



Ministry for the
Environment
Manatū Mō Te Taiao



>> New Zealand's Environmental Reporting Series



2014 Air domain report

DATA TO 2012

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New Zealand's air quality at a glance

This section provides a summary of New Zealand's air quality, using data to 2012.

Good outdoor air quality is fundamental to our well-being. On average, a person inhales about 14,000 litres of air every day, and the presence of contaminants in this air can adversely affect people's health. People with pre-existing respiratory and heart conditions, diabetes, the young, and older people are particularly vulnerable to these effects. Poor air quality can also cause damage to the natural and built environment.

Air pollution occurs through the introduction of gases, chemicals, particulate matter (airborne particles), and natural materials into the atmosphere from both human-made and natural sources (such as sea salt, pollen, wildfires, and volcanic activity).

This report includes data to 2012. Data for 2013 was not available for all our national indicators and case studies, or could not be collected, validated, and analysed in time to meet our publication schedule.

Summary

From 2006 to 2012, our national air quality indicators showed some improvement to the pressures on air quality, state of air quality, and impacts of air quality in New Zealand. However, national indicators are not available for all aspects of air pollution. At the local level, exceedances of the national and international guidelines for some air pollutants occur.

Figure 1 summarises the results for the three national air quality indicators for 2006–12.

Figure 1: National indicators of air quality, 2006–12



The state of New Zealand's air

By reporting on the state of New Zealand's air, we provide information (where available) on the quality of our air and how it is changing over time. Air quality is measured by the concentrations of pollutants within the air.

We compared the state of our air with guidelines or standards that provide a maximum concentration a pollutant should not exceed to ensure an appropriate level of protection is provided for human and environmental health.

The adverse effects from pollutants can result from exposure over long-term periods (annual and/or short-term periods (hourly or daily)). When reporting on the state of New Zealand's air we report first on the period over which the greatest health risk from the pollutant occurs, and then the alternative time period where appropriate. For many pollutants the greatest health risks are associated with long-term exposure, though for some pollutants these occur over the short-term. Reporting against long-term guidelines also gives a good indication of general air quality conditions and best represents the typical exposure of most New Zealanders, while reporting on the short-term has more of a focus on peak events.

For long-term exposure to pollutants we report against these guidelines:

- World Health Organization (WHO) long-term guidelines
- Ministry for the Environment's Ambient Air Quality Guidelines (where they differ from the WHO guideline).

For short-term exposure to pollutants we report against these guidelines:

- National Environmental Standards for Air Quality (NESAQ)
- WHO short-term exposure guidelines (where they differ from NESAQ).

To put New Zealand's air pollution into context, we also provide a comparison with other Organisation for Economic Co-operation and Development (OECD) countries.

PM₁₀ is a collective term for very small airborne particles, 10 micrometres or less in diameter, that are associated with health problems, ranging from respiratory irritation to cancer.

- From 2006 to 2012, the national annual average PM₁₀ concentration fell 8 percent.
- New Zealand's average national PM₁₀ concentration was the seventh lowest of 32 OECD countries in 2011.
- In 2012, 87 percent (48 out of 55) of PM₁₀ monitoring sites met the WHO long-term guideline. Of the seven exceeding locations:
 - PM₁₀ levels at two sites exceeded the annual guideline by 1–10 percent
 - PM₁₀ levels at three sites exceeded it by 11–20 percent
 - PM₁₀ levels at two sites exceeded it by 21–40 percent.
- In 2012, 50 percent (19 out of 38) of airsheds experienced concentrations that exceeded the national short-term standard, down from a peak of 26 airsheds in 2008. Of these 19 airsheds:

- eight exceeded the daily PM₁₀ standard on 2–10 days
- seven exceeded it on 11–20 days
- four exceeded it on 21–50 days.

PM_{2.5} is a collective term for the finer airborne particles, 2.5 micrometres or less in diameter, that are a component of PM₁₀ and are therefore associated with similar health problems.

- In 2012, six out of seven PM_{2.5} monitoring sites met the WHO long-term guideline. The one site exceeding the guideline did so by 17 percent.
- In 2012, four out of seven PM_{2.5} monitoring sites exceeded the WHO short-term guideline. Two of these sites exceeded the guideline on between one and five days, and the other two sites exceeded the guideline on between 30 and 40 days.

Nitrogen dioxide is a gas that at elevated concentrations can aggravate asthma symptoms and reduce lung development in children.

- In 2012, monitoring of nitrogen dioxide indicated that the WHO long-term guideline was met at 98 percent of monitoring sites (121 out of 124). Those where the guideline was likely exceeded are close to state highways and busy local roads.
- In 2012, all 15 regional council and unitary authority monitoring sites that can be compared directly to guidelines met both the WHO long-term guideline and national short-term standard for nitrogen dioxide. Many of these sites are where high concentrations are expected.

Carbon monoxide is a gas that can aggravate heart conditions. A long-term guideline does not exist as most of the negative health problems are associated with high short-term concentrations.

- In 2012, all 20 monitoring sites for carbon monoxide met the national short-term guideline. Many of these sites are where high concentrations are expected.

Ground-level ozone is associated with increased respiratory and cardiovascular diseases. Only a short-term guideline exists as most of the negative health problems are associated with high short-term concentrations.

- From 2002 to 2012, the WHO short-term guideline and national short-term standard for ground-level ozone was met at all three monitored sites. These sites are where high concentrations are expected.

Sulphur dioxide is associated with, and can aggravate, respiratory conditions. The WHO only provides a short-term guideline for sulphur dioxide.

- In 2012, sulphur dioxide concentrations exceeded the WHO short-term guideline at three out of nine sites. At these three sites, the standard was exceeded on 13, 54, and 69 days over the year. These three sites were expected to have high concentrations due to nearby industry and shipping activities. Other sites close to industry did not exceed the guideline. All nine sites met the national short-term standard.

Arsenic, benzene, and benzo(a)pyrene are pollutants that are associated with health problems ranging from respiratory irritation to cancer.

- Limited monitoring of arsenic, benzene, and benzo(a)pyrene allows for very few comparisons to be made with New Zealand's long-term health guidelines, but monitoring does indicate that annual concentrations are elevated in some locations.

The pressures on New Zealand's air

By reporting on pressures on New Zealand's air, we provide information (where available) on the significant activities (human and natural) that may be causing, or have the potential to cause, changes in air quality.

On-road vehicle emissions are a source of gases, particulate matter, metals, and volatile organic compounds.

- From 2001 to 2012, estimated emissions (using modelling) from on-road transport fell between 25 and 49 percent for the range of pollutants, mainly due to technological advances in vehicles and fuel. This decrease may have contributed to the overall reduction in PM₁₀ concentrations from 2006 to 2012.
- The decrease in estimated emissions occurred despite an 11 percent increase in vehicle kilometres travelled (or vehicle use).
- Pollutants from on-road transport continue to be an issue, with high levels of nitrogen dioxide and benzene in some peak traffic locations.

Home-heating emissions are a source of gases, particulate matter, metals, and volatile organic compounds. In New Zealand home heating is considered the main source of human-made PM₁₀ emissions.

- From 1996 to 2013, the number of households that burnt wood or coal for home heating decreased 25 percent. This decrease is likely to have contributed to the overall reduction in PM₁₀ concentrations from 2006 to 2012.
- Burning wood and coal for home heating continues to be associated with air quality issues, including high levels of PM_{2.5}, arsenic (from burning treated timber), and benzo(a)pyrene at some locations.

The impacts of air quality

By reporting on the impacts of air quality, we provide information (where available) on how the state of air quality impacts on public health. Under the proposed Environmental Reporting Bill, reporting on these can also include impacts on ecological integrity, economic benefits derived from using natural resources, and culture and recreation. However, we do not have quantitative information that meets our reporting standards for impacts in these other categories.

Human health impacts are one of the major impacts of poor air quality. The health effects associated with PM₁₀ (ranging from subtle effects – such as respiratory irritation – to premature deaths) represent the major health impacts of air pollution in New Zealand.

These estimates are produced from modelling and not from hospital records. Modelling is a common approach used to estimate health impacts from air quality and different modelling approaches exist. The model used was developed for use in New Zealand, and the methodology is consistent with international practice and has been internationally and nationally peer-reviewed.

- PM₁₀ concentrations have fallen from 2006 to 2012. The model predicts this fall to have resulted in:
 - an estimated 14 percent fewer premature deaths from exposure to human-made PM₁₀
 - an estimated 15 percent fewer hospital admissions from exposure to human-made PM₁₀
 - an estimated 9 percent fewer days of restricted activity from exposure to human-made PM₁₀.

About the *2014 Air domain report*

This section contains:

- [message from the Secretary for the Environment and the Government Statistician](#)
- [purpose and scope](#)
- [acknowledgements](#).

Message from the Secretary for the Environment and the Government Statistician

The environment is important to New Zealanders. It is critical to our economic, social, and cultural well-being. Environmental reporting must then be comprehensive, independent, and relevant so that it provides New Zealanders with information they can trust and understand.

In 2013, the Ministry for the Environment and Statistics New Zealand began working together to achieve these goals. Our partnership aims to combine the respective strengths of both organisations and deliver sustainable long-term improvements to New Zealand's environmental reporting. The Environmental Reporting Bill, currently before Parliament, proposes to make this an official partnership while formalising the role of the Parliamentary Commissioner for the Environment.

2014 Air domain report is the first report in the new Environmental Reporting Series. Published jointly by our agencies, it provides information about the human and natural pressures on New Zealand's air, its state, the trends in air quality, and the impacts these are having.

We developed the report using the [Principles and Protocols for Producers of Tier 1 statistics](#). This ensures New Zealand has access to information on air quality that is relevant, trustworthy, representative, and based on sound statistical methodology.



Paul Reynolds
Secretary for the Environment



Liz MacPherson
Government Statistician

Air domain purpose and scope

This page provides information on the purpose of the *2014 Air domain report* and scope of the air domain.

Purpose of the report

New Zealand's Environmental Reporting Series: 2014 Air domain report presents information on New Zealand's air quality. It shows the changes in our air quality over time, and the associated pressures and impacts. It helps us identify and understand air quality issues at the national level.

This report includes data to 2012. Data for 2013 was not available for all our national indicators and case studies, or could not be collected, validated, and analysed in time to meet our publication schedule.

This report covers one of five environmental domains that the Environmental Reporting Bill has proposed the Ministry for the Environment and Statistics New Zealand report on. The five domains are air, atmosphere and climate, fresh water, land, and the marine environment.

Reports on each domain will be published every three years, as part of the Environmental Reporting Series, published jointly by the Ministry for the Environment and Statistics New Zealand. As well as individual reports on each domain, a synthesis report will combine information on all the domains and will provide analysis on areas like biodiversity.

We wrote this report while the Environmental Reporting Bill was being considered by Parliament. We produced it using the same rigorous quality control and independent processes that the Bill proposes us to take.

The new reporting framework set out in the Environmental Reporting Bill covers not just the **state** of our environment but also:

- the **pressures** that influence the state of our environment
- the **impacts** this state has on ecological integrity, public health, economic benefits derived from using natural resources, and culture and recreation.

The reporting framework, and therefore this report, does not cover responses to the issues. Responses would constitute policy advice or policy evaluation and we have deliberately excluded this from the reporting framework so we can independently articulate what the data is telling us.

See [The Environmental Reporting Bill and environmental reporting framework](#) for more information.

We are still working through the details of the scope of future environmental reporting. The Environmental Reporting Bill proposes to have the topics for environmental reporting set in regulations to ensure consultation, transparency, and consistency. On this occasion, we used a provisional set of air domain topics to inform reporting. These provisional topics were

developed with the advice of external air quality experts and, in the absence of the Bill being in place, were approved by the Minister for the Environment and the Minister of Statistics. If the Environmental Reporting Bill is enacted in its current form, we will review the provisional air topics and develop regulations, along with the topics for other domains.

We use available data to report on some of these topics using national indicators. Indicators simplify complex environmental data to tell us about the state of our environment, the pressures influencing this state, and the effects of this state on us. In some instances, we don't have robust or national-scale data to report an indicator. We used case studies where we have data that either illustrates a significant component of a topic or where information is only available at the regional level.

See [Criteria for selecting our environmental indicators](#) for more about the indicators and the processes we used to determine them.

To help present the picture about New Zealand's air quality, we also include commentary, sometimes with reference to localised monitoring results.

The Ministry for the Environment and Statistics New Zealand are working with data providers to investigate how the coverage of high-quality, nationally representative information could be improved. We will consult, assess, and advise ministers and councils on the costs and benefits of improving this information.

For some air topics, it is not anticipated that a national indicator will be required to be developed. For example, if a particular pollutant is monitored at several locations where concentrations are expected to be high, but the concentrations consistently meet guidelines, then the need for a nationally representative indicator may not be necessary and improvements will be focused elsewhere.

See the [Acknowledgements](#) for the many organisations that helped us by providing data, giving advice on the topics and indicators, or reviewing the report. We are very grateful for all the help received.

Scope of the air domain

The air domain comprises the shallow gas layer that surrounds the Earth above ground level. This gas layer is primarily made up of oxygen and nitrogen, and also includes other gases and small quantities of vapour and particulates. Many of these lesser components exist because of unwanted emissions from human activities, and can be considered pollutants.

We measure air quality by the concentrations of pollutants within the air. Poor air quality can cause adverse health and environmental effects.

In this report, we define the air domain to include only the lower atmosphere (the troposphere) in which people live, and focus on the outdoor environment. We exclude indoor air quality, though in terms of health effects this often has an important influence.

The pressure-state-impact framework used in this report

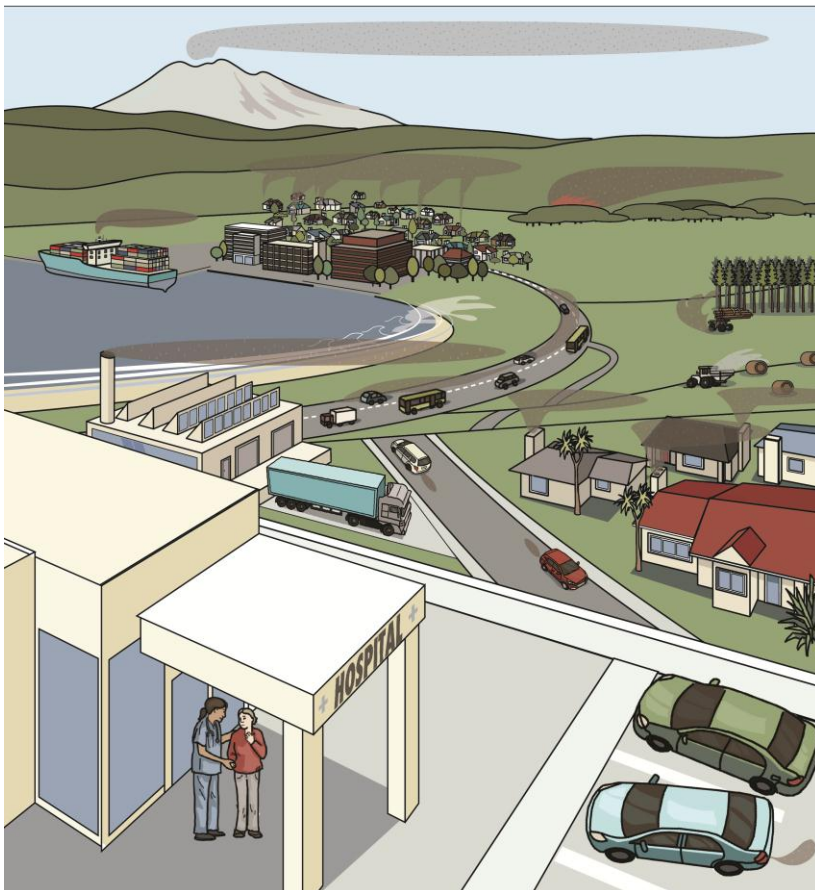
We use a pressure-state-impact framework for national-level environmental reporting. The framework traces substances from their source, through the environment, to their effect on ecological integrity, public health, economic benefits derived from using natural resources, and culture and recreation.

The framework helps us to answer these questions about the air domain:

- What are the **pressures** on New Zealand's air quality?
- What is the **state** of New Zealand's air quality?
- How does the quality of our air **impact** on ecological integrity, public health, economic benefits derived from using natural resources, and culture and recreation?

Figure 2 illustrates the key pressures on New Zealand's air quality (such as households, transport, industry, and natural sources), and the impacts of the state of air quality (eg on public health).

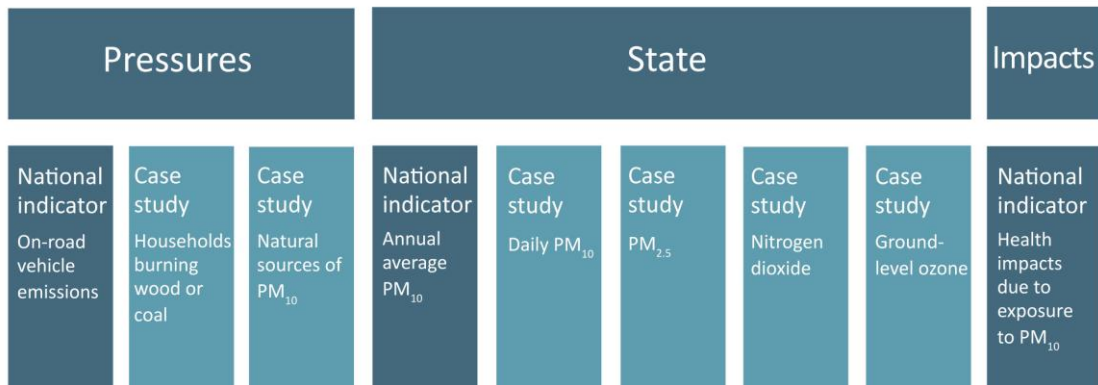
Figure 2: Air quality – pressures and impacts



Source: Ministry for the Environment

Indicators and case studies were selected to show the pressures, state, and impacts of New Zealand's air quality. These are shown in figure 3.

Figure 3: National indicators and case studies in the 2014 Air domain report



Acknowledgements

We would like to thank the following people and organisations for their invaluable contribution to this report.

Data providers

Auckland Council, Bay of Plenty Regional Council, Environment Canterbury, Environment Southland, Genesis Energy Limited, GNS Science International Limited, Greater Wellington, Hawke's Bay Regional Council, Horizons Regional Council, Marlborough District Council, Lincoln University, Ministry for the Environment, Ministry of Transport, National Institute of Water and Atmospheric Research, Nelson City Council, New Zealand Transport Agency, Northland Regional Council, Otago Regional Council, Statistics New Zealand, Tasman District Council, Waikato Regional Council, Wellington Regional Council, West Coast Regional Council.

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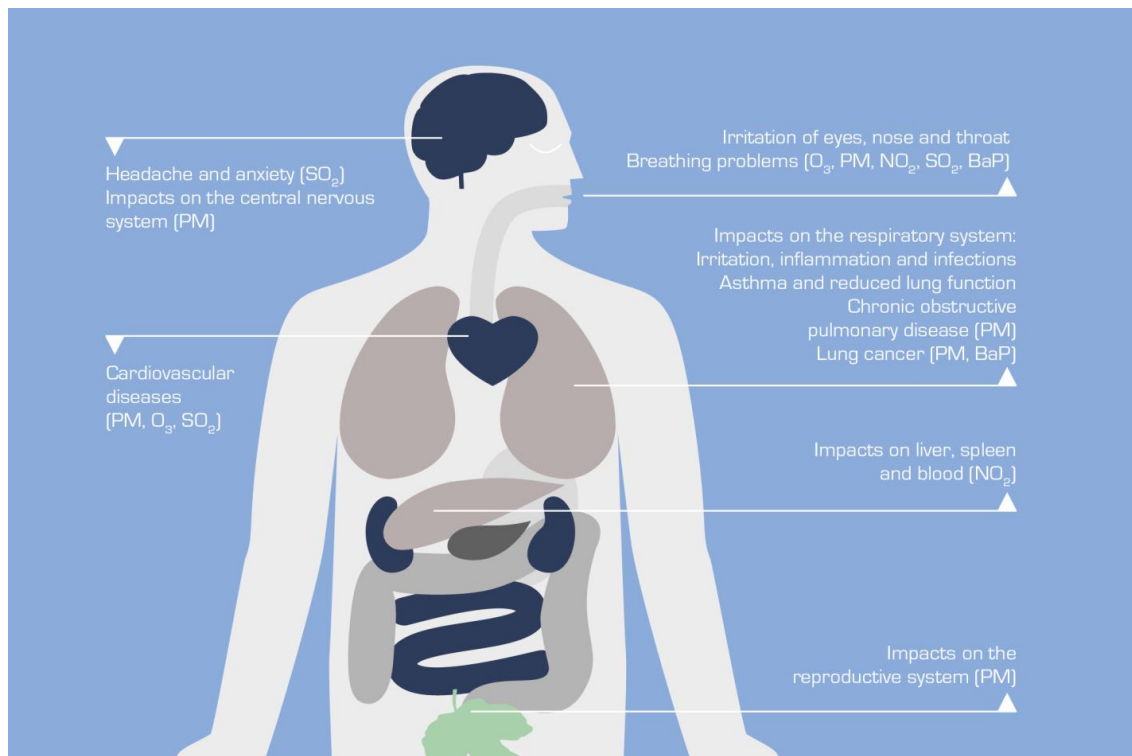
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The Technical Advisory Group provided valuable advice on refining the topics and identifying potential statistics to report on.

Why good air quality is important

Good outdoor air quality is fundamental to our well-being. On average, a person inhales about 14,000 litres of air every day, and the presence of contaminants in this air can adversely affect people's health (see figure 4). People with pre-existing respiratory and heart conditions, diabetes, the young, and older people are particularly vulnerable.

Figure 4: Examples of health impacts of air pollution



Note: BaP = benzo(a)pyrene; NO_2 = nitrogen dioxide; O_3 = ozone; PM = particulate matter; SO_2 = sulphur dioxide.

Source: European Environment Agency, 2013

Overseas studies have shown poor air quality can also adversely affect the natural environment. Ecological damage may occur when air pollutants come into direct contact with vegetation or when animals inhale them. Pollutants can also settle out of the air onto land and water bodies. From the soil, they can wash into waterways, or be taken up by plants and animals. Poor air quality can also affect our climate: some pollutants have a warming effect while others contribute to cooling (European Environment Agency, 2013). There have been limited studies conducted in New Zealand to explore these impacts.

These effects of poor air quality on human health and the environment can, in turn, have negative economic impacts. We incur major costs, for example, for hospitalisation and medical treatment, premature deaths, and lost work days. Damage to soils, vegetation, and waterways may reduce the productivity of our agriculture and forestry industries. In urban areas, air

pollution can be costly when, for example, transport is disrupted (due to large-scale events like volcanic eruptions), or corroded buildings need to be repaired.

The sources of some of these pollutants also have positive effects. For example, having a warm home (from burning wood or coal, or other heating sources) has health benefits, while transport provides people with mobility and the distribution of goods and services.

The state of New Zealand's air

This section reports on the state of New Zealand's air quality and how it is changing over time. See:

- [measuring air quality](#)
- [particulate matter 10 micrometres or less in diameter \(PM₁₀\)](#)
- [particulate matter 2.5 micrometres or less in diameter \(PM_{2.5}\)](#)
- [nitrogen dioxide](#)
- [ground-level ozone](#)
- [other air pollutants.](#)

Measuring air quality

In a 2013 survey, 90 percent of New Zealanders surveyed considered New Zealand's air quality to be adequate, good, or very good. The remaining 10 percent said it was bad, very bad, or didn't know (Hughey, Kerr, & Cullen, 2013).

Another survey asked people in Auckland, Wellington, Porirua, Hutt, Christchurch, and Dunedin areas whether they felt their local air quality was or was not a problem. Results showed that in Wellington, 79 percent of respondents were satisfied with air quality, compared with 49 percent in Christchurch (Nielsen, 2013).

Objective information on the state of New Zealand's air can be obtained from the routine air quality monitoring that is carried out across the country by regional councils and unitary authorities. These agencies are responsible for monitoring and managing air quality within their regions. Monitoring can occur at peak sites (locations where concentrations are expected to be high), background sites (locations where concentrations are expected to be low), or sites that are between these limits.

With the assistance of [a technical advisory group](#), we selected these pollutants because they are associated with significant health and environmental effects. Their concentrations are measured using annual averages and short-term levels to represent their long- and short-term effects.

Comparing concentrations to guidelines and standards

We compared annual concentrations with the World Health Organization (WHO) long-term guidelines. These guidelines are the recommended maximum concentrations that should not be exceeded to provide a set level of protection against the long-term health effects from exposure. In cases where WHO guidelines do not exist (eg for arsenic and benzo(a)pyrene), we used the Ministry for the Environment's 2002 [Ambient Air Quality Guidelines](#).

For comparing daily and hourly monitoring data, we used New Zealand's National Environmental Standards for Air Quality (NESAQ) (Resource Management Regulations, 2004). In a few cases, where WHO guidelines and NESAQ differ (eg for sulphur dioxide), we report against both. These also represent the recommended maximum concentrations that should not be exceeded to provide a set level of protection against the short-term health effects from exposure.

Particulate matter 10 micrometres or less in diameter (PM₁₀)

Key points

- From 2006 to 2012, the national average PM₁₀ concentration fell 8 percent, from 17.0 µg/m³ (micrograms per cubic metre of air) to 15.6 µg/m³.
- New Zealand's average national PM₁₀ concentration was the seventh lowest of 32 Organisation for Economic Co-operation and Development (OECD) countries in 2011.
- In 2012, 87 percent (48 out of 55) of PM₁₀ monitoring sites met the World Health Organization (WHO) long-term guideline. Of the seven exceeding locations:
 - PM₁₀ levels at two sites exceeded the annual guideline by 1–10 percent
 - PM₁₀ levels at three sites exceeded it by 11–20 percent
 - PM₁₀ levels at two sites exceeded it by 21–40 percent.
- In 2012, 50 percent (19 out of 38) of airsheds experienced concentrations that exceeded the national short-term standard, down from a peak of 26 airsheds in 2008. Of these 19 airsheds:
 - eight exceeded the daily PM₁₀ standard on 2–10 days
 - seven exceeded it on 11–20 days
 - four exceeded it on 21–50 days.
- From 2006 to 2012, average PM₁₀ concentrations at monitoring sites decreased by:
 - 8 percent in cities
 - 11 percent in medium-sized towns
 - 19 percent in small towns.
- Monitoring sites in rural areas had the lowest average PM₁₀ concentration (10.1 µg/m³) while monitoring sites in medium-sized towns had the highest (17.0 µg/m³) in 2012.

PM₁₀ and why it's important

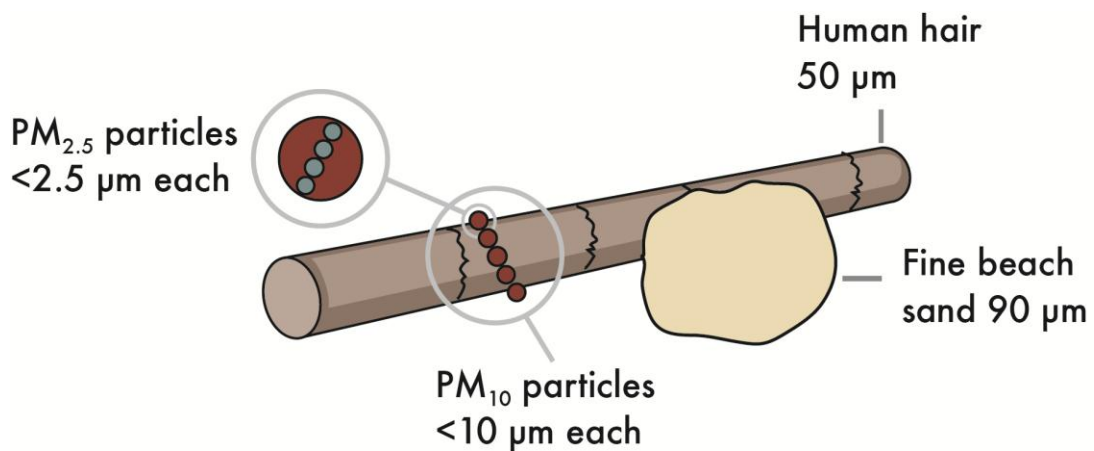
PM₁₀ is a mixture of solid particles and liquid droplets found in the air that are 10 micrometres or less in diameter (see figure 5). Particulates can be a mix of combustion particles, organic matter, metals, sulphates, nitrates, sea salt, and dust.

PM₁₀ is emitted from the combustion of fuels, such as wood and coal (from home heating and industry) and petrol and diesel (from vehicles). Natural sources such as volcanoes, pollen, wild fires, dust, and sea salt can also produce PM₁₀. It is also formed in the air from reactions between gases or between gases and other particles.

PM₁₀ is a pollutant of particular concern in New Zealand because:

- it is associated with severe health effects such as cancer, respiratory problems, and cardiovascular disease
- relative to other pollutants, it is the pollutant that most frequently breaches national standards and international guidelines.

Figure 5: The relative size of particulate matter



Source: Ministry for the Environment

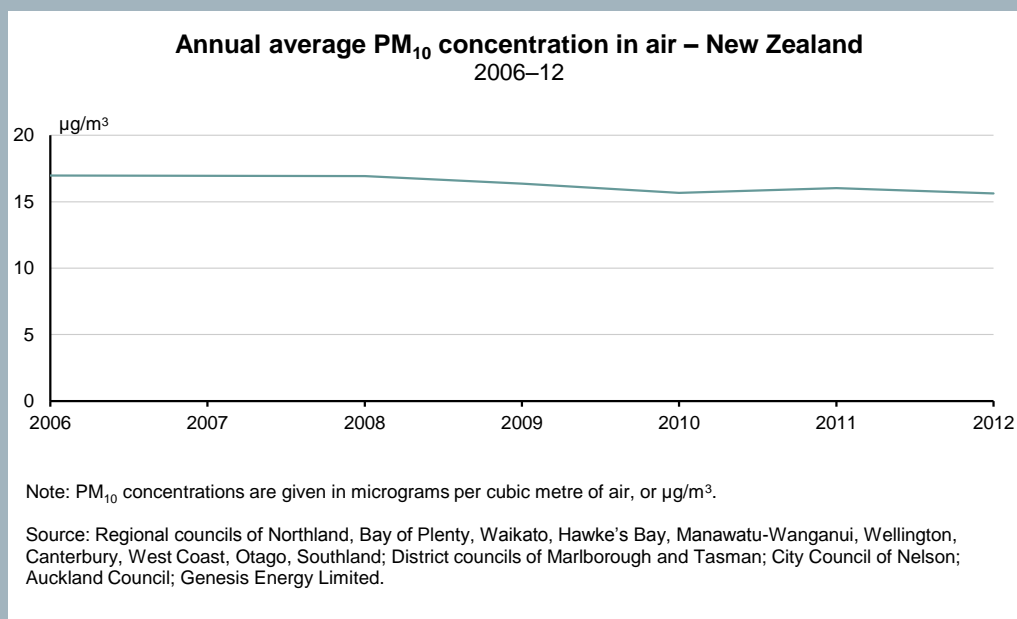
National indicator: Annual average PM₁₀ concentrations are decreasing

From 2006 to 2012, New Zealand's annual average PM₁₀ concentration declined (see figure 6). Since a peak of 17.0 µg/m³ in 2006 and 2007, overall concentrations have fallen 8 percent to 15.6 µg/m³.

The increase in 2011 (up 0.3 µg/m³ from 2010) was influenced by higher concentrations in Christchurch. This was due to increased dust dispersion from liquefaction and damaged roads resulting from the Canterbury earthquakes (Environment Canterbury, 2011a).

We report on annual averages as they give the best indication of general air quality conditions and long-term exposure. Most PM₁₀ health impacts are associated with long-term exposure to PM₁₀.

Figure 6

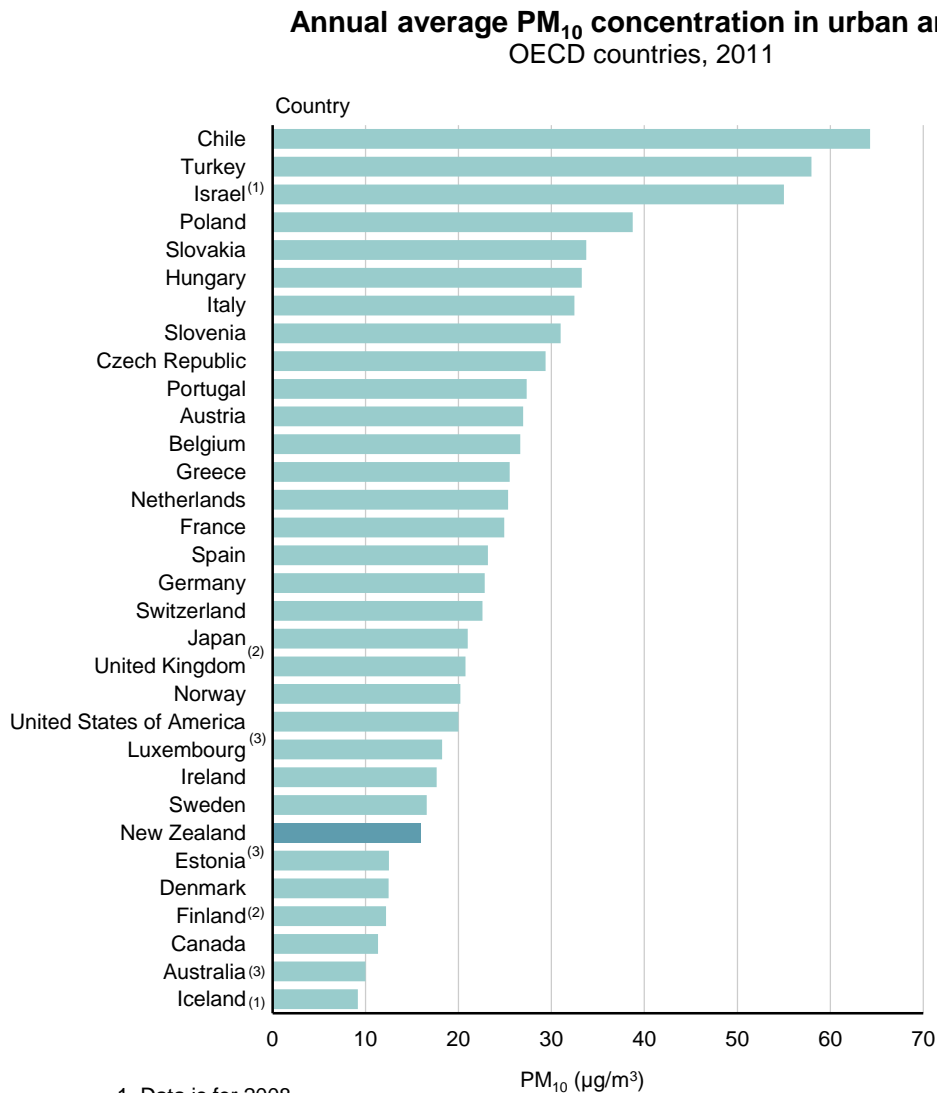


See [About the indicators](#) for more information on this indicator.

Figure 7 presents a snapshot of annual average PM₁₀ concentrations in OECD countries. New Zealand's national PM₁₀ concentration is low compared with other countries. The figure also illustrates the different air quality challenges different countries face.

This international comparison covers only urban areas selected by the WHO, unlike our estimate which covers all monitored urban areas. As a result the WHO estimate and our own differ. The WHO apply the same methodology to calculate each country's estimate. However, countries can use different monitoring approaches, so international comparisons are indicative only.

Figure 7



1. Data is for 2008.
2. Data is for 2010.
3. Data is for 2012.

Note: PM₁₀ concentrations are given in micrograms per cubic metre of air, or µg/m³.

Source: World Health Organization

Annual average PM₁₀ concentrations at most sites meet WHO long-term guideline

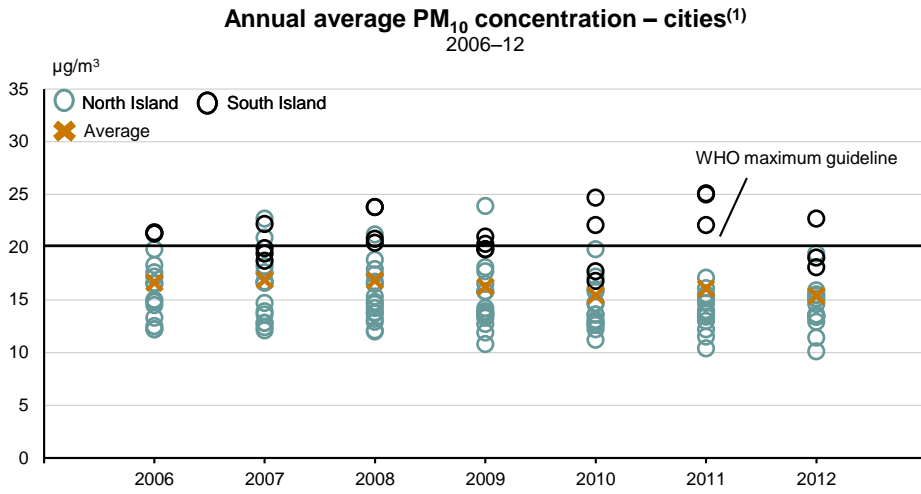
This section reports on annual average PM₁₀ concentrations at North and South Island cities, towns, and rural locations.

Local monitoring sites have a range of annual PM₁₀ concentrations. Figures 8–11 show the averages for different urban groups, and compare them with the World Health Organization (WHO) long-term guideline.

- In 2012, 87 percent (48 out of 55) of PM₁₀ monitoring sites met the WHO long-term guideline. Exceedances occurred at monitoring sites in each of the urban groups (cities, one site; medium-sized towns, three sites; and small towns, three sites).
- On average, monitoring sites in medium-sized towns had the highest average concentration of the groups (17.0 µg/m³) in 2012. Three of the 10 monitoring sites in medium-sized towns exceeded the WHO long-term guideline in 2012.
- On average, monitoring sites in rural areas had the lowest average concentration of the groups (10.1 µg/m³) in 2012. These low concentrations reflect the fewer emission sources in these areas. No rural sites exceeded the WHO long-term guideline in 2012. Rural monitoring is limited to the North Island only.
- From 2006 to 2012, average PM₁₀ concentrations at monitoring sites decreased by:
 - 8 percent in cities
 - 11 percent in medium-sized towns
 - 19 percent in small towns.
- In 2012, average PM₁₀ concentrations at monitoring sites were higher in the South Island than the North Island by:
 - 42 percent in cities
 - 33 percent in medium-sized towns
 - 32 percent in small towns.
- Higher annual PM₁₀ concentrations in the South Island reflect the greater use of wood and coal for home heating, and relatively settled winter conditions which mean less pollutant dispersion.

The WHO provides an annual health guideline of 20 µg/m³ for PM₁₀ concentrations. However, adverse health effects can be experienced at very low concentrations (even below the guideline). WHO recommends this guideline to provide a minimum level of protection against long-term health risks (WHO, 2006).

Figure 8

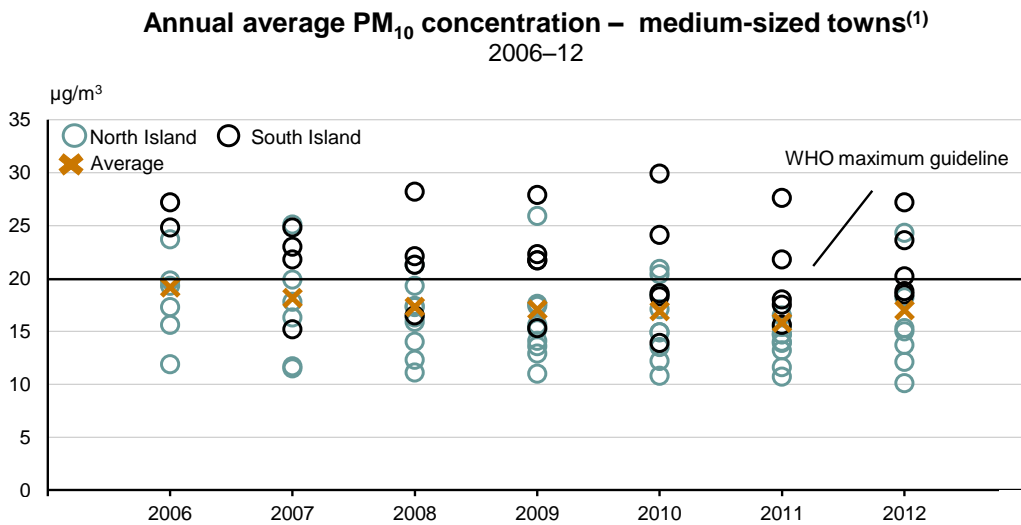


1. Greater than 60,000 people.

Note: PM₁₀ concentrations are given in micrograms per cubic metre of air, or µg/m³.
WHO - World Health Organization.

Source : Regional councils of Waikato, Wellington, Canterbury, Otago; Auckland Council

Figure 9



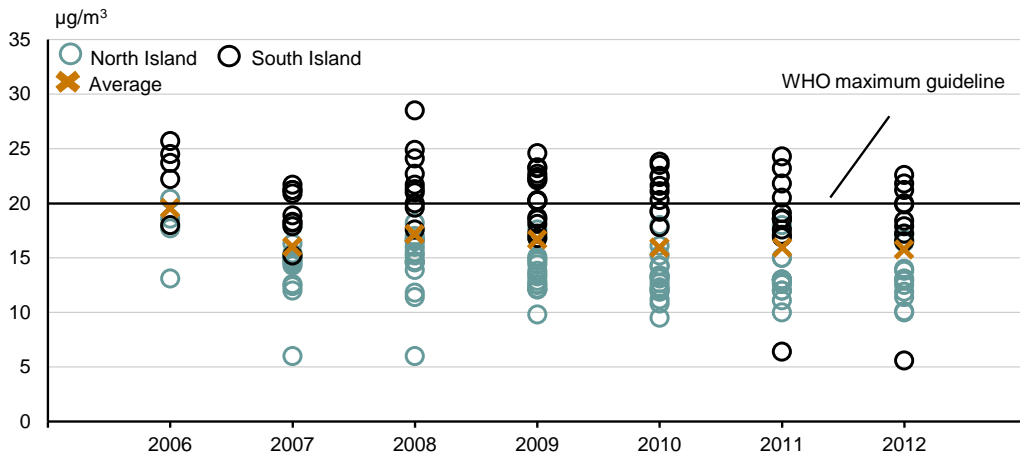
1. Between 25,000 and 60,000 people.

Note: PM₁₀ concentrations are given in micrograms per cubic metre of air, or µg/m³.
WHO – World Health Organization.

Source: Regional councils of Northland, Bay of Plenty, Hawke's Bay, Manawatu-Wanganui, Wellington, Canterbury, Southland; Marlborough District Council; Nelson City Council

Figure 10

Annual average PM₁₀ concentration – small towns⁽¹⁾
2006–12



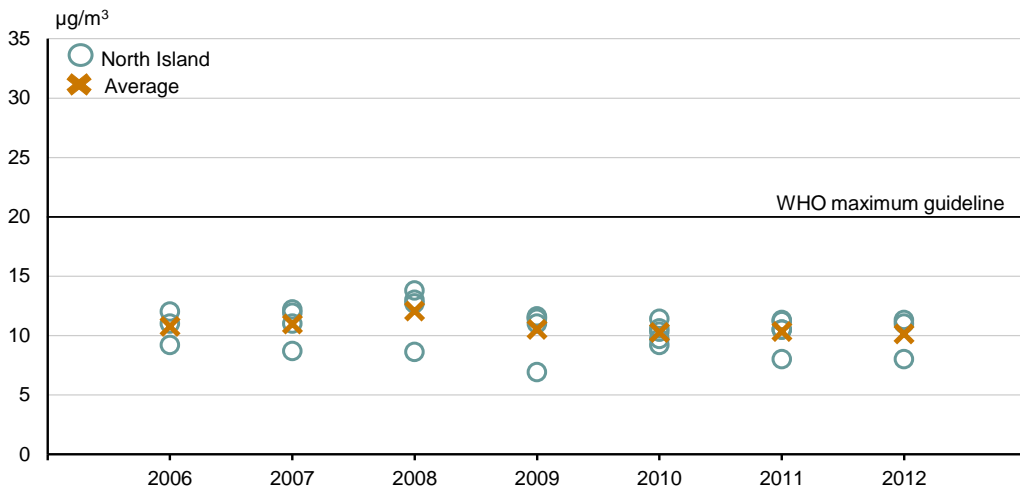
1. Less than 25,000 people.

Note: PM₁₀ concentrations are given in micrograms per cubic metre of air, or µg/m³.
WHO – World Health Organization.

Source: Regional councils of Northland, Waikato, Manawatu-Wanganui, Wellington, West Coast, Canterbury, Otago, Southland; Tasman District Council; Auckland Council; Genesis Energy Limited

Figure 11

Annual average PM₁₀ concentration – North Island rural areas⁽¹⁾
2006–12



1. As defined by Statistics New Zealand (see glossary).

Note: PM₁₀ concentrations are given in micrograms per cubic metre of air, or µg/m³.
There is no rural monitoring in the South Island.
WHO – World Health Organization.

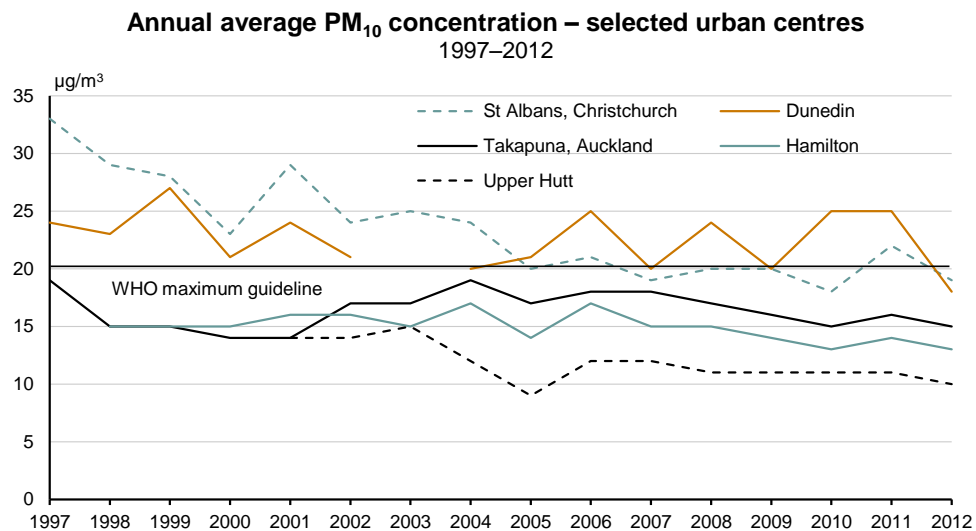
Source: Regional councils of Bay of Plenty, Waikato; Auckland Council; Genesis Energy Limited

Five locations in New Zealand have been monitoring and reporting annual average PM₁₀ longer than many other locations. The information they provide shows their long-term trends in PM₁₀ concentrations (see figure 12).

Figure 12 shows the PM₁₀ concentrations for one site in each of the five main cities over the past 15 years. For cities with more than one monitoring site, we selected the site based on how long the site had been monitored and on advice from councils about representativeness.

For every city, the concentrations were lower in 2012 than 10 years before. Concentrations at the Christchurch site have been declining since 1997. The higher concentrations in Christchurch during 2011 were attributed to increases in dust and its dispersion due to liquefaction and damaged roads resulting from the Canterbury earthquakes (Environment Canterbury, 2011a). The Auckland and Hamilton monitoring sites recorded decreasing concentrations from 2006 to 2010.

Figure 12



Note: PM₁₀ concentrations are given in micrograms per cubic metre of air, or µg/m³.
A 2003 PM₁₀ annual average concentration for Dunedin is not available as monitoring did not meet good practice guidance.
WHO – World Health Organization.

Source: Regional councils of Waikato, Wellington, Canterbury, Otago; Auckland Council

Case study: The national standard for daily PM₁₀ concentrations are exceeded at some locations

PM₁₀ concentrations across New Zealand are routinely monitored by local authorities. The National Environmental Standards for Air Quality (NESAQ) (Resource Management Regulations, 2004) includes a daily PM₁₀ standard that defines the minimum requirements outdoor air quality must meet. Monitoring the number of times the national standard is exceeded helps us understand how often people are exposed to short-term poor air quality.

In 2012, daily PM₁₀ concentrations were measured in 38 airsheds (an area defined for air-quality management purposes, generally based around urban and city areas). Of these, 19 exceeded the daily PM₁₀ standard (experienced short-term poor air quality) on two or more days. This is a decrease from 26 airsheds (the highest number of airsheds exceeding the daily PM₁₀ standard) in 2008 and 2009 (see figure 13).

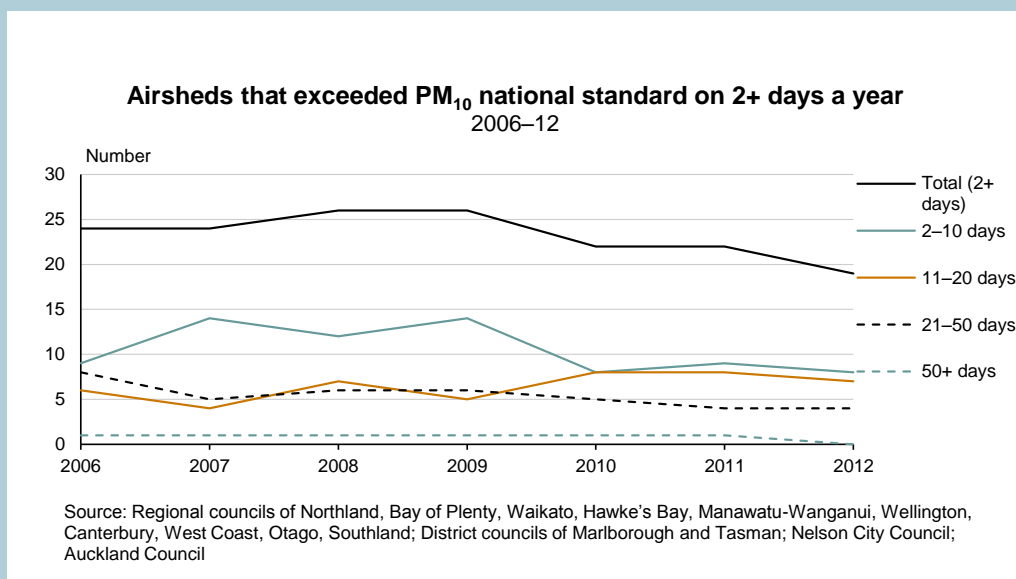
The NESAQ requires the 19 airsheds to meet the daily PM₁₀ standard by 2016 or 2020. (The different target dates reflect the extent of air quality issues experienced and the levels of effort needed to comply with the daily PM₁₀ standard.)

Of these 19 airsheds, 15 are in the South Island and four in the North. Eight airsheds exceeded the daily PM₁₀ standard on 2–10 days, seven exceeded it on 11–20 days, and four exceeded it on 21–50 days. There have been decreases in the number of airsheds exceeding the daily PM₁₀ standard in the 2–10 days and 21–50 day categories since 2006 and an increase in the 11–20 days category.

Of the number of times the PM₁₀ daily standard was exceeded, 94 percent occurred during May to August. This suggests they can largely be attributed to home-heating emissions, as supported by council studies (Auckland, Waikato, Hawke's Bay, Manawatu-Wanganui, Wellington, Marlborough, Nelson, Tasman, Canterbury, West Coast, Southland) (Airshed progress reports provided by regional councils to the Ministry for the Environment for compliance reporting).

Weather conditions – such as cooler temperatures, still days, and temperature inversions that prevent the dispersal of pollutants – can occur more often in the cooler months. These conditions are also important factors in these seasonal exceedances.

Figure 13



See [About the case studies](#) for more information on this case study.

Particulate matter 2.5 micrometres or less in diameter (PM_{2.5})

Key point

In 2012, PM_{2.5} concentrations met the World Health Organization (WHO) long-term guideline in all but one location, but four of the seven monitored locations exceeded the WHO short-term health guideline between 1 and 38 days.

PM_{2.5} and why it's important

Particulate matter 2.5 micrometres in diameter or less (PM_{2.5}) is a component of PM₁₀. PM_{2.5} is included in PM₁₀ measurements, but they are not separately recorded. PM_{2.5} comes mainly from human activities (home heating, transport, industry), and is much less influenced by natural sources than PM₁₀.

Research shows that many of the main health effects (eg cardiovascular morbidity and mortality) attributable to particulates are more likely associated with the finer PM_{2.5} component than the coarser particles within PM₁₀ (World Health Organization, 2013). This is because the smaller particles penetrate more deeply into the lungs and can be absorbed directly into the bloodstream. As a result of these findings, international interest in and monitoring of PM_{2.5} concentrations is increasing, and more monitoring networks are focusing on PM_{2.5}.

Case study: The WHO long-term PM_{2.5} guideline is generally met, but the WHO short-term guideline is exceeded at some locations

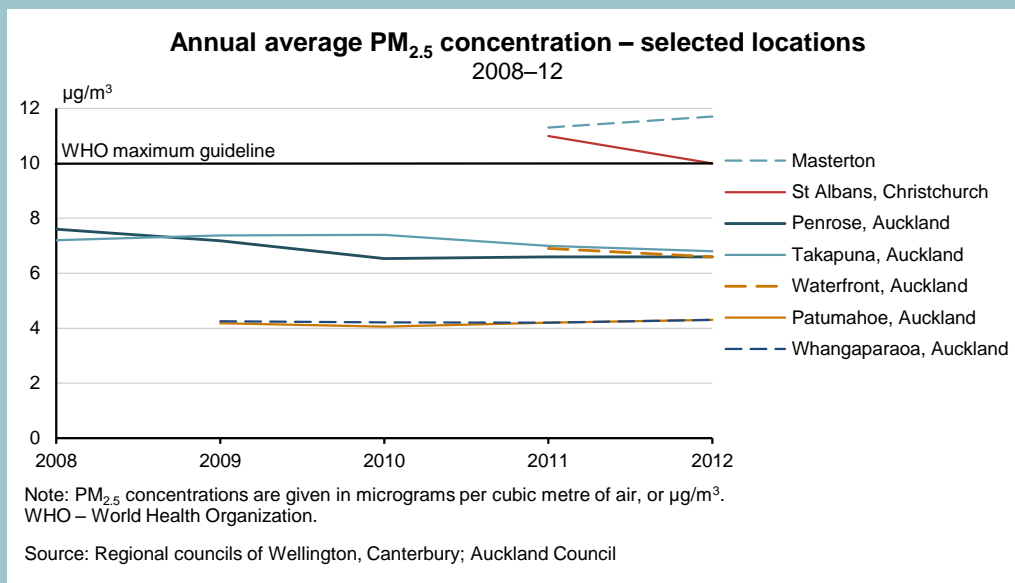
In New Zealand, several locations are monitored for long-term (annual) and short-term (daily) PM_{2.5} concentrations.

Annual PM_{2.5} concentrations are generally lower than the WHO long-term guideline of 10µg/m³. In 2012, one exceedance was recorded.

Annual average concentrations of PM_{2.5} at five Auckland locations meet the WHO long-term guideline (see figure 14). In 2011, annual average concentrations in Christchurch (St Albans) exceeded the WHO guideline, but did not do so in 2012. PM_{2.5} annual average concentrations in Masterton exceeded the WHO guideline in 2011 and 2012.

The Christchurch and Masterton sites are ‘peak sites’ where concentrations are expected to be high due to surrounding emission sources. The Patumahoe and Whangapararua sites are ‘background sites’ where low concentrations are expected due to few emission sources. The remaining Auckland sites are between peak and background sites.

Figure 14



In 2012, the WHO short-term guideline for PM_{2.5} concentrations was exceeded one day at Penrose and four days at Takapuna. The daily WHO guideline was exceeded in Masterton on 38 days while in Christchurch it was exceeded on 31 days.

Ninety-five percent of exceedances at these sites occurred from May to August, which suggests they are largely due to home heating emissions and weather conditions that prevent the dispersal of pollutants. This is supported by studies that showed home heating as the main source of winter PM_{2.5} at Masterton and Christchurch (Mitchell, 2012; Environment Canterbury, 2011b).

Masterton and Christchurch sites experienced relatively high PM₁₀ concentrations, which can be attributed to home heating (Mitchell, 2012; Environment Canterbury, 2011b). Given there are a number of other sites in New Zealand with high PM₁₀ concentrations due to home heating, it is likely that they also have high PM_{2.5} concentrations.

See [About the case studies](#) for more information on this case study.

Nitrogen dioxide

Key points

- In 2012, monitoring of nitrogen dioxide indicated that the WHO long-term guideline was met at 98 percent of monitoring sites (121 out of 124). Those where the WHO guideline was exceeded are close to state highways and busy local roads.
- In 2012, all 15 regional council and unitary authority monitoring sites that can be compared directly to guidelines, met both the WHO long-term guideline and national short-term standard for nitrogen dioxide. Many of these sites are where high concentrations are expected.

Nitrogen dioxide and why it's important

Nitrogen dioxide is a gas and can be directly emitted into the air. However, it is most often formed when nitric oxide emissions react with other chemicals in the air. Both nitrogen dioxide and nitric oxide (collectively known as nitrogen oxide) are emitted from the combustion of fossil fuels such as coal, gas, diesel, and oil, and from natural sources such as volcanoes. Transport, particularly heavy-duty diesel vehicles, and some industrial activities, are especially important emission sources.

Nitrogen dioxide has been linked to increases in asthma symptoms, and reduced lung development and function in children. Nitrogen dioxide can also reduce the lung's defences against bacteria, making people more susceptible to infections.

Case study: The WHO long-term nitrogen dioxide guideline is met most of the time

In 2012, monitoring of nitrogen dioxide indicated that the World Health Organization (WHO) long-term (annual) guideline of $40 \mu\text{g}/\text{m}^3$ was met at 98 percent of monitoring sites (121 out of 124). However, each year, between 2010 and 2012, three to six sites are likely to exceed the WHO guideline. These sites are close to busy local roads and state highways in major urban centres.

These findings are based on the New Zealand Transport Agency's monitoring network which uses a screening method. This method gives a good indication of nitrogen dioxide concentrations at a number of sites; but it does not enable the recorded concentrations to be used to determine whether the WHO long-term guideline is exceeded.

Figures 15–17 show the annual average nitrogen dioxide concentrations for three different location types from 2010 to 2012:

- close to state highways (70 sites in 2012, 69 in 2011, and 68 in 2010)
- close to busy local roads (34 sites in 2012, 33 in 2011, and 32 in 2010)
- urban background sites (not close to state highways or local roads) (20 sites in 2012, 19 in 2011, and 15 in 2010).

The WHO long-term guideline shows a minimum level of protection against health risks from long-term exposure to nitrogen dioxide.

The concentrations at busy local roads and state highway sites vary, with a few sites likely to exceed the WHO long-term guideline. The urban background sites are well below the WHO guideline.

Concentrations are typically much higher in winter than in summer. This is likely because winter conditions prevent dispersal, rather than an increase in transport emissions or winter-specific emission sources.

Figure 15

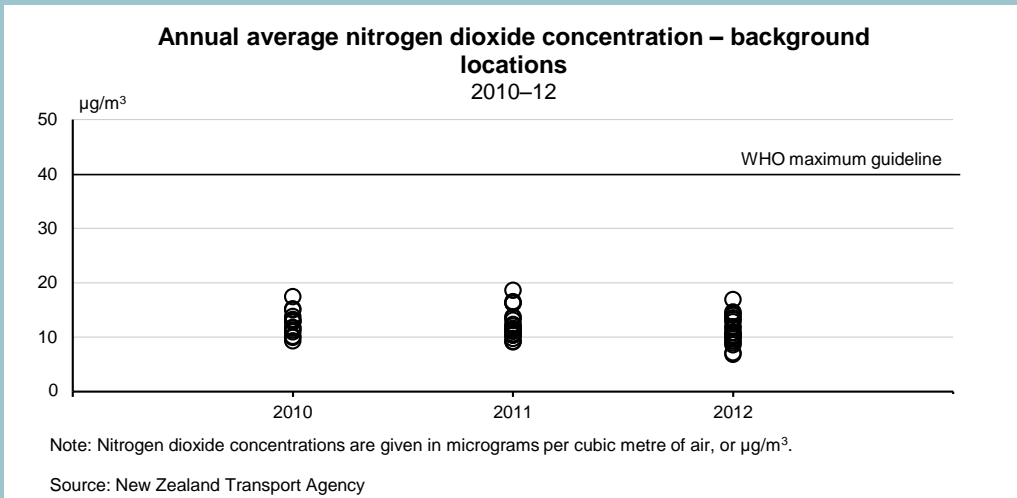


Figure 16

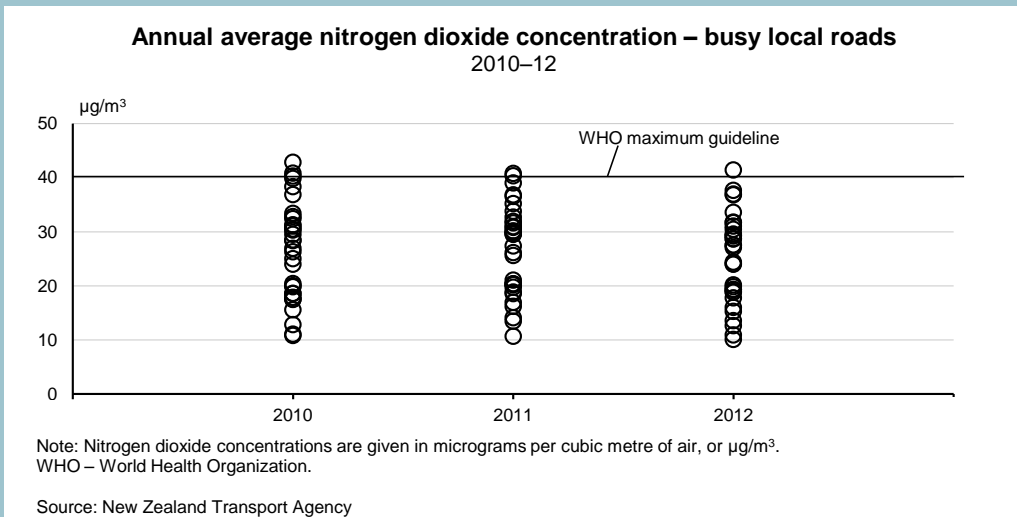
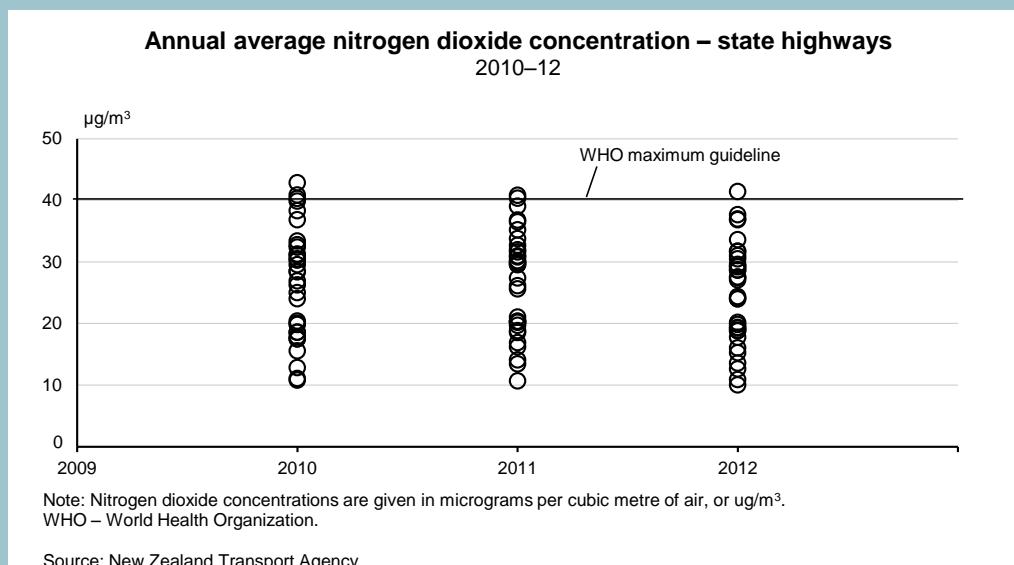


Figure 17



See [About the case studies](#) for more information on this case study.

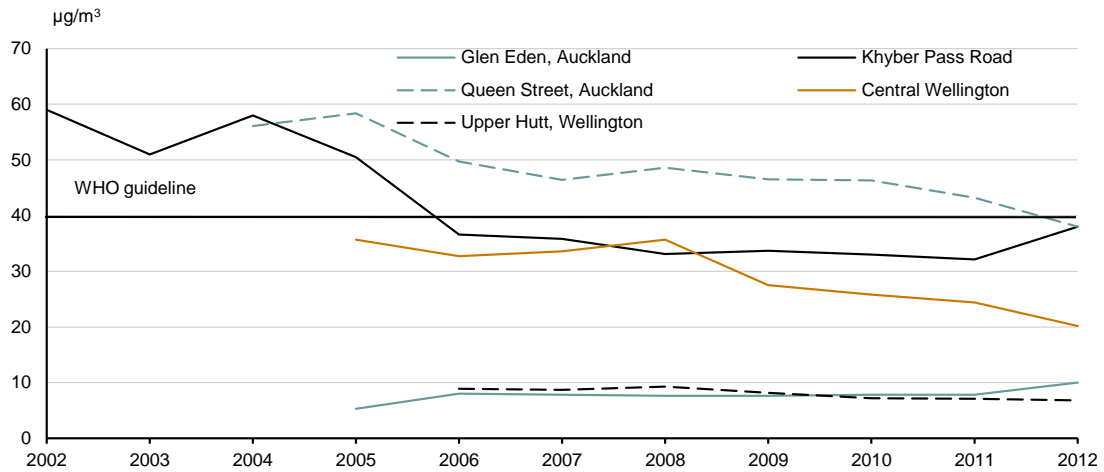
In addition to the New Zealand Transport Agency's monitoring, three regional councils and one unitary authority also monitor nitrogen dioxide and were doing so before 2010. The monitoring methods used by regional councils and unitary authorities can be compared with the WHO long-term guideline, unlike the New Zealand Transport Agency monitoring, which is indicative only (see figures 15, 16, and 17).

Figure 18 shows the levels of nitrogen dioxide concentrations in Auckland and Wellington. Two types of sites are represented: 'peak sites' (where concentrations are expected to be high, such as busy transport sites – Queen Street and Khyber Pass Road in Auckland, and Central Wellington) and 'background sites' (where concentrations are expected to be low, such as urban areas away from busy roads – Glen Eden, Auckland and Upper Hutt, Wellington).

At Khyber Pass Road and Central Wellington, concentrations have decreased since monitoring began. In contrast, concentrations at Glen Eden and Upper Hutt have remained relatively constant. In 2012, all 15 monitoring sites of the three regional councils and one unitary authority that monitor nitrogen dioxide met the WHO long-term guideline.

Figure 18

Annual average nitrogen dioxide concentrations – selected locations, 2002–12



Note: Nitrogen dioxide concentrations are given in micrograms per cubic metre of air, or $\mu\text{g}/\text{m}^3$. WHO – World Health Organization.

Source: Auckland Council, Wellington Regional Council

Nitrogen dioxide monitoring for short-term exposure

In 2012, hourly nitrogen dioxide concentrations were recorded by four councils at 15 monitoring sites. These sites met the one-hour standard for nitrogen dioxide provided in the National Environmental Standards for Air Quality. Most of these monitoring sites are at peak sites. This therefore suggests that concentrations of these pollutants in non-monitored locations would also likely be lower than the national standard.

Ground-level ozone

Key point

Ground-level ozone concentrations met the World Health Organization (WHO) short-term guideline and the national short-term standard all of the time over the past 15 years – with the exception of one exceedance at one site.

Ground-level ozone and why it's important

Ozone helps screen out harmful ultraviolet radiation in the upper atmosphere, where it naturally occurs. However, at ground level it can be harmful to human health as it increases the risks of respiratory and cardiovascular diseases.

Ozone is not directly emitted into the air. It is formed by chemical reactions involving nitrogen oxides, volatile organic compounds, and sunlight. The increased duration and intensity of sunlight in summer makes this primarily a summer issue. There is much international interest

in ozone because concentrations are generally increasing worldwide and they regularly exceed the World Health Organization (WHO) short-term guideline in many countries.

In New Zealand, ozone concentrations remain below the short-term national standard and WHO guideline for ozone. The long, thin shape of the country and our weather are not favourable for forming high concentrations of ground-level ozone. Our geographical isolation also means ozone or ozone-generating pollutants emitted in other countries rarely reach us. The exception is ozone and the pollutants that create it coming from Australia (Xie, Fisher, & Gimson, 2004).

Case study: The short-term WHO guideline and national standard for ozone were met in Auckland

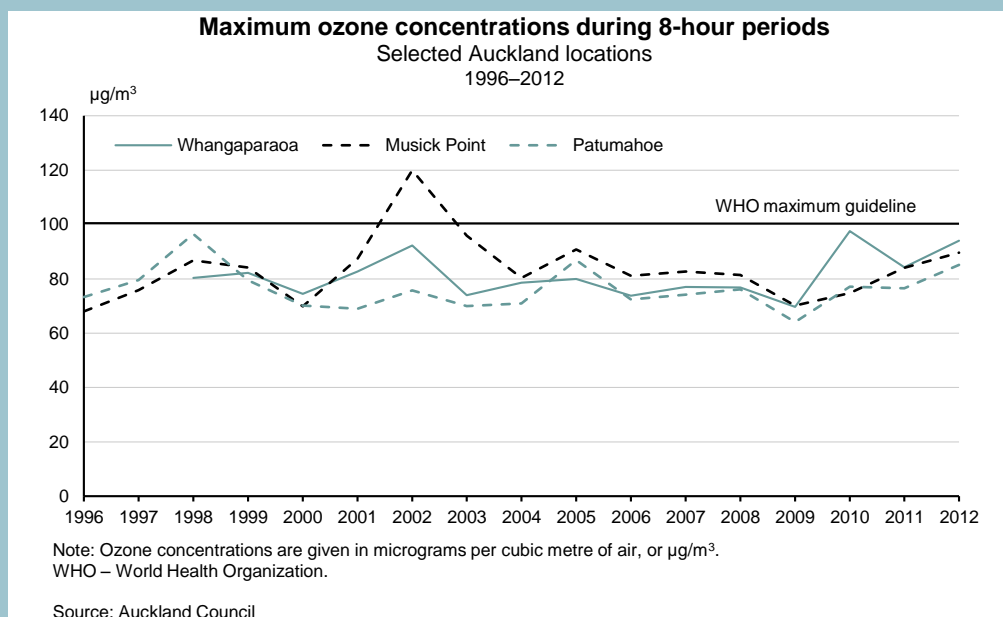
Auckland ozone concentrations meet the WHO short-term (eight-hour) guideline for health risks all of the time, with one exception at one site over the past 15 years. A long-term guideline does not exist as most of the negative health problems are associated with high short-term concentrations.

Ozone is not directly emitted into the outdoor air, but develops through reactions with other pollutants and sunlight. High concentrations occur away from where pollutants that form ozone are emitted. This is because it takes time for the chemical reactions to occur, by which stage the chemicals have dispersed away from their source.

Because of Auckland's large volume of vehicle emissions, ozone concentrations there are expected to be the highest in New Zealand. The highest concentrations are likely to develop downstream from major roads in the city centre.

Figure 19 shows the ozone concentrations at three such sites in Auckland – Whangaparaoa, Musick Point, and Patumahoe. The data shows that concentrations meet the WHO short-term guideline all the time, but exceeded it in 2002. This was attributed to bush fires near Sydney, Australia (Xie, Fisher, & Gimson, 2004).

Figure 19



In 2012, hourly ozone concentrations were recorded at the three Auckland monitoring sites. These results met the one-hour standard for ozone in the National Environmental Standards for Air Quality. As these are peak sites, the results suggest ozone concentrations elsewhere are likely to be low and below the one-hour ozone standard.

See [About the case studies](#) for more information on this case study.

Other air pollutants

In addition to the key pollutants covered in this report, we have some background information on other pollutants that affect our air quality. However, the representativeness, and in some cases, the quality, of the available data does not allow us to draw firm conclusions on the state of these pollutants at the national level.

We intend to examine these instances on a case by case basis to assess their significance to future environmental reporting. We will consult, assess, and advise ministers and councils on the costs and benefits of improving this information.

See [Improving environmental reporting data web page](#) for more information.

The other pollutants are compared with the National Environmental Standards for Air Quality (NESAQ) and against the World Health Organization (WHO) guidelines where they differ. Some pollutants are compared with the Ministry for the Environment's Ambient Air Quality Guidelines when they are not included in the NESAQ or WHO guidelines.

Because carbon monoxide and sulphur dioxide are included in the NESAQ, we discuss them first. Other pollutants follow in alphabetical order.

Carbon monoxide

Carbon monoxide can interfere with the blood's ability to carry oxygen and can aggravate heart conditions.

In 2012, no breaches of the national standard for carbon monoxide occurred at the 20 sites where it was monitored, with 17 of the 20 sites having concentrations less than half the national standard. The national short-term (eight-hour) standard is the same as the World Health Organization (WHO) short-term guideline. Many of these sites were peak sites and these results suggest that carbon monoxide concentrations elsewhere are also low.

Carbon monoxide is a gas formed by the combustion of fuels such as petrol (from motor vehicles) and wood and coal (from home heating and industry). Natural sources include wild fires.

Sulphur dioxide

Sulphur dioxide is associated with respiratory problems, such as bronchitis, and can aggravate the symptoms of asthma and chronic lung disease.

In 2012, none of the nine sites monitoring sulphur dioxide breached the short-term (one-hour) national standard. Of the nine sites, three peak sites exceeded the WHO short-term (daily) guideline for sulphur dioxide. These sites have large emissions from industrial or shipping activities. The two sites influenced by industry emissions (Woolston in Christchurch and Mount Maunganui) exceeded the guideline 54 and 69 times over the year respectively, and the site influenced by shipping (Auckland waterfront) did so 13 times.

The five sites that did not exceed the guideline were a mix of industrial and urban sites.

Sulphur dioxide is produced from the combustion of fossil fuels that contain sulphur, such as coal and oil (used for home heating, industry, and shipping). Industrial sources include milk powder production, thermal electricity generation, petrol refining, aluminium smelting, and steel manufacturing. Natural sources include geothermal activity and volcanoes.

Arsenic

Arsenic can aggravate and is associated with heart conditions, and damage nerves. Arsenic is also associated with cancer of the skin and lungs.

In 2012, annual arsenic concentrations in Wainuiomata (7.1 ng/m³ (nanograms per cubic metre of air)), near Wellington, exceeded the annual health-based guideline set out in the Ministry for the Environment's Ambient Air Quality Guidelines (2002) of 5.5 ng/m³ by 29 percent.

Other monitoring studies that use screening methods (methods that cannot be directly compared with the annual health-based guideline, but still provide a good indication of concentrations) suggest that arsenic concentrations could exceed the annual health-based guideline in other locations. These locations are in the urban areas of Auckland, Christchurch, Napier, Hastings, Masterton, Blenheim, Nelson, and Timaru (Cavanagh, Davy, Ancelet, & Wilton, 2012).

Some councils are undergoing, or planning to start, monitoring studies to help understand arsenic concentrations in their region. Greater Wellington Regional Council and GNS Science, for example, are conducting a study which may help improve the comparability of results from arsenic monitoring using screening methods with the annual health-based guideline.

Arsenic in New Zealand's outdoor air comes largely from burning timber treated with the preservative copper-chromate-arsenic. The timber is treated to stop rotting when it is used outdoors, for example, for decking and fencing. Offcuts from building projects are sometimes burnt for home heating. Some industrial activities also emit arsenic.

Lead

Lead can have adverse effects on the nervous system and can impair mental development in children and hearing.

Since petrol in New Zealand became lead free in 1996, lead concentrations have been well below the health-based guideline set out in the Ambient Air Quality Guidelines (2002). Because of this, the monitoring of lead has reduced. In 2012, monitoring occurred at one peak site and the results were well below the guideline. These results suggest that lead concentrations elsewhere are also low.

Lead can be emitted from some industrial discharges, such as at metal smelters, and houses or other structures where lead-based paint is being, or has been, removed without the proper safety precautions.

Benzo(a)pyrene

Benzo(a)pyrene (BaP) can irritate the eyes, nose, and throat, and is associated with lung cancer.

Monitoring of BaP has not been routinely undertaken in New Zealand but a small number of discrete studies were undertaken between 2001 and 2010. These studies used screening methods, or were done over short timeframes, so are only indicative of whether the annual health-based guideline set out in the Ministry for the Environment's Ambient Air Quality Guidelines (2002) has been exceeded.

The limited monitoring of BaP does indicate that BaP concentrations in Christchurch in 2004 and in 2009, and in Timaru in 2007, are likely to have exceeded the annual health-based guideline. These are the only years that monitoring has occurred at these sites (Cavanagh, Davy, Ancelet, & Wilton, 2012).

Some councils are monitoring BaP to help them understand concentrations in their region. These studies will provide more information on high BaP concentrations in New Zealand.

BaP in New Zealand is largely emitted from the combustion of fuels, such as wood and coal from home heating. Vehicle emissions and some industrial processes also emit BaP.

Benzene

Benzene can have adverse effects on the nervous system and is associated with cancer.

In 2012, annual benzene concentrations in one peak site in Auckland ($5.1 \mu\text{g}/\text{m}^3$) exceeded the annual health-based guideline set out in the Ministry for the Environment's Ambient Air Quality Guidelines (2002) of $3.6 \mu\text{g}/\text{m}^3$ by 42 percent. This peak site was close to busy roads and is therefore influenced by transport emissions – one of the main sources of benzene.

Other monitoring sites are a mix of peak and non-peak sites using screening methods. The results indicate the annual health-based guideline was not exceeded and suggest that only exceptional peak sites exceed the guideline. However, this cannot be confirmed due to the limited monitoring and use of screening methods.

Benzene is a volatile organic compound and motor vehicles and home heating are the main sources of emissions. There are also some industrial activities that emit benzene.

The pressures on New Zealand's air

This section reports on the pressures on New Zealand's air quality. It describes the significant human activities and natural factors that may cause, or have the potential to cause, changes in air quality.

This section reports on:

- [on-road vehicle transport emissions](#) (excludes off-road transport emissions such as shipping, rail, aviation, and farm and construction vehicles)
- [home-heating emissions](#)
- [the contribution of natural sources of pollutants to PM₁₀ concentrations](#)
- [other pressures on air quality](#).

On-road vehicle emissions

Key points

- From 2001 to 2012, estimated emissions from New Zealand's on-road vehicles decreased for carbon monoxide (39 percent), nitrogen oxides (36 percent), PM₁₀ (25 percent), PM_{2.5} (26 percent), and volatile organic compounds (49 percent).
- These decreases occurred despite an increase in vehicle use of 11 percent during the same period.

Transport emissions and air quality

Emissions from transport sources include nitrogen oxides, carbon monoxide, sulphur dioxide, particulate matter, and volatile organic compounds. Nationally, on-road vehicles are the most significant source of PM₁₀ emissions from transport (Kuschel et al, 2012). This excludes off-road vehicle emissions such as shipping, rail, aviation, and farm and construction vehicles.

National indicator: Estimated emissions from on-road vehicles down from 2002

Estimated pollutant emissions (using modelling) from on-road vehicles have decreased over the past 10 years, despite an increase in vehicle kilometres travelled (11 percent). Emissions include those from vehicle exhaust and brake and tyre wear (see figures 20–24).

All the key pollutants from on-road vehicles were estimated to have decreased from 2001 to 2012:

- carbon monoxide, down 39 percent
- nitrogen oxides, down 36 percent
- PM₁₀, down 25 percent
- PM_{2.5}, down 26 percent
- volatile organic compounds, down 49 percent.

Figure 20

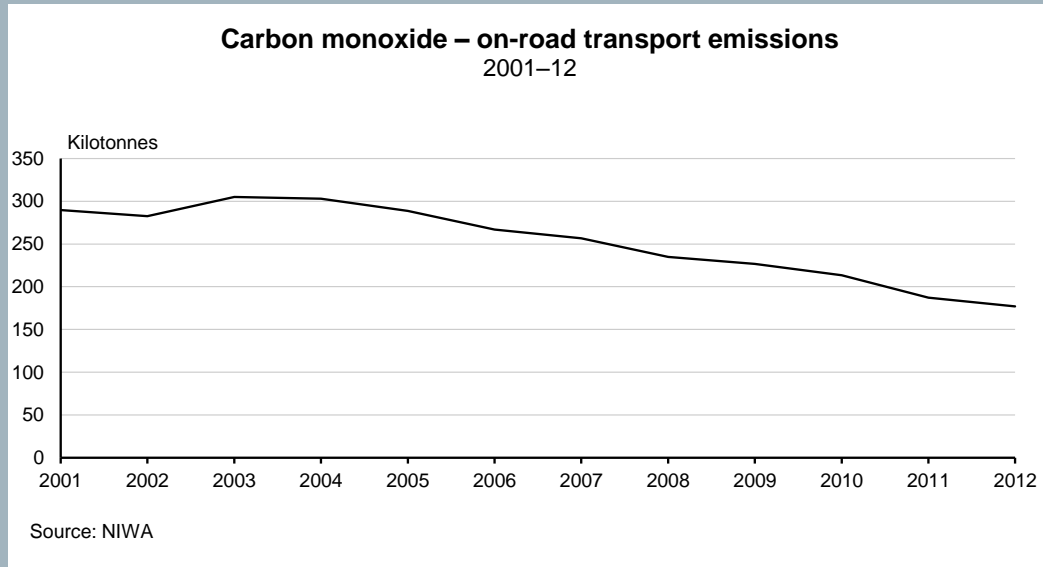


Figure 21

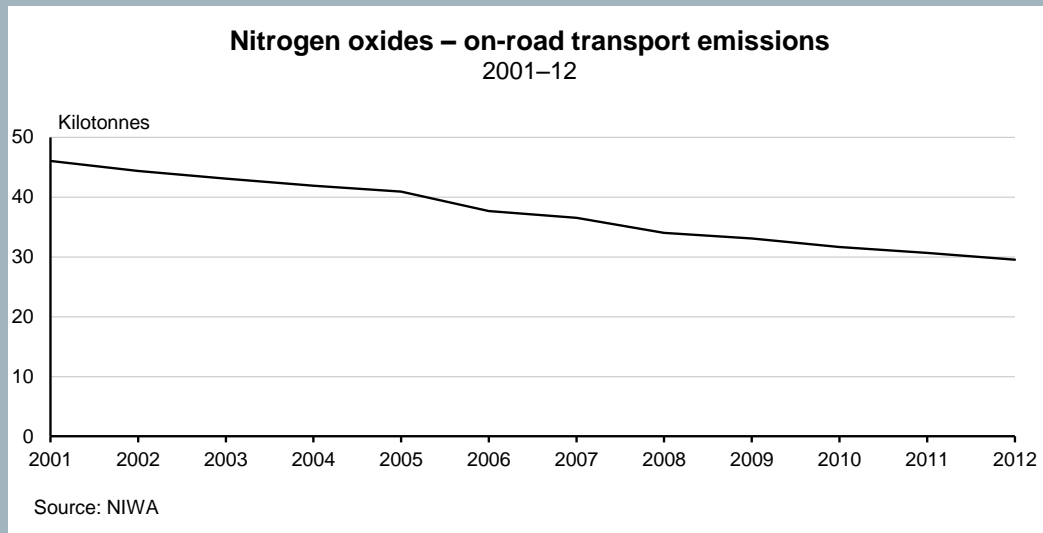


Figure 22

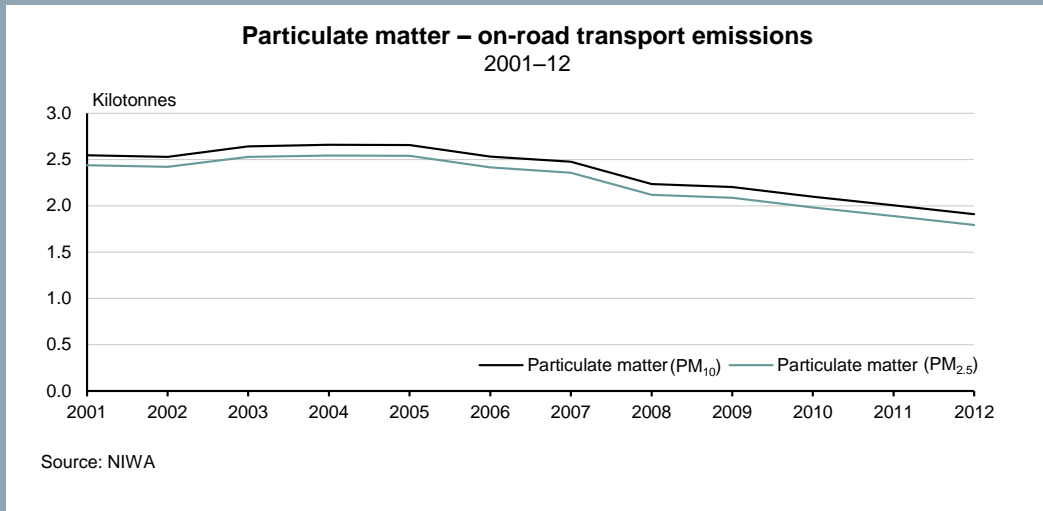


Figure 23

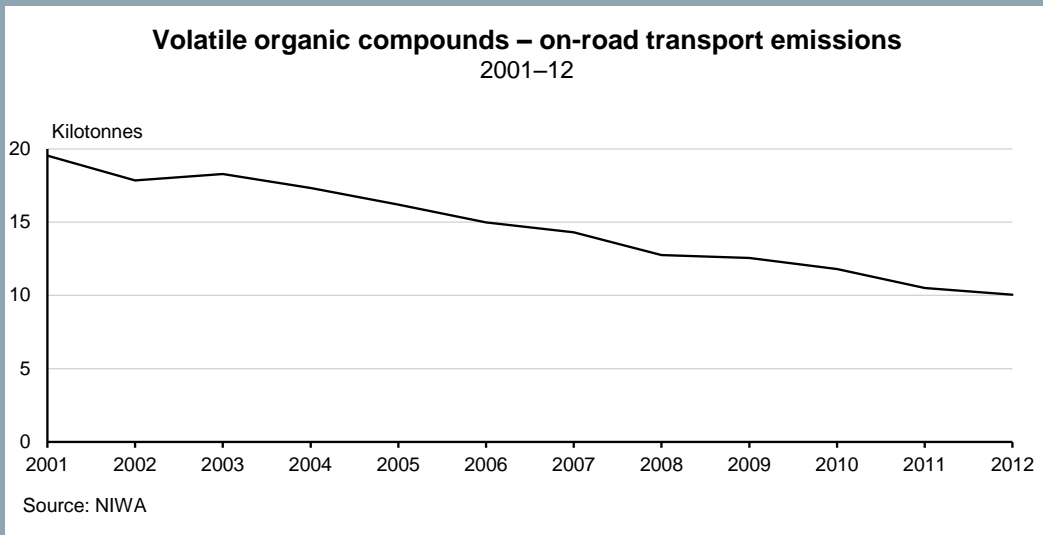
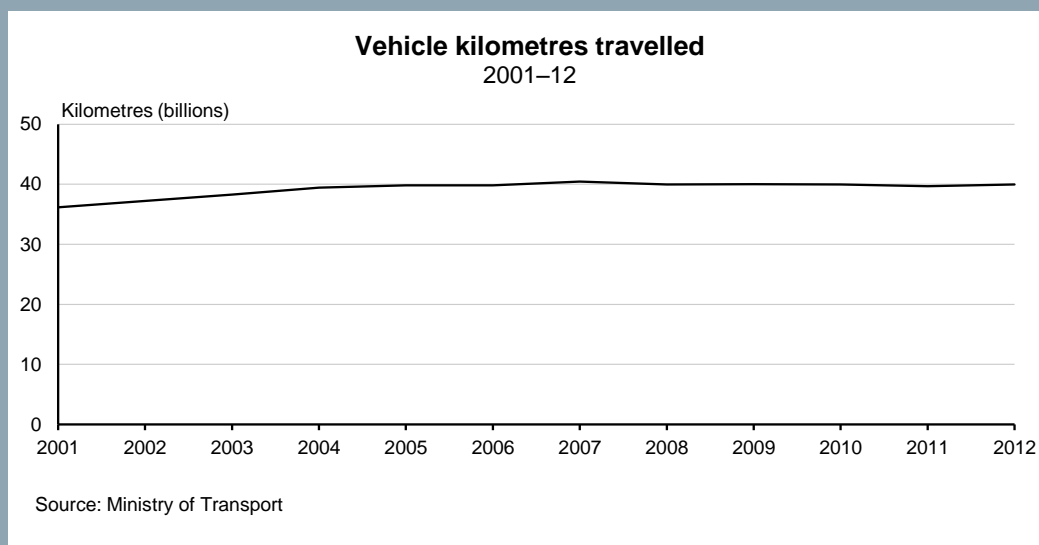


Figure 24



Improvements in our vehicle fleet and fuel quality have resulted in reduced emissions from on-road vehicles between 2001 and 2012. These reductions may have contributed to the national decrease in PM₁₀ concentrations between 2006 and 2012.

This reduction in PM₁₀ concentrations due to reductions in estimated transport emissions, is also supported by the small number of council PM₁₀ monitoring sites located close to busy transport locations, which also showed decreasing PM₁₀ concentrations over the same period – for example, Khyber Pass Road and Queen Street in Auckland, and Wellington Central.

See [weather conditions](#) for other factors that contribute to concentrations.

See [About the indicators](#) for more information on this indicator.

Home-heating emissions

Key point

From 1996 to 2013, the number of households that burnt wood or coal for home heating decreased 25 percent.

Home-heating and air quality

Burning wood or coal for heating homes emits many pollutants, including PM₁₀, carbon monoxide, sulphur dioxide, benzo(a)pyrene, and arsenic (if treated timber is used). Nationally, burning wood or coal for home-heating is the main source of human-made PM₁₀ emissions (Kuschel et al, 2012).

Home-heating generally occurs during May to August and so does not affect air quality throughout the year.

Nearly all exceedances of the national environmental standard for PM₁₀ (94 percent from 2010 to 2012) occur during the cooler months. These exceedances are due to:

- increased emissions from burning wood or coal for home heating, which accounts for 90 percent of human-made winter-time PM₁₀ emissions in some areas of Waikato, Hawke's Bay, Nelson, Canterbury, Otago, and Southland (Airshed progress reports provided by regional councils to the Ministry for the Environment for compliance reporting)
- the increased incidence of weather conditions that prevent dispersal of pollutants, such as low wind speeds and temperature inversions.

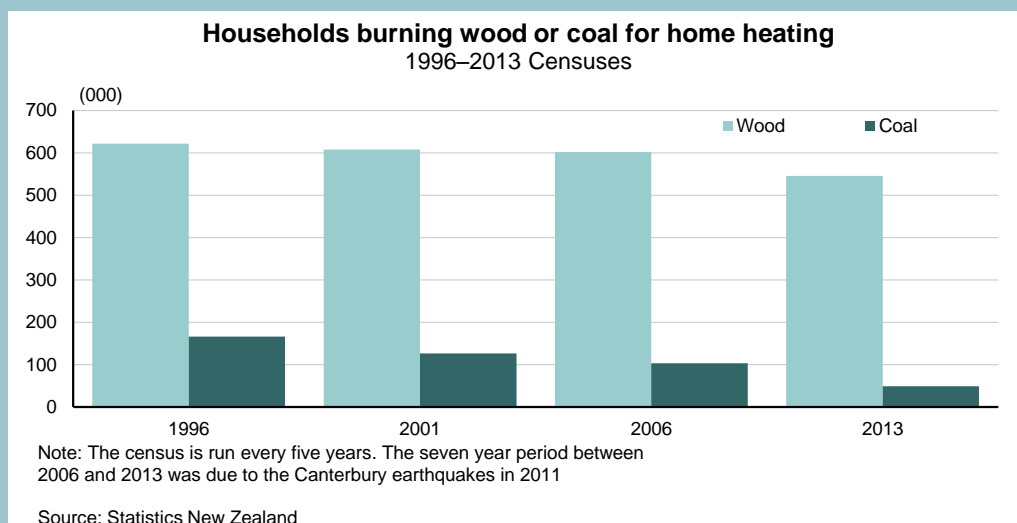
Case study: Fewer households are burning wood or coal for home heating

The number of households burning wood or coal for home heating decreased 25 percent from 1996 to 2013. Approximately 788,000 dwellings (or 62 percent of all dwellings) burnt wood or coal for home heating in 1996, reducing to 594,000 dwellings (38 percent of all dwellings) in 2013 (see figure 25). Data sourced from Statistics NZ's 2013 Census.

Between 1996 and 2013, the number of households burning wood for home heating fell 12 percent (from approximately 622,000 dwellings to 546,000), while those burning coal fell 71 percent (from approximately 166,000 dwellings to 49,000) This decrease occurred despite a 22 percent increase in the number of households in New Zealand.

Burning wood or coal for home heating is the key source of New Zealand's PM₁₀ concentrations during the cooler months (Kuschel et al, 2012). The decrease in homes burning wood or coal has likely resulted in a decrease in emissions from home heating, which is likely to have led to lower PM₁₀ concentrations from 2006 to 2012. The rate at which wood burners are being replaced by newer more efficient appliances is unknown but will likely result in a further decrease in emissions from home heating. Other factors, such as quantities of wood and coal burnt also affect emissions.

Figure 25



Despite reductions in the number of households burning wood or coal for home heating, it still causes high levels of PM₁₀, PM_{2.5}, arsenic (due to burning treated timber offcuts), and benzo(a)pyrene in some locations (see state section of this report for more information).

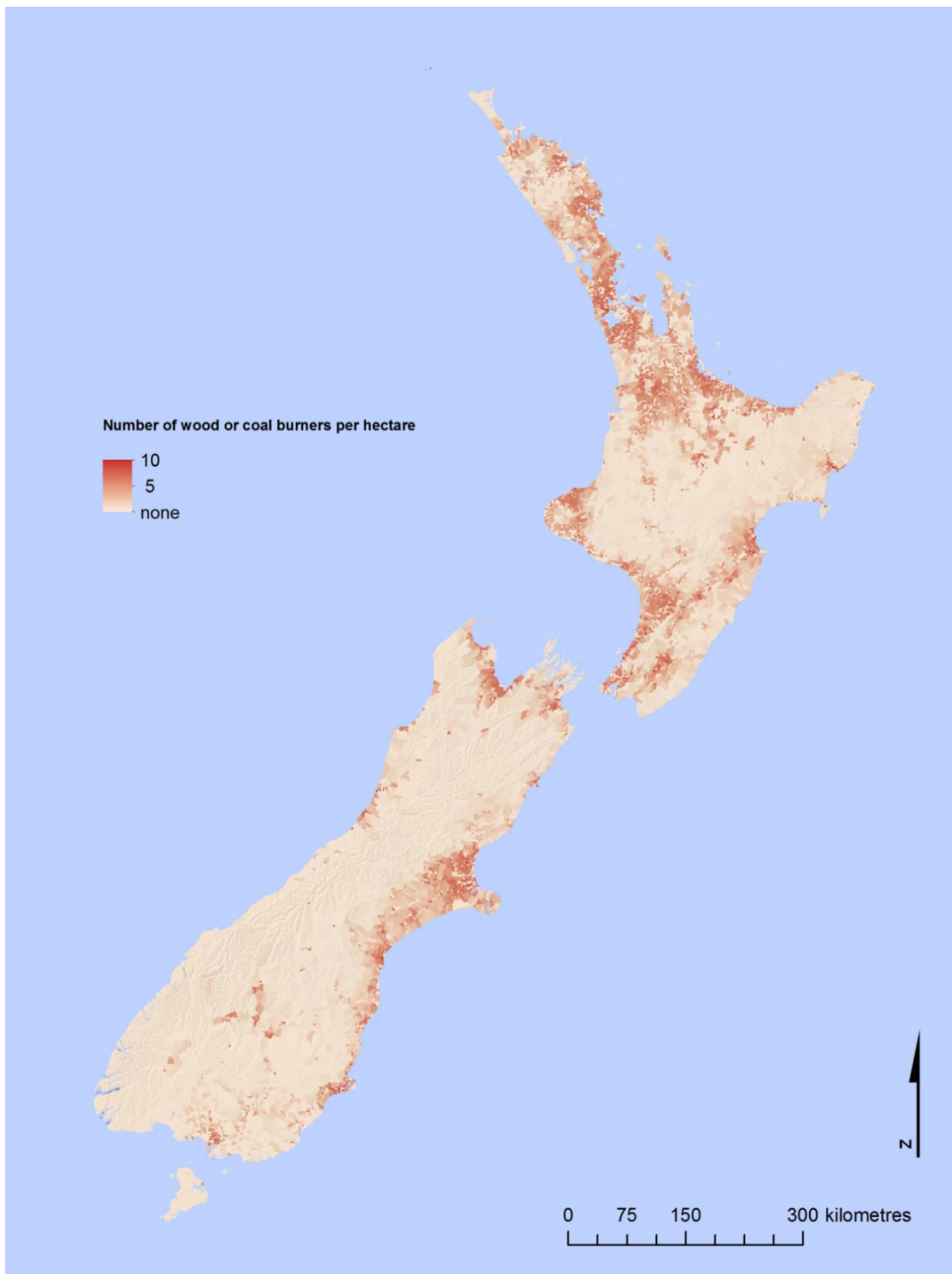
See [About the case studies](#) for more information about this case study.

Home-heating is the main source of PM₁₀ in most urban areas

Studies by some councils (Auckland, Waikato, Hawke's Bay, Manawatu-Wanganui, Wellington, Marlborough, Nelson, Tasman, Canterbury, West Coast, and Southland) showed that home-heating using coal or wood is the main source of PM₁₀ in most urban locations – particularly in winter (Airshed progress reports provided by regional councils to the Ministry for the Environment for compliance reporting).

Many factors influence people's home-heating choices, such as how cold the winters get, local regulations on options for home heating, and the ease of access to and the cost of wood, coal, or other heating sources. These factors can result in differences in the number of appliances, and likely emissions, at the local level (see figure 26 to see home-heating using coal or wood by area).

Figure 26: Home-heating using wood and coal burners, by area 2013



Source: Data provided by Statistics New Zealand

Natural sources of pollutants

Key point

The contribution of natural sources to PM₁₀ ranges from 29 percent to 55 percent of annual PM₁₀ concentrations at urban locations.

Sea salt, pollen, dust, bushfires, and volcanoes can produce air pollutants. However, their contribution can be relatively stable (over a year) except when natural events occur, such as volcanic eruptions or bush fires.

Case study: Natural sources contribute up to half of annual PM₁₀ concentrations

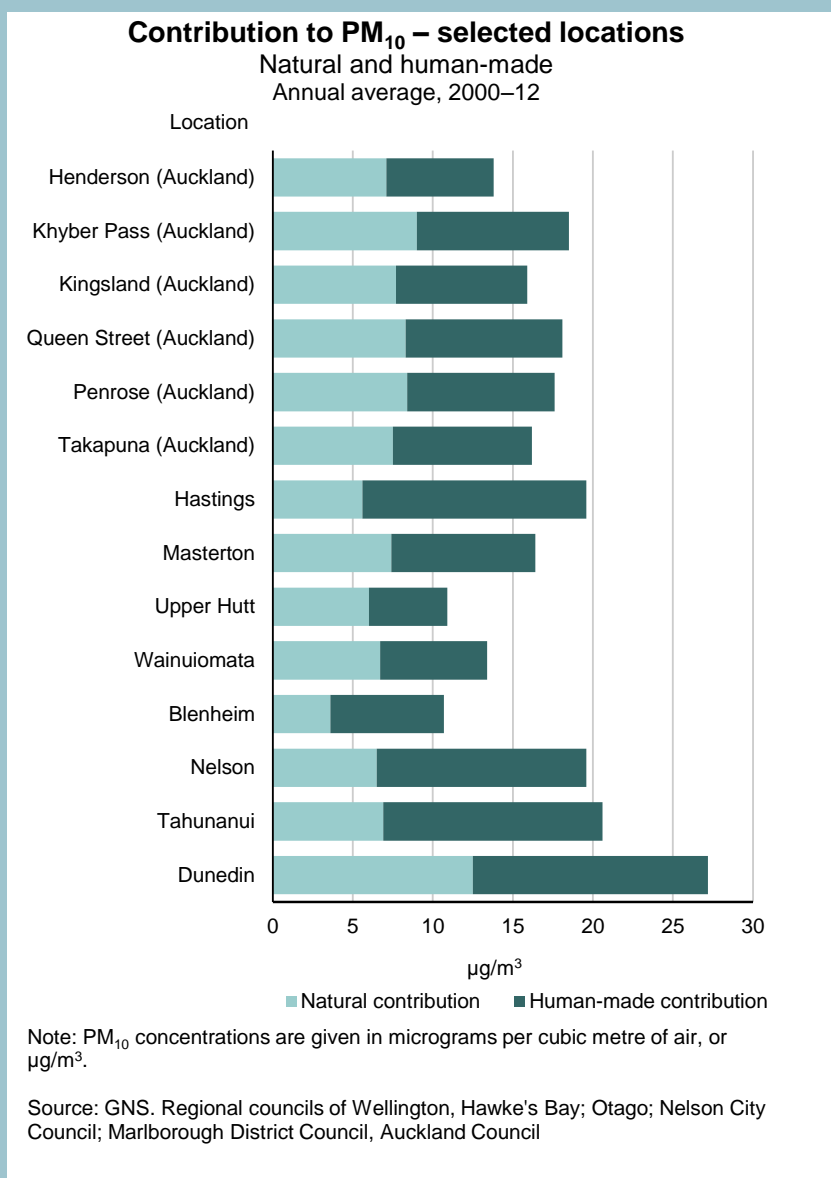
The amount and proportion of PM₁₀ from natural sources varies between sites, and within sites throughout the year.

From 2000 to 2012, the estimated annual average contribution from natural sources at urban areas ranged from 4 µg/m³ in Blenheim to 13 µg/m³ in Dunedin, or about 18 to 63 percent of the World Health Organization (WHO) long-term guideline for PM₁₀, respectively (see figure 27). Upper Hutt had the greatest proportion of its annual PM₁₀ concentrations contributed from natural sources at 55 percent. Hastings had the lowest proportion at 29 percent.

These values can fluctuate from year to year. As the information presented covers different monitoring periods the results from the different sites may not be directly comparable across all sites but gives a good indication of variation.

PM₁₀ from natural sources generally makes up a small proportion of total PM₁₀ on peak PM₁₀ days, but in some locations on some days it can be a major contributor (up to 90 percent) (GNS Science, 2009, 2011, & 2013). The proportion from natural sources, however, decreases during winter as contributions from home heating increase.

Figure 27



See [About the case studies](#) for more information, including the monitoring time periods, on this case study.

Other pressures on air quality

In addition to the key pressures covered in this report, we have some background information on other pressures that affect our air quality. We intend to examine these pressures on a case-by-case basis to assess their significance to future environmental reporting. We will consult, assess, and advise ministers and councils on the costs and benefits of improving this information.

See [Improving environmental reporting data web page](#) for more information.

Emissions from fuel used off road

Off-road emissions from liquid fuels (diesel and petrol) affect air quality. Off-road fuel is used in shipping, rail, aviation, recreational boating, tractors, construction vehicles, and equipment (eg lawnmowers, chainsaws, generators).

We do not have information on the quantity of emissions at the national level.

Industry emissions

Some manufacturing, construction, and electricity production activities produce emissions of air pollutants. The most common pollutants are sulphur dioxide, PM₁₀, and nitrogen oxides. While we do not have information on emissions from all industries, emissions from the transport industry are captured, from on-road activity, in the on-road vehicle emissions national indicator, but cannot be separated from non-industry emissions.

The contribution of industry emissions to air pollutant concentrations varies by areas, depending on how much industrial and other air pollutant emitting activities exist. For example, in 2010–11, industry contributed 5 percent of winter-time sulphur dioxide emissions in Hastings, compared with 48 percent in Gore. Likewise, industry accounted for 17 percent of winter-time nitrogen oxides emissions in Invercargill, but only 1 percent in Napier (Wilton, 2011; Hawke's Bay Regional Council, 2010).

Primary sector emissions

Many primary sector activities can release substantial levels of air pollutants:

- pollutants from biomass burning
- pollutants dispersed from using fertilisers and pesticides
- wind-borne dust (from logging activities, tilling soil, quarrying, mining).

We do not have information on how much the primary sector contributes to our air quality.

Weather conditions

Weather conditions can affect the quantity, patterns, and dispersal and removal rates of emissions.

The state of air quality is not only influenced by the pollutants emitted but also by the extent to which the pollutants are dispersed and removed from the air. Weather conditions play a key role in determining the quantity of emissions (eg home heating, release by 'cold start' of vehicles, sea spray, wind erosion) and in patterns and rates of dispersal and removal (by rain).

High wind speeds can quickly disperse pollutants, preventing them from accumulating. Low wind speeds can prevent pollutants from dispersing therefore allowing them to build up. Low wind speeds and cold temperatures can cause temperature inversions (see figure 28), which can further inhibit pollutant dispersion.

The impact of wind speed can be large. This is evident in small towns that emit lower quantities of pollutants than larger towns, but report higher concentrations of them.

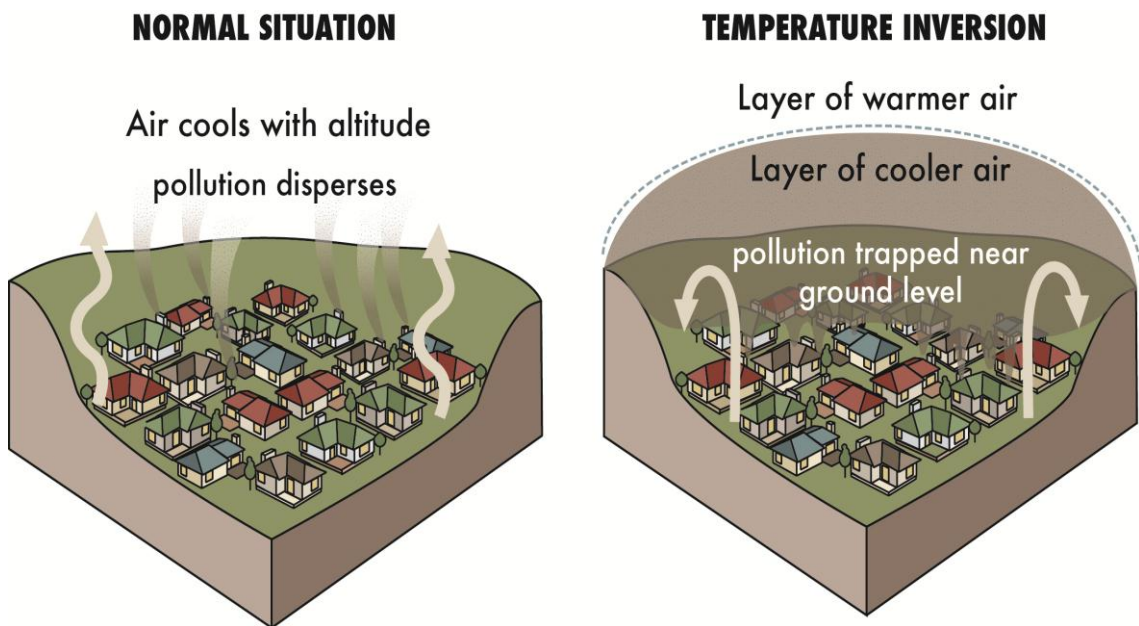
Conversely, high wind speeds can also increase concentrations of pollutants in some conditions. For example, strong wind can create and disperse spray from the sea, or raise dust, which contribute to PM₁₀ concentrations.

Sunlight and temperature also play a key role in producing, transforming, and breaking down air pollutants. Concentrations of ground-level ozone, for example, show a strong diurnal and seasonal pattern, driven by these factors.

Weather conditions can vary from year to year, which can cause changes in pollutant concentrations.

Topography can also influence local air quality, largely by its influence on weather conditions. For example, valley locations can be more favourable for temperature inversions. Topography can also influence wind patterns and therefore pollutant dispersal.

Figure 28: How temperature inversions trap pollution



Source: Ministry for the Environment

The impacts of air quality

The quality of our air may have significant impacts on public health, ecological integrity, economic benefits derived from using natural resources, and culture and recreation.

This section reports on:

- [health impacts of air quality](#)
- [other impacts of air quality](#)
 - [atmosphere and climate](#)
 - [visibility](#).

Health impacts of air quality

Key points

- PM₁₀ concentrations decreased between 2006 and 2012. Using modelling, this reduction was associated with an estimated:
 - 14 percent fewer premature deaths from exposure to human-made PM₁₀
 - 15 percent fewer hospital admissions from exposure to human-made PM₁₀
 - 9 percent fewer days of restricted activity from exposure to human-made PM₁₀.
- The decrease in estimated health impacts occurred despite an increase in the population.

The health impacts are modelled and are not determined from hospital records. Modelling is a common approach used to estimate health impacts from air quality and different modelling approaches exist. The estimates are determined from the PM₁₀ concentrations the population is exposed to and the probability of the health risks being experienced at these concentrations. These health risks have been determined from international and national population studies.

The model used was developed to estimate health impacts in New Zealand. The methodology used for these estimates is consistent with international practice and has been internationally and nationally peer reviewed. Other methodologies for estimating health impacts from air quality also exist.

PM₁₀ and health

The health impacts from air quality focus on those caused by exposure to PM₁₀. This is because PM₁₀ is associated with a range of effects, from minor irritation to more severe impacts, and it is the pollutant that most often breaches the national short-term standard and exceeds the World Health Organization long-term guideline. We have a good understanding of the concentrations of PM₁₀ experienced in New Zealand, and epidemiological evidence about the health risks is well established.

As PM₁₀ is a collection of pollutants, such as metals, nitrates, sulphates, and organic matter, the health impacts are from more than one type of pollutant and provide a broader

assessment of health impacts. The health impacts from PM₁₀ or PM_{2.5} (which is a component of PM₁₀) are the most commonly assessed by other countries as they are seen as the air pollutants of greatest concern. While other air pollutants may have adverse health impacts and are not captured in the measures below, the majority of health impacts in New Zealand are associated with PM₁₀ (Kuschel et al, 2012).

The health effects associated with exposure to PM₁₀ are diverse, ranging from very subtle effects to premature mortality. People with existing health conditions, the young, and older people are more vulnerable to these effects.

National indicator: Estimated health impacts from human-made PM₁₀ down from 2006

The estimated health impacts (using modelling) from exposure to human-made PM₁₀ decreased from 2006 to 2012 in all three categories.

- Estimated premature deaths decreased from 1,170 to 1,000 (down 14 percent). This equates to about 3 percent of the total deaths in New Zealand that year.
- Estimated hospital admissions for cardiac and respiratory conditions due to exposure to PM₁₀ decreased from 610 to 520 (down 15 percent).
- Estimated restricted activity days in which symptoms were sufficient to prevent usual activities, such as work or study, decreased from 1.49 million to 1.35 million (down 9 percent).

These decreases in estimated health impacts occurred despite an increase of 200,000 in New Zealand’s population between 2006 and 2013.

Information on the estimated health impacts of human-made PM₁₀ is important because it is possible to manage its sources.

Table 1: Estimated health impacts from exposure to PM₁₀ 2006 and 2012

Health impact	2006	2012	% change
Premature deaths	1,170	1000	-14
Hospital admissions	610	520	-15
Restricted activity days	1,490,000	1,350,000	-9

Source: NIWA

Note: See [Key points](#) for methodology.

These estimated health impacts are associated with exposure to PM₁₀, but PM₁₀ is not necessarily the sole cause of the estimated health impact as other factors may be involved. For example, exposure to PM₁₀ can aggravate existing conditions such as asthma, which is not caused by exposure to PM₁₀, but can result in hospital admissions. In this example, it is the combination of another factor (a pre-existing condition) with exposure to PM₁₀ that produces the estimated health impact.

The estimate of hospital admissions is lower than the number of premature deaths, as hospitalisations exclude cases leading to premature death.

See [About the indicators](#) for more information, including the methodology, on this indicator.

Other impacts of air quality

The health effects associated with PM₁₀ represent the major health impacts of air pollution in New Zealand. Other health impacts may exist, but knowledge of the risks, and information on exposure levels, are not enough for us to make reliable estimates.

We intend to examine the national significance of other health impacts, as well as economic (eg medical costs and lost work days) and ecological effects (eg pollution of waterways) for future environmental reporting. We will consult, assess, and advise ministers and councils on the costs and benefits of improving this information.

See [Improving environmental reporting data web page](#) for more information.

Impacts on atmosphere and climate

Air pollution and the state of our atmosphere and climate affect each other in many ways. Air pollution can affect the atmosphere and climate directly through the warming and cooling properties of pollutants. Indirectly, air pollution can change rainfall and the reflectivity and distribution of clouds.

Particulate matter and ground-level ozone are two of many air pollutants that affect our atmosphere and climate. Some particulate matter have a cooling effect (such as sulphates and nitrates) by reflecting sunlight. Others (such as black carbon – a component of soot particles) have a warming effect by absorbing sunlight. Research has identified black carbon as the second-most important human emission in terms of its potential to change our climate (Bond et al, 2013).

Ozone absorbs some of the infrared energy emitted by the earth and creates warming effects in its immediate surroundings. Ozone also reduces vegetation's ability to remove carbon dioxide from the atmosphere – an important global warming gas.

While the above information demonstrates an impact, the level of the impact New Zealand's air pollution has on our, and the global, atmosphere and climate is unknown.

Visibility

Poor visibility occurs when sunlight encounters tiny pollution particles in the air (particulate matter, nitrogen dioxide, and aerosols), reducing the clarity and colour of what we see. Sources of this pollution include burning of wood or coal for home heating, transport emissions, industrial activities, and natural sources (eg sea spray).

Visibility is the most widely perceived measure of air quality. Poor visibility can disrupt transport (due to large-scale events like volcanic eruptions) and can influence people's perception of air quality and sometimes the activities they engage in. We do not have quantitative measures of the impact of air pollution on visibility.

Data and supporting information

Access the following supporting information:

- [data files](#)
- [about the indicators](#)
- [about the case studies](#)
- [technical report commissioned to provide us with information.](#)

Data files

Here are the [Excel files](#) containing data used in this report.

About the indicators

In *2014 Air Domain Report* we presented three national indicators of air quality. This page provides the background, supporting information, methodology, and limitations for the data used in the report. See [Criteria for selecting our environmental indicators](#) on how indicators are selected.

Indicator	Emissions of key pollutants from on-road vehicles
Related topic	Transport emissions (pressure)
Indicator definition	Estimated tonnes of emissions from on-road vehicles for these pollutants: carbon monoxide, volatile organic compounds, nitrogen oxides, PM ₁₀ , and PM _{2.5} .
Background	Emissions from transport sources include nitrogen oxides, carbon monoxide, sulphur dioxide, particulate matter, volatile organic compounds, and other pollutants. The health effects caused by exposure to these pollutants are related to increased lung and heart disease incidents.
Presentation of indicator components	Estimated total emissions (tail pipe and brake and tyre wear, in kilotonnes) from on-road vehicles for these pollutants: <ul style="list-style-type: none">• carbon monoxide• volatile organic compounds• nitrogen oxides• PM₁₀• PM_{2.5}.
Methodology	This indicator uses a model developed for the New Zealand Transport Agency and Auckland Council to estimate emissions from New Zealand's vehicle fleet over time. The model considers the types of vehicles on the road, their fuel efficiency, and the distances and speed they travel. See NIWA's Indicators for Environmental Domain Reporting report for more information. Information on accessing the model is available from the New Zealand Transport Agency website .
Data coverage	National (2001–12)

Emissions of key pollutants from on-road vehicles	
Data source	<p>Ministry of Transport data series used, available from the Ministry of Transport:</p> <ul style="list-style-type: none"> • fleet composition (TV034) • vehicle speed (SS008) • congestion (NR002) • vehicle fleet statistics (TV001). <p>See NIWA's Indicators for Environmental Domain Reporting report for more information.</p>
Limitations to data and analysis	<p>The model is based on internationally recommended approaches, uses internationally recognised emission factors, and is validated with road testing results. However, limited validation of the model outputs for heavy diesel vehicles exist. See NIWA's Indicators for Environmental Domain Reporting report for more information.</p> <p>Modelling assumptions and parameters are reviewed periodically to ensure the model best reflects the emissions from on-road transport at a given point in time. Any changes to the model are peer-reviewed internationally.</p> <p>The modelling assumes that the vehicle fleet composition is the same throughout New Zealand as the regional information is of variable quality.</p> <p>Estimated pollutant emissions do not always equal the measured concentrations. Other factors also contribute to concentrations, such as weather conditions.</p>
Additional information to understand the link between the topic and the indicator	<p>Only national on-road transport is included. Off-road transport, including sea, air, and rail transport, is excluded.</p>
Changes to time series	<p>None</p>

National annual average PM₁₀ concentrations	
Related topic	<p>Concentration of particulate matter (state)</p>
Indicator definition	<p>A population weighted annual average PM₁₀ concentration indicator from both natural and anthropogenic (human-made) sources.</p> <p>The long-term (annual) average concentration takes into account both peak and low pollution periods and gives an indication of long-term health risks. Annual averages also represent a larger area and population than short-term (daily) measurements.</p>
Background	<p>Exposure to high PM₁₀ concentrations are linked to adverse health effects such as lung and heart conditions. PM₁₀ is the measured air pollutant that most frequently exceeds national and international thresholds in New Zealand.</p>
Presentation of indicator components	<p>Population weighted annual average concentration of PM₁₀ (micrograms per cubic metre).</p>

Indicator	National annual average PM ₁₀ concentrations
Methodology	<p>The national annual average PM₁₀ concentration is estimated using regional council and unitary authority monitoring stations data (54 sites in 2012) and Statistics NZ's population estimates.</p> <p>The national average is calculated by using the average concentration for each monitoring site, weighted by the population each site represents.</p> <p>The population represented by each monitoring site is considered to be the population of the urban area the monitoring site is located in. Where multiple monitoring sites are located within an urban area, the population of the urban area is divided across each of the monitoring sites.</p> <p>This approach accounts for the difference in the distribution of monitoring sites within New Zealand relative to the represented population. For example, in 2012, 40 percent of monitoring sites were in small towns but populations in small towns represent much less than 40 percent of the total population. An average of all monitoring results would be influenced more by the concentrations in small towns than the proportion of the population it represents.</p> <p>Monitoring information is only included if the site achieves greater than 75 percent valid data collection and follows good practice approaches (Ministry for the Environment, 2009). This helps ensure the data is representative of the location.</p> <p>See NIWA's Indicators for Environmental Domain Reporting report for more information.</p>
Data coverage	Approximately 75 percent of the population in 2012.
Data source	Regional council and unitary authority monitoring data. See Data files page .
Limitations to data and analysis	<p>Rural areas and some urban areas are not included as no air quality monitoring occurs at these locations or the population at the monitoring location is unknown. These unmonitored areas are approximately 25 percent of New Zealand's population. Currently there is no robust method to estimate air quality concentrations in these areas. This is an improvement that will be considered for future reporting.</p> <p>Some of the monitoring occurs at sites expected to have the highest concentrations (eg close to road traffic or peak urban areas), and so may not be representative of the whole population it is assumed to represent.</p> <p>See NIWA's Indicators for Environmental Domain Reporting report for more information.</p>
Additional information to understand the link between the topic and the indicator	Annual average concentration of PM ₁₀ is an indicator of long-term concentration. Short-term indicators are measured by daily concentrations. Long-term concentrations give a better indication of the impact on public health and provide greater representation of area and population than short-term (daily) measurements.
Changes to time series	The sample includes monitoring sites achieving 75 percent valid data. The sample of monitoring sites varies year to year, with additional sites being included if best practice approaches are followed, or omitted if not of adequate standard.

Indicator	National-level health impacts due to exposure to PM ₁₀
Related topic	Public health effects (impact)
Indicator definition	The estimated number of premature deaths, hospitalisations, and restricted activity days for the New Zealand population from exposure to sources of PM ₁₀ from human activities.
Background	Exposure to PM ₁₀ is linked to adverse health effects such as lung and heart conditions. Estimates can be made on the impact exposure to PM ₁₀ is having on the health of New Zealanders. Tracking these estimates over time shows whether population health impacts due to PM ₁₀ concentrations from human activities are improving or worsening.
Presentation of indicator components	Estimated number of premature deaths due to PM ₁₀ exposure. Estimated number of hospitalisations due to PM ₁₀ exposure. Estimated number of restricted activity days due to PM ₁₀ exposure.
Methodology	<p>Health impacts due to air pollution are estimated by determining the concentrations of the pollutant the population is exposed to and the probability of health risks after exposure to concentrations of that pollutant.</p> <p>Information on the PM₁₀ concentrations the population is exposed to comes from regional council and unitary authority monitoring stations data and the census.</p> <p>Dose response functions are calculated from international and national epidemiological studies.</p> <p>The focus is on anthropogenic (human-made) sources of PM₁₀ as these sources can be managed and abated. Information on the anthropogenic component of PM₁₀ comes from GNS Science.</p> <p>Health effects from PM_{2.5} exposure are not measured as there is insufficient monitoring information to do so.</p> <p>Data for 2006 are based on monitoring data from 2006 to 2008, while 2012 data are based on monitoring data from 2010 to 2012. The time period reflects the year of the census or the closest to it for which monitoring data is included. Results are based on the average concentration over a three-year period. This provides an indicative estimate of the long-term health effects by smoothing out short-term extremes caused, for example, by a particularly warm or cold winter.</p> <p>See NIWA's Indicators for Environmental Domain Reporting report for more information.</p> <p>The model is available from the Health and Air Pollution in New Zealand website.</p>
Data coverage	National (2006, 2012)
Data source	Health and air pollution in New Zealand model, 2012 (model framework). Regional councils and unitary authorities (PM ₁₀ monitoring data). Census (population estimates). GNS Science (natural PM ₁₀ concentrations).

Indicator	National-level health impacts due to exposure to PM ₁₀
<p>Limitations to data and analysis</p>	<p>Concentrations of PM₁₀ are imputed in census area units where monitoring has not occurred.</p> <p>Location-specific anthropogenic PM₁₀ component information was applied where available. For other locations, a national average anthropogenic component estimate (based on the location-specific information) was used.</p> <p>The most relevant dose response functions based on national and international studies are used.</p> <p>The base incidence rates for health outcomes were not updated as new data was not available. This is expected to have a minor impact on the results – an increase or decrease in premature mortality and hospitalisations by approximately 1.5 percent. Restricted activity days are not influenced by base incidence rates.</p> <p>See NIWA's Indicators for Environmental Domain Reporting report for more information.</p>
<p>Additional information to understand the link between the topic and the indicator</p>	<p>The estimates reflect only the public health effects of PM₁₀ from human activities and do not show the effects of other pollutants that have adverse health effects. Therefore, this indicator understates the total effect of air quality on public health.</p>
<p>Changes to time series</p>	<p>The sample includes monitoring sites achieving 75 percent valid data. The sample of monitoring sites varies year to year, with additional sites included if best practice approaches are followed, or omitted if not of adequate standard.</p>

About the case studies

In *2014 Air Domain Report* we presented three national indicators of air quality. In some instances, we do not have robust or national-scale data to report on an indicator. For these, we used case studies where we have data that showed a significant component of a topic or a region. This page provides information on the case studies we used.

Case study	Daily PM ₁₀ concentrations
Related topic	Particulate matter (state)
Case study definition	The number of airsheds where daily PM ₁₀ concentrations exceed the short-term national health standard – providing an understanding of how many locations experience short-term poor air quality.
Background	<p>Exposure to high PM₁₀ concentrations are linked to adverse health effects such as lung and heart conditions. PM₁₀ is the air pollutant that most frequently exceeds national and international thresholds in New Zealand.</p> <p>Reporting the number of airsheds that exceed national health standards provides an understanding of how many locations experience poor short-term air quality. Providing grouped information on how often these exceedances occur provides information on the frequency of exceedances.</p>
Presentation of case study components	<ul style="list-style-type: none"> • The number of airsheds that exceed the national health standard. • Grouped information on how often this standard is exceeded.
Methodology	<p>The number of airsheds where daily PM₁₀ concentrations exceed the short-term national health standard, and the number of days it exceeds, is obtained from regional council and unitary authority monitoring stations.</p> <p>Monitoring information is only included if the site achieves greater than 75 percent valid data collection and follows good practice approaches. This helps ensure the data is representative of the location.</p>
Data coverage	Approximately 40 airsheds which cover a number of locations. The population coverage is unknown, meaning a nationally representative average cannot be compiled.
Data source	Regional council and unitary authority monitoring data.
Limitations to data and analysis, including level of confidence	<p>Some of the monitoring occurs at locations expected to have the highest concentrations (for example close to road traffic or peak urban areas) in that area and may therefore not be representative of the whole population of the area it is located in.</p> <p>The population experiencing the exceedances is unknown.</p>
Changes to time series	<p>The sample includes monitoring sites achieving 75 percent valid data. The sample of monitoring sites varies year to year, with additional sites being included if best practice approaches are followed or omitted if not of adequate standard.</p> <p>Generally, those airsheds that do exceed the standard are continually monitored until they regularly no longer exceed the standard. Therefore, the trend in the number of airsheds exceeding the standard reflects changes in airsheds exceeding the standard rather than a change in monitoring sites.</p>

Case study	PM _{2.5}
Related topic	Particulate matter (state)
Case study definition	Annual average PM _{2.5} concentrations for seven sites. The concentrations are compared against the World Health Organization (WHO) long-term guideline.
Background	Particulate matter less than 2.5 micrometres in diameter (PM _{2.5}) is a subset of PM ₁₀ . On average, PM _{2.5} is largely emitted from human activities, with a much smaller contribution from natural sources than PM ₁₀ . Some research shows that certain health effects (eg cardiovascular disease and mortality) caused by PM ₁₀ are more likely to be associated with the PM _{2.5} component (WHO, 2013; European Environment Agency, 2013).
Presentation of case study components	Annual average concentration (micrograms per cubic metre). Frequency of daily PM _{2.5} concentrations above the WHO short-term guideline.
Methodology	PM _{2.5} concentrations are determined from council monitoring stations. Annual averages are reported as they indicate long-term health risks. Information is only included if the site achieves a greater than 75 percent valid data rating to help ensure the data is representative of the location. The monitoring must also use reference methods and follow good practice methodologies. The sites selected are those that have greater than 75 percent valid data for 2012 and at least one other year. The number of times the WHO short-term guideline is exceeded is reported as they indicate the short-term state and health risks. The WHO long-term guideline is set at 10 micrograms per cubic metre. The WHO short-term guideline is set at 25 micrograms per cubic metre.
Data coverage	Whangaparoa, Patumahoe, Penrose, Takapuna (Auckland); Masterton; St Albans, Woolston (Christchurch); Timaru. (2008–12)
Data source	Auckland Council Greater Wellington Regional Council Environment Canterbury
Limitations to data and analysis	Average PM _{2.5} concentrations across measured sites are not nationally representative.
Changes to time series	None

Case study	Nitrogen dioxide
Related topic	Concentration of gases (state)
Indicator definition	Annual average nitrogen dioxide concentrations at three location types: state highways; (busy) local roads; and urban background sites.
Background	<p>Nitrogen dioxide is a gas and can be directly emitted into the air. It is more commonly formed, however, from nitric oxide being emitted into the air and then reacting with other air pollutants. Both nitrogen dioxide and nitric oxide (collectively known as nitrogen oxides) are emitted from the combustion of fossil fuels (coal, gas, and oil) and from natural sources such as volcanoes.</p> <p>Exposure to high nitrogen dioxide concentrations are linked to asthma symptoms and reduced lung development and function in children.</p>
Presentation of indicator components	<p>Annual average concentration of nitrogen dioxide (micrograms per cubic metre) at three location types:</p> <ul style="list-style-type: none"> • state highways • busy local roads • urban background sites.
Methodology	<p>Information is obtained from the New Zealand Transport Agency's (NZTA) nitrogen dioxide monitoring network.</p> <p>The network consists of approximately 130 monitoring stations over 2010–12. Monitoring stations are located in each region and cover all the main urban areas, as well as other urban areas. The network uses passive monitoring to determine nitrogen dioxide concentrations.</p> <p>Information is only included if the site achieves a greater than 75 percent valid data rating to help ensure the data is representative of the location.</p> <p>For more information on the monitoring methodology used for the NZTA monitoring network see the National air quality (NO₂) monitoring network information on NZTA's website.</p>
Data coverage	Approximately 130 monitoring sites that cover many locations. The population coverage of the monitoring network is unknown, meaning a nationally representative average cannot be compiled.
Data source	NZTA monitoring network
Limitations to data and analysis, including level of confidence	<p>Only one gas is reported.</p> <p>The NZTA monitoring network uses a screening method which provides results that cannot be compared directly to WHO long-term guidelines.</p> <p>For more information on this and other limitations see the National air quality (NO₂) monitoring network information on NZTA's website.</p> <p>The population coverage of the monitoring network is unknown.</p>
Changes to time series	Minor changes in monitoring sites during the reported period.

Case study	Ground-level ozone
Related topic	Gases (state)
Case study definition	Eight-hour maximum ozone concentration at ground level at three sites in Auckland. The concentrations are compared against the World Health Organization (WHO) short-term guideline.
Background	Ozone at ground level is linked to increased health risks, like respiratory and cardiovascular diseases. Ozone is not directly emitted into the air, rather it is formed by chemical reactions involving nitrogen oxides, volatile organic compounds, sunlight, and time. There is much international interest in ozone as in many countries ozone concentrations are increasing and regularly exceed WHO short-term guideline values.
Presentation of case study components	Eight-hour maximum concentrations (micrograms per cubic metre) at three Auckland sites.
Methodology	<p>The ground-level ozone concentrations are determined from Auckland Council monitoring stations. Auckland Council is the only council that regularly monitors ozone.</p> <p>Eight-hour maximum ozone concentrations are presented as this is the time period the WHO short-term guideline is based on to provide a set level of protection against adverse health effects.</p> <p>Monitoring information is only included if the site achieves greater than 75 percent valid data collection and follows good practice approaches (Ministry for the Environment, 2009). This helps ensure the data is representative of the location.</p> <p>The WHO short-term guideline is set at 100 micrograms per cubic metre.</p>
Data coverage	Auckland: Musick Point, Whangaparoa, and Patumahoe, 1996–2012
Data source	Auckland Council
Limitations to data and analysis	The monitoring of ozone occurs at sites where concentrations are expected to be the highest. The ozone concentrations reported cannot be taken to represent all of Auckland, or outside of Auckland.
Changes to time series	None

Case study	Number of households that burn wood or coal for home heating
Related topic	Home-heating emissions (pressure)
Case study definition	<p>This case study presents the number of households that burn solid fuel (wood or coal) for home heating. Tracking these values over time illustrates whether, at a national level, a key component of home heating emissions is increasing or decreasing.</p> <p>This is based on information from the national census that determines the fuel type used to heat occupied private dwellings. More than one fuel type may be used, for example, electricity, gas, coal, and wood.</p>
Background	Home heating emissions have been identified as a key source of air pollution, like particulate matter (Kuschel et al, 2012). The number of homes burning solid fuel is a key component for calculating home heating emissions, along with emissions factors (which account for appliance efficiency) and quantity of fuel burnt.
Presentation of case study components	<p>Total number of homes burning solid fuel and by type of solid fuel:</p> <ul style="list-style-type: none"> • wood • coal.
Methodology	<p>The number of households that burn solid fuel for home heating is determined from the census.</p> <p>The census asks each household to say which heat sources are used to heat this dwelling. The two options, which emit outdoor air pollutants of concern, are wood and coal. The number of households that say they burn either wood or coal, either as the only heating source or in combination with any heating source, are reported as the number of households that burn solid fuel for home heating.</p>
Data coverage	National (1996, 2001, 2006, 2013)
Data source when possible	<p>Census (1996–2013) – Statistics NZ customised request.</p> <p>More information on the fuel types used to heat dwelling variable is available from Statistics New Zealand.</p>
Limitations to data and analysis, including level of confidence	<p>The fuel type by dwelling variable has been given a quality rating of ‘high’ by Statistics NZ and is fit for use with only minor quality issues.</p> <p>The type of fuel used by non-respondents is unknown. In each census, a number of households (approximately 5.5 percent of total households in 2013) did not respond to this question. Of these households, we assume that the proportion burning solid fuel for home heating is the same as the dwellings that responded.</p> <p>There are other factors that influence how burning solid fuel for home heating affects air quality. This includes the quantity of solid fuel burnt and the efficiency of the appliance being used to burn the fuel. These factors are known for some urban areas, but are not currently known at a national level. This is an improvement that will be considered for future reporting.</p>
Changes to time series	<p>The same question was asked in censuses in 1996, 2001, 2006, and 2013.</p> <p>There was a two-year delay for the last census following the Canterbury earthquakes. This means absolute changes between earlier adjacent censuses (eg 2001–2006) cannot be directly compared with the change from 2006–2013.</p>

Case study	Contribution of natural sources to PM₁₀ concentrations
Related topic	Emissions from natural sources (pressure)
Case study definition	For selected monitoring sites, this case study presents the natural and anthropogenic (human-made) components of total annual PM ₁₀ concentrations.
Background	<p>Natural sources (eg sea salt, dust, bushfires, volcanoes, pollens, and other biogenic material) can contribute to the presence of air pollutants. However, the contributions of air pollutants from natural sources are expected to remain relatively stable in the absence of significant natural events, such as large volcanic eruptions or bushfires.</p> <p>While impacts from PM₁₀ include the effects of natural and anthropogenic (human-made) sources, the contribution of natural sources to PM₁₀ concentrations is beyond the control of management or abatement strategies.</p>
Presentation of case study components	<p>Annual average concentrations of PM₁₀ (micrograms per cubic metre), for sites which have conducted source apportionment studies, by:</p> <ul style="list-style-type: none"> • natural sources • anthropogenic (human-made) sources.
Methodology	<p>Uses information from source apportionment studies conducted over time. Source apportionment studies analyse the particles collected at some monitoring stations.</p> <p>Source apportionment studies have been conducted at many sites in New Zealand. This case study uses the results from these studies where the results are considered to be representative of that site (at least one year of monitoring).</p> <p>See NIWA's Indicators for Environmental Domain Reporting report for more information. The values used for this case study are those used for the health impacts indicator, as outlined in appendix B of NIWA's report.</p>
Data coverage	<p>Blenheim (2006–07) Nelson (2006–12) Masterton (2002–04) Tahunanui (2008–09) Hastings (2006–07) Upper Hutt (2000–02) Dunedin (2010) Wainuiomata (2011–12) Kingsland, Auckland (2004–07) Henderson, Auckland (2006–12) Penrose, Auckland (2006–12) Takapuna, Auckland (2006–12) Khyber Pass, Auckland (2006–12) Queen Street, Auckland (2006–12)</p> <p>More information is needed before a national average can be compiled.</p>

Case study	Contribution of natural sources to PM₁₀ concentrations
Data source	Source apportionment data and analysis provided by GNS Science
Limitations to data and analysis, including level of confidence	The data accurately represents the monitoring site but are not nationally representative.
Changes to time series	The data covers different time periods for different sites.

Glossary

Airshed	An area, formally notified in the <i>New Zealand Gazette</i> , that is likely or known to have unacceptable levels of pollutants , or may require air-quality management.
Annual average	The average of all values in a range of samples or measurements over a given year.
Arsenic	A heavy metal and in New Zealand comes mainly from burning timber treated with preservative copper-chromate-arsenic. Arsenic can be emitted into the air by burning offcuts of treated timber from building projects for home heating. Some industrial processes also emit arsenic.
Benzene	A volatile organic compound. Motor vehicles and home heating are the main sources, and some industrial activities. Benzene can affect the nervous system and is associated with cancer.
Benzo(a)pyrene (BaP)	A polycyclic aromatic hydrocarbon. Largely emitted from the combustion of fuels (such as wood and coal from home heating), vehicle emissions, and some industrial processes. BaP can irritate the eyes, nose, and throat, and is associated with cancer.
Breach	Where the concentration of a pollutant exceeds the levels permitted under a national environmental standard (see also exceedance).
Busy local road	Where the annual average daily traffic count is greater than 20,000 vehicles per day or is a known hot-spot for traffic congestion.
Carbon monoxide	A colourless and odourless gas produced by incomplete burning of carbon-containing fuels such as wood, coal, petrol, and diesel.
Concentration	The measure of the relative quantity of a given substance contained within a specified medium (eg the amount of pollution in the air). Concentrations are given in mass per unit volume of air.
Corrosive/corrosion	The ability of a substance to wear away the surface of another substance by a chemical reaction.
Emission	The release of a pollutant into the atmosphere; its concentration in the air will depend on how the pollutant subsequently disperses in the atmosphere.

Exceedance	Where the concentration of a pollutant exceeds a standard or a guideline.
Exposure	Contact with a chemical, physical, or biological agent that can have either a harmful or beneficial effect.
Fossil fuel	Coal, natural gas, liquefied petroleum gas (LPG), crude oil or a fuel derived from crude oil (including petrol and diesel), so called because they have been formed from ancient organic matter over long periods of time.
Fuel combustion	The controlled burning of solid, liquid, or gaseous fossil fuels to generate heat or energy.
Ground-level ozone	A colourless and odourless gas that is produced by other gases reacting in the presence of sunlight. Examples of pollutants that form ozone are oxides of nitrogen and volatile organic compounds caused by transport, home heating, and industrial processes.
Heavy metal	Subset of elements which exhibit metallic properties and have relatively high atomic weight. They are naturally occurring within the air, but can be emitted from anthropogenic activities, such as vehicle tyre/brake wear and battery and steelmaking facilities.
Microgram per cubic metre ($\mu\text{g}/\text{m}^3$)	A measuring unit of density used to measure volume in cubic millimetres to estimate weight or mass in micrograms.
Monitoring site	The site where equipment to sample and/or measure the quality of air is deployed.
National environmental standards	Regulations produced by central government under the Resource Management Act 1991 (sections 43 and 44), which are binding on local authorities.
Nitrogen dioxide	A reddish-brown, pungent gas that is produced mainly from the combustion of fossil fuels (coal, gas, diesel, and oil) and some industrial processes.
Particulate matter	Small airborne particles composed of solid and/or liquid matter.
Pollutant	Any substance (including gases, odorous compounds, liquids, solids, and micro-organisms) or energy, or heat, that results in an undesirable change to the physical, chemical, or biological environment.
PM₁₀ particulates	Airborne particles that are 10 μm or less in diameter (about a fifth of the thickness of a human hair). They are produced by the combustion of wood and

	fossil fuels , as well as by various industrial and natural processes.
PM_{2.5} particulates	Airborne particles that are 2.5 µm or less in diameter and mostly come from combustion sources (see PM₁₀ particulates). Most particulate matter from natural sources is larger than 2.5 µm in diameter.
Rural areas	Determined by Statistics NZ by classifying areas that are urban. See New Zealand: An urban/rural profile update [Statistics New Zealand website] for more information.
Screening method	Any non-standard method that provides indicative data for a particular contaminant. It uses lower resolution instruments. It cannot be used to determine compliance with a standard or guideline.
Standard method	An air quality monitoring method recommended by a national or international body that can be used to determine compliance with a standard or guideline.
Sulphur dioxide	A colourless gas with a pungent smell, produced during the combustion of fuels containing sulphur, such as coal and diesel.
Temperature inversion	A layer of warm air that sits over a layer of cooler air near the ground. Because cool air is heavier than warm air, it often remains trapped close to the ground. Air pollution that gets trapped beneath the inversion layer can build up, causing air pollution concentrations to increase.
Valid data	Valid data only includes observations that reflect actual conditions being monitored. For example, monitors may register spurious values or collect data while they are being calibrated. These observations need to be removed otherwise the datasets would include known measurement errors. A requirement for 75 percent valid data ensures that the data is representative over the course of a year.
Volatile organic compound	Any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions.
Weather conditions	Prevailing weather (eg wind, precipitation, temperature) conditions.
Wood burner	An appliance designed for or capable of burning wood, generally to provide heat for households.

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