelines for air quality

- This report evaluates monitored data against two primary air quality standards or guidelines – one national and one international – to indicate potential impacts on human health.

- Nationally, the Resource Management National Environmental Standards for Air Quality (NESAQ) Regulations 2004 set legally binding levels of air pollution that must not be exceeded. In addition, the WHO Global Air Quality Guidelines (WHO, 2021) (WHO guidelines) are non-binding international guidelines based on an evaluation of the most recent science on health impacts from air pollution and identify air pollution levels above which there are significant risks to human health. Table 1 summarises the guidelines and standards we report against from each of these sources.

Table 1: **National Environmental Standards for Air Quality (NESAQ) and World Health Organization (WHO) air quality guidelines for particulate matter (PM$_{2.5}$, PM$_{10}$), ozone, nitrogen dioxide, sulphur dioxide and carbon monoxide**

Air pollutant	NESAQ			WHO air quality guidelines	
	Time period	Concentration	Number of exceedances allowed	Time period	Concentration
Particulate matter (PM$_{10}$)	24-hour	50 µg/m^3	1 in a 12-month period	24-hour[a]	45 µg/m^3
				Annual	15 µg/m^3
Fine particulate matter (PM$_{2.5}$)	No standard	No standard	No standard	24-hour[a]	15 µg/m^3
				Annual	5 µg/m^3
Nitrogen dioxide (NO$_2$)	1-hour	200 µg/m^3	9 in a 12-month period	24-hour[a]	25 µg/m^3
				Annual	10 µg/m^3
Sulphur dioxide (SO$_2$)	1-hour	350 µg/m^3	9 in a 12-month period	24-hour[a]	40 µg/m^3
	1-hour	570 µg/m^3	None		
Ozone (O$_3$)	1-hour	150 µg/m^3	None	8-hour[a]	100 µg/m^3
				Peak season[b]	60 µg/m^3
Carbon monoxide (CO)	8-hour	10 mg/m^3	1 in a 12-month period	24-hour[a]	4 mg/m^3

Notes:

a: 99th percentile (ie, 3–4 exceedance days per year).

b: average of daily maximum 8-hour mean O$_3$ concentration in the six consecutive months with the highest six month running-average O$_3$ concentration

µg/m³: micrograms per cubic metre

mg/m³: milligrams per cubic metre

Indicators of air quality: sites description and trend assessments

- **Trend assessments:** All trends were assessed at the 95 percent confidence level. Where a trend was 'indeterminate', there was not enough certainty to determine a trend direction. Stats NZ only included sites in our analysis of trends where both sampling location and instrumentation were consistent for the considered period. For more information, see the indicators.

- **Observed coarse particulate matter (PM_{10}) concentrations** are reported from 58 monitoring sites across Aotearoa New Zealand. Daily exceedances, along with 24-hour and annual average PM_{10}, are reported for state between 2020 and 2023. Annual average daily concentrations are also available. Annual trends are reported for 41 sites between 2016 and 2023. (See indicator: PM_{10} concentrations (air quality): Data to 2023.)

- **Observed fine particulate matter ($PM_{2.5}$) concentrations** are reported from 31 monitoring sites across New Zealand. Annual average and 24-hour $PM_{2.5}$ are reported for state, as well as annual average daily concentrations, between 2020 and 2023. Annual trends are reported for 16 sites between 2016 and 2023. (See indicator: $PM_{2.5}$ concentrations (air quality): Data to 2023.)

- **Observed nitrogen dioxide (NO_2) concentrations** are reported from two data sources: 10 monitoring sites from regional councils and unitary authorities, and 114 monitoring sites from the New Zealand Transport Agency's (NZTA's) monitoring network. For the regional council and unitary authority monitoring network, hourly exceedances, along with 24-hour and annual average NO_2 concentrations are reported for state between 2020 and 2023. Annual trends are reported for 9 sites between 2016 and 2023. For the NZTA network, annual trends are presented for 114 sites between 2014 and 2023. (See indicator: Nitrogen dioxide concentrations: Data to 2023.)

- **Observed sulphur dioxide (SO_2) concentrations** are reported from 9 monitoring sites across New Zealand. Hourly exceedances and 24-hour SO_2 are reported for state between 2020 and 2023. Annual average daily concentrations are also reported. Annual trends are reported for 4 sites between 2016 and 2023. (See indicator: Sulphur dioxide concentrations: Data to 2023.)

- **Observed carbon monoxide (CO) concentrations** are reported from 4 monitoring sites across the Auckland and Greater Wellington regions. State is reported at 4 sites between 2020 and 2023, and trends across 3 sites for the period between 2016 and 2023. (See indicator: Carbon monoxide concentrations: Data to 2023.)

- **Observed ground-level ozone (O_3) concentrations** are reported from 2 monitoring sites: Patumāhoe and Wellington Central. Hourly exceedances, along with 8-hour averages are reported for state between 2020 and 2023. Eight-year trends from 2016 to 2023 are reported. (See indicator: Ground-level ozone concentrations: Data to 2023.)

Human health impact and social costs of air pollution

- Evidence supported by the indicator: Human health impacts of $PM_{2.5}$ and NO_2 has been updated with information from the latest Health and Air Pollution in New Zealand (HAPINZ) release, with data up to 2019 (Metcalfe & Kuschel, 2023) (see table 2).

- Metcalfe and Kuschel (2023) also estimated the social costs from $PM_{2.5}$ and NO_2 as $15,613 million in 2016 and $15,267 million in 2019.

Table 2: **Estimated human health impacts per year from $PM_{2.5}$ and NO_2 air pollution in 2016 and 2019**

	2016 (See indicator: Human health impacts of $PM_{2.5}$ and NO_2)	2019 (Metcalfe & Kuschel, 2023)
Cases due to $PM_{2.5}$		
Premature deaths (30+ years)	1,292	1,275
Cardiovascular hospitalisations (all ages)	2,639	2,746
Respiratory hospitalisations (all ages)	1,985	2,041
Restricted activity days (all ages)	1,745,354	1,771,197
Cases due to NO_2		
Premature deaths (all adults)	2,025	1,964
Cardiovascular hospitalisations (all ages)	1,987	2,010
Respiratory hospitalisations (all ages)	6,544	6,440
Asthma prevalence (0–18 years)	13,229	12,653

Atmosphere and climate

Greenhouse gas emissions for New Zealand

- This report used the 2024 submission of the New Zealand's Greenhouse Gas Inventory 1990–2022 (MfE, 2024c) because it contains the most up-to-date information.

- Greenhouse gas emissions for Aotearoa New Zealand presented in this report are not directly comparable with values presented in the previous environmental reports. This is because inventory estimates are continuously improved. The whole inventory time series, from the base year (1990) to the latest year, is recalculated when the methodology or underlying data change. This means the emissions estimates are only up to date in the latest inventory, and previous inventories are not useful for comparisons. Changes made to the inventory are often related to improvements in activity data collection, emission factors and methodology, or the identification of additional emission sources.

Climate site descriptions and trend assessments

- **Climate stations:** Stats NZ atmosphere and climate indicator information in *Our environment 2025* is based on data from 30 sites that use NIWA's climate stations for the following indicators: Temperature, Frost and growing degree days, Rainfall, Extreme rainfall, Drought, Extreme wind, El Niño Southern Oscillation, and Wildfire risk. These sites are spread across New Zealand, in locations designed to capture data in the areas where most people live, while also reflecting monitoring practicalities. As such, lower elevation coastal areas have a high representation and inland higher elevation locations have a low representation.

- **Extreme rainfall:** Extreme rainfall (R95pTOT) measures the percentage of annual rainfall from very wet days, where very wet days are defined as those where the daily rainfall exceeds the 95th percentile of daily rainfall totals. For this release, the latest climate normal (1991 to 2020 average) was used to determine the 95th percentile range, where daily rainfall total is greater than or equal to 1mm. (See indicator: Extreme rainfall.)

- **Drought:** This indicator uses the Standardised Precipitation Evapotranspiration Index (SPEI) which incorporates temperature and precipitation. SPEI allows drought to be assessed in the context of increasing temperature associated with climate change. SPEI is applied to three different periods: short-term (3 months), medium-term (6 months), and long-term (12 months), approximately equivalent to meteorological, agricultural and hydrological drought, respectively. (See indicator: Drought.)

- **Extreme wind:** Extreme wind measures the annual average of the daily maximum wind gust (a measure of windiness) and annual maximum wind gust (a measure of wind strength). (See indicator: Extreme wind.)

- **Wildfire:** Comparison of fire risk between sites is complicated due to differences in fuel type at each station used for analysis. A fuel type may be one of 'forest', 'grass' or 'scrub', and was derived for each station based on Land Information New Zealand geographic databases. Comparing between sites is therefore not appropriate, because the calculated wildfire risk is dependent on fuel type. Nevertheless, the data support the assessment of trends over time for each site. (See indicator: Wildfire risk.)

Frequency of extreme temperature events in Thomas et al, 2023

(See Thomas et al, 2023.)

- Thomas et al, (2023) quantify how human influences have altered the frequency of extreme temperatures in New Zealand. Using regional climate models, the authors compare pre-industrial conditions (natural scenarios with no human-induced changes) and present-day conditions (anthropogenic (human-made) scenarios).

- Extreme temperature events are defined as days exceeding the 90th percentile for daily maximum temperatures (percentage of warm days) and daily minimum temperature (percentage of warm nights). In pre-industrial scenarios, extremes occur due to natural variability, while in anthropogenic scenarios, both natural variability and human-induced changes contribute to extremes.