Centre for Public Health Research

Environmental Health Indicators for New Zealand 2009

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Executive Summary

The environment is a key determinant of health as it provides our basic needs for leading healthy lives, including clean air and fresh water. The term 'environmental health' is used to describe those aspects of health that are related to the environment through physical, biological, chemical, social and psychosocial factors. Therefore, the monitoring of environmental health is important for providing key evidence to environmental health practitioners, decision-makers and the community, in order to improve human health.

This descriptive report provides a broad overview of selected key environmental health issues in New Zealand. The indicators cover a number of aspects of environmental health, using the Driving Forces – Pressures – State – Exposure – Effects – Actions (DPSEEA) framework, developed by the World Health Organization. The framework encompasses the driving forces and pressures on the environment, the state of the environment, exposure to environmental hazards, and related health effects.

The report examines indicators for these aspects of environmental health, focusing on three broad environmental health issues:

1. air quality
2. water quality
3. biosecurity.

Data for the report were sourced from existing data collections, including several outside the health sector, reflecting the diversity of agencies involved in promoting the various aspects of environmental health in New Zealand.

The overall purpose of the report is to provide robust and reliable scientific evidence to assist with decision-making and action on environmental health issues in New Zealand. The report will be of interest to the Ministry of Health, the Ministry for the Environment, public health units, District Health Boards, the wider health sector, regional councils, local councils and the general public.

It should be noted that the nature of environmental health means that it is not possible to capture all the interdependencies between the environment and human health within a single set of environmental health indicators. Therefore, it was not feasible, within the scope of a descriptive monitoring report, to explore all environmental health issues, or to analyse the causal relationships between the state of the environment and human health outcomes. It is hoped that the report will encourage interest in environmental health issues, and will be built on in future years with further environmental health indicator reports and more in-depth epidemiological reports and studies.

Key results

This section outlines the key results for driving forces, pressures on the environment, and the environmental health issues of air quality, water quality and biosecurity.

Driving forces

Driving forces are broadly defined as the socioeconomic activities that put pressure on the environment. In New Zealand, key findings suggest that population growth and tourism numbers may be placing pressures on the environment, as follows.

- The size of the New Zealand population has more than doubled over the past 50 years, to over 4 million people in 2006.
- Some territorial authorities have seen a population increase of more than 20% over the past 10 years.
- There has been an ever-increasing number of people arriving in New Zealand over the past 20 years.

Pressures

Pressures are placed on the environment as a result of driving forces. Pressures generally include key aspects of human habitation, and the use and exploitation of the environment. In New Zealand, the following key pressures on the environment have been identified.

- Energy consumption has increased by around 70% in the past 30 years.
- The number of vehicles has been increasing.
- Vehicles in New Zealand are relatively old by international standards, with an average age of about 12 years for light vehicles.
- A large proportion of houses are heated by wood fires (39.0%) and a smaller proportion by coal fires (6.7%).
- There has been a marked decrease in the proportion of houses heated by wood and/or coal fires from 1996 to 2006.
- The overall number of livestock has been steadily decreasing in New Zealand.
- There has been a large increase in the number of dairy cattle in the South Island over the past 17 years, particularly from 2007 to 2009.
- The annual amount of cargo and number of sea containers imported into New Zealand has generally increased since 2000.

Overall, these driving forces and pressures can affect the state of the environment, particularly air quality, water quality and biosecurity, which can lead to exposure to environmental hazards and related health effects.

Air quality

Air quality is a critical aspect of environmental health in New Zealand. Air pollutants include fine particulate matter and toxic gases such as nitrogen dioxide. Sources of outdoor air pollution include vehicle emissions, industrial processes, power stations, home heating and natural sources. Indoor air quality can be affected by tobacco smoke, as well as fuels used for cooking and heating. Human health effects from poor air quality (indoor and outdoor/ambient air) include respiratory problems, particularly in the young and old, and in people with pre-existing medical problems.

- In 2009, 27 of the 40 monitored airsheds in New Zealand breached the National Environmental Standard for Air Quality for small particulate matter (PM_{10}), four more than in 2008. Those in breach included all of the 17 South Island airsheds. The three airsheds with the highest number of exceedance days in 2009 were Otago 1 (Alexandra and Arrowtown), Mosgiel and Timaru.
- From 1998 to 2005 the airshed at Khyber Pass Road in Auckland consistently exceeded the national environmental standard for nitrogen dioxide (NO_2).
- In 2006/07 almost one in 10 children and one in 15 non-smoking adults aged 15 years and over were exposed to second-hand tobacco smoke in the home. The following had significantly higher rates of children exposed to second-hand smoke in the home, compared with the national average: Waikato, Northland, Tairawhiti, Hawke's Bay, Lakes and Whanganui.
- In 2007 there were high hospitalisation rates for respiratory disease among children aged 0–4 years, in the District Health Boards of Northland, Counties Manukau, Lakes, Bay of Plenty, Tairawhiti, Hawke's Bay, Whanganui, Hutt, Wairarapa and Canterbury.

Water quality

Water quality is another important environmental health issue in New Zealand. Water (including ground, surface and recreational water) can become contaminated with toxins, excessive nutrients, and human and animal wastes. Contamination of drinking-water and recreational water can lead to health problems, including gastrointestinal (enteric) diseases.

- In 2008/09, 80% of the population had access to drinking-water that was known to comply with bacterial (*E. coli*) requirements. Therefore 20% of the population did not have access to water that meets national health standards for bacteria levels.
- In 2008/09, 76% of the population had access to drinking-water that was protozoally (*Cryptosporidium*) compliant. Approximately one in four people (24%) did not.
- In 2008/09, 11% of the population was not served by a registered reticulated drinking-water supply.
- In the 2008–2009 bathing season, 71.2% of all monitored recreational marine beaches were suitable for swimming 'almost all of the time', and 54.6% of all monitored freshwater beaches were suitable for swimming 'almost all of the time', compared with 71.6% and 46.9% respectively in the 2007–2008 season.
- From 2001 to 2009, there were decreases in the rates of campylobacteriosis, cryptosporidiosis and giardiasis with a risk factor of either drinking untreated water, or having contact with recreational water at a marine or freshwater beach.

Biosecurity
Biosecurity is an emerging issue for New Zealand. With the greater movement of goods and mobility of populations, more tourists, products and vessels are visiting New Zealand each year. Consequently there has been an increased risk of a border incursion of a pest or disease with the potential to impact on the health of New Zealanders.

- Currently in New Zealand there are only a few species of exotic mosquitoes that are known vectors for a notifiable infectious disease.
- From 2002 to July 2009 there were 47 interceptions of mosquitoes at the New Zealand border.
- Annually the number of cases of notified vector-borne disease is generally very low, with just over 1000 cases notified between 1997 and 2007. The majority of these cases were overseas during the incubation period, while others had previous overseas travel as a possible risk factor. In 2008/09, 336 cases of vector-borne disease were notified, representing around 25% of the total number of cases between 1997 and 2009.

Conclusion
The report highlights the key issues in environmental health in New Zealand, with particular focus on air quality, water quality and biosecurity. The results show that there are a number of pressures on the environment, mainly from the effects of population growth, but also from increasing energy consumption and the increasing number of aged vehicles on the road.

The report indicates that the majority of drinking-water is safe to drink, although a sizeable proportion of drinking-water supplies do not meet the drinking-water standards. There are similar findings in regard to air quality, with a large number of airsheds exceeding air quality guidelines at least once during 2009. Biosecurity efforts are important to ensure that new pests and diseases are not introduced in New Zealand.

It is important to continue monitoring and addressing environmental health issues such as water quality, air quality and biosecurity, to ensure that future generations of New Zealanders can enjoy the natural resources of this country, without exposure to environmental hazards and subsequent poor health.

Chapter 1: Introduction

The environment plays an important role in the health and wellbeing of a population as it provides our basic needs for leading healthy lives, including clean air and fresh water. The state of the environment is a modifiable risk factor for a number of health conditions, and contributes significantly to the global burden of disease (Prüss-Üstün and Corvalán 2006).

The term 'environmental health' describes those aspects of health that are related to the environment, through physical, biological, chemical, social and psychosocial factors. Environmental health covers aspects such as water quality, air quality, sanitation, vector-borne disease and noise. The monitoring of environmental health involves the routine and ongoing collection, analysis, interpretation and reporting of data on aspects of environmental health. Monitoring of environmental health is important, as robust and reliable scientific information provides key information for decision-makers, environmental health practitioners and the community, to improve and address environmental health concerns.

The purpose of this report is to present key indicators of environmental health in New Zealand. It examines indicators for driving forces and pressures, specifically focusing on exposures, effects and actions in three broad areas:

1. air quality
2. water quality
3. biosecurity.

The indicators cover the driving forces and pressures on the environment, the state of the environment, exposure to environmental hazards and related health effects. Data have been sourced from existing data collections, many outside the health sector, reflecting the diversity of agencies involved in promoting environmental health in New Zealand.

Understanding the complex relationship between the environment and health is simplified by a set of indicators. However, given the complex nature of environmental health, a single set of environmental health indicators will not capture all the interdependencies between the environment and human health.

The analyses in this report are descriptive only and do not explore all environmental health issues, nor do they examine the causal relationships between the state of the environment and human health outcomes. It is hoped that the report will encourage interest in environmental health issues, and will provide a base for further reports on environmental health indicators as well as epidemiological studies.

The following sections provide background information about environmental health, the development of environmental health indicators, and the purpose and scope of the report.

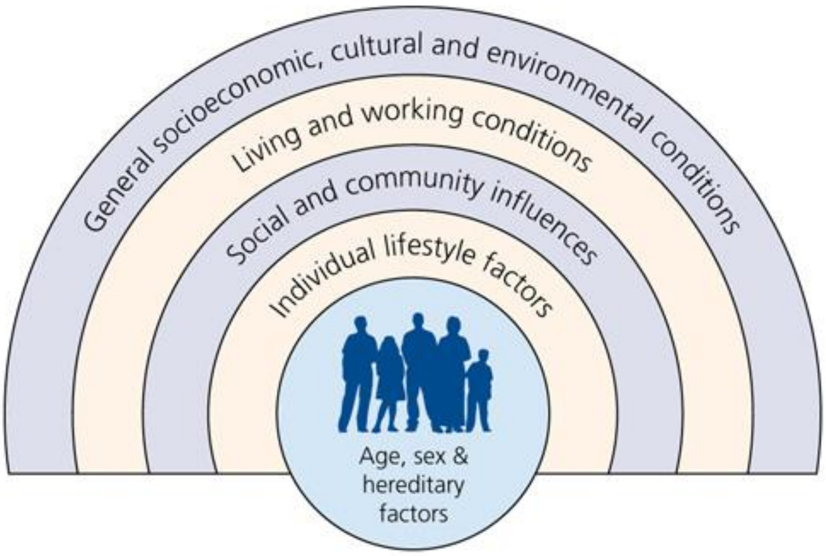
Environmental health

The environment as a determinant of health

It has long been accepted that environmental factors play a major role in influencing human health and wellbeing. Poor water quality and inadequate sanitation were recognised as key factors affecting human health in the 1840s (Ashton 1991), and this knowledge in turn has contributed to the foundation of modern activities to prevent and monitor public health diseases.

The environment is widely accepted as an important determinant of health, alongside social, economic, individual and related factors (Figure 1) (Dahlgren and Whitehead 1991). The World Health Organization (WHO) highlighted the importance of the environment to human health and wellbeing in the Ottawa Charter for Health Promotion 1986, by identifying the necessity of having a stable ecosystem and sustainable resources for good health.

Figure 1: Determinants of health



Source: Dalgren and Whitehead (1991), in London Health Commission (2008)

Definition of environmental health

Environmental health generally covers those aspects of health that are related to the environment. The WHO developed the following draft definition of environmental health at a meeting in Sofia, Bulgaria in 1993:

> Environmental health comprises those aspects of human health, including quality of life, that are determined by physical, chemical, biological, social and psychosocial factors in the environment.
> It also refers to the theory and practice of assessing, correcting, controlling and preventing those factors in the environment that can potentially affect adversely the health of present and future generations.

Environmental health covers a broad range of topics, including air pollution, water quality, noise, sanitation, housing, radiation, waste management, food safety, traffic accidents, vector-borne disease, occupational health and chemical emergencies (Briggs 1999).

More recently, environmental health has also been viewed from a more holistic ecosystems approach. Ecosystems play vital roles as life-support systems, providing essential services such as food production, water supply, nutrient recycling and waste treatment (Matsumura 1996; Parkes and Weinstein 2004). Disruptions to the ecosystem and ecosystem services can have major effects (both directly and indirectly) on human health and wellbeing. This link highlights the importance of interpreting specific environmental health issues not just in isolation, but in the wider context of ecosystem health.

The global burden of environmental health

The importance of the environment to human health is well recognised. A recent WHO study estimated that modifiable environmental risk factors contributed to 24% of the global burden of disease (using Disability-Adjusted Life Years, or DALYs), and 23% of deaths globally (Prüss-Üstün and Corvalán 2006). These results suggest that in the Western Pacific region (Australia, New Zealand, Japan, Singapore and Brunei), modifiable environmental risk factors contributed to 16% of the overall burden of disease, and 18% of all deaths (Prüss-Üstün and Corvalán 2006).

Generally, environmental health issues can have a larger impact on the young. In particular, the WHO study found that globally, for children aged 0–4 years, 36% of the burden of disease and 37% of mortality were attributable to modifiable environmental factors (Prüss-Üstün and Corvalán 2006). The main health issues that had environmental risk factors and affected children in this age group were diarrhoea, malaria and respiratory infections.

Environmental health in New Zealand

Environmental health plays a key role in the New Zealand Health Strategy, in which one goal is to have a healthy physical environment (Minister of Health 2000). Achieving this goal includes reducing the adverse health effects of environmental hazards, and working to ensure that all people have access to safe drinking-water supplies and effective sanitation services.

Furthermore, an overall aim of the New Zealand Health Strategy is to reduce inequalities, which include environmental inequalities that impact on health.

New Zealand legislation covering aspects of environmental health include the:

- Health Act 1956 including Part 2A: inserted, on 1 July 2008, by section 7 of the Health (Drinking Water) Amendment Act 2007
- Resource Management Act 1991
- Smoke-free Environments Act 1990
- Hazardous Substances and New Organisms Act 1996
- Biosecurity Act 1993
- Local Government Act 2002
- Building Act 2004
- Radiation Protection Act 1965

- Local Government (Auckland Council) Act 2009
- Waste Minimisation Act 2008
- Climate Change Response Act 2002
- Land Transport Management Act 2003
- Civil Defence and Emergency Management Act 2002.

A number of agencies are involved in the various aspects of environmental health in New Zealand, including the following at a national level.

- The Ministry of Health is responsible for the health and wellbeing of the New Zealand population.
- The Ministry for the Environment is the government's principal advisor on the environment.
- As part of the Ministry of Agriculture and Forestry, Biosecurity New Zealand (MAF BNZ) leads New Zealand's biosecurity efforts, protecting New Zealand from the potential introduction of pests and disease.
- The New Zealand Food Safety Authority (NZFSA) is responsible for food safety in New Zealand. (Note: on 1 July 2010 NZFSA and MAF were amalgamated).
- The Environmental Risk Management Authority is responsible for hazardous substances.
- The Accident Compensation Corporation (ACC) is responsible for preventing injuries.
- The Department of Building and Housing is responsible for ensuring that buildings contribute to the health, physical independence and wellbeing of the people who use them; and that buildings are designed, constructed and able to be used in ways that promote sustainable development.
- The Ministry of Transport is the government's principal transport advisor.
- The New Zealand Transport Agency is the crown agency responsible for contributing to an affordable, integrated, safe, responsive and sustainable land transport system, which involves the planning and funding of land transport.
- The Ministry of Civil Defence and Emergency Management is responsible for managing hazards in a way that contributes to the wellbeing and safety of the public and to the protection of property.

A large number of other organisations also help in the monitoring and surveillance of biosecurity.

Additionally, a number of different types of agencies work at the sub-national level, as follows.

- Twelve public health units are responsible for core public health services in their area, including environmental health, communicable disease control and health promotion programmes.
- Twenty District Health Boards (DHBs) are the funders and providers of publicly funded health services for the population in their area.
- Seventy-three local councils (territorial authorities or TAs) are responsible for controlling the effects of land use and resources, and promoting the social, economic, environmental and cultural wellbeing of their communities; 5 of the 73 TAs are unitary authorities (Gisborne, Nelson, Tasman, Marlborough and Chatham Islands), which means they have both regional and local council responsibilities and/or functions under the Resource Management Act 1991.
- Twelve regional councils and the five unitary authorities are responsible for the management of the natural and physical resources of their region.

Underpinning this work are the principles of the Treaty of Waitangi, which recognise the special relationship between Māori and the Crown in New Zealand. Treaty settlements have recognised the significance of environmental health to Māori by ensuring mahinga kai (traditional food harvesting sites) and waahi tapu (areas of spiritual significance) are protected.

Environmental health indicators

Environmental health indicators (EHIs) are used primarily for monitoring aspects of the environment and human health that relate to one another – that is, health-related environmental issues and environment-related health issues – as well as the driving forces and pressures that lead to environmental health issues.

The monitoring of environmental health involves the routine and ongoing collection, analysis, interpretation and reporting of data on aspects of environmental health. Relevant, reliable and timely monitoring data provide the basis for informed decision-making, and are essential for actions such as the development and evaluation of effective environmental health policies, programmes and services.

The development of environmental health indicators

The concept of EHIs has only been developed over the past 10–15 years. In part, the development of EHIs resulted from the recognition of the close link between health and sustainable development (Kjellström and Corvalán 1995; Wills and Briggs 1995).

In 1987 the World Commission of Environment and Development defined the concept of sustainable development as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. At the 1992 Earth Summit, world leaders globally endorsed sustainable development, with more than 178 countries adopting a comprehensive programme of action for sustainable development (Agenda 21) and the principles of the Rio Declaration on Environment and Development.

The Rio Declaration and Agenda 21 acknowledged and highlighted that it is vital to improve human health in order to achieve sustainable development. The first principle of the Rio Declaration states:

> Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature (United Nations Environment Programme 1992).

Agenda 21 also acknowledged the improvement of health as a central aim for achieving sustainable development, as well as the importance of monitoring to track progress towards the goal of sustainable development.

As a result of Agenda 21, the WHO assumed responsibility for developing key indicators for monitoring environmental health in 1992 (Kjellström and Corvalán 1995). As part of the WHO environmental health programme, a conceptual framework was developed for EHIs. The development work built from the Organisation for Economic Co-operation and Development (OECD) framework for environmental indicators (Pressure–State–Response), but also recognised the need to include aspects of human exposure and health effects (Kjellström and Corvalán 1995).

The result of this work was the Driving Forces–Pressures–State–Exposure–Effects–Actions (DPSEEA) framework for environmental health indicators (Kjellström and Corvalán 1995; Briggs 1999; Corvalán et al 1999) (see Chapter 2 for more details). The WHO (Briggs 1999) list of EHIs was based on the following 12 issues:

1. sociodemographic context
2. air pollution
3. access to safe drinking-water
4. vector-borne disease
5. hazardous/toxic substances
6. non-occupational health risks
7. sanitation
8. shelter
9. solid waste management
10. food safety
11. radiation
12. occupational health risks.

Although the WHO has developed a core set of EHIs, there are acknowledged differences in environmental health issues between countries. As a result, no one set of indicators will fit all purposes, and indicators (and the DPSEEA framework more generally) can be adapted to fulfil the needs of the specific context and country (Briggs 1999). Other frameworks have also been developed for monitoring environmental health, such as the Hazard–Exposure–Health-Effect–Intervention framework developed for the Environmental Public Health Indicators in the United States (CDC 2006).

As part of the WHO work on developing EHIs, Briggs (1999) also identified criteria to use when selecting EHIs, to make the indicators effective and useful. These criteria were that EHIs should:

- provide a good measure of the condition of interest
- be scientifically valid (ie, robust, sound and transparent)
- be sensitive to changes
- be cost-effective.

Other important criteria (Kjellström and Corvalán 1995; Briggs 1999; Dalbokova and Krzyzanowski 2001) to be considered for indicators include being:

- based on an established or plausible association between the environment and health
- clearly defined and measurable
- able to use existing data, or data that are easy to collect
- issues that can be addressed by specific actions and/or policies
- based on accurate data that are consistent over time
- easily understandable and useable by decision-makers and non-specialists
- spatially representative.

The development of environmental health indicators in New Zealand

The Ministry of Health has a statutory responsibility to monitor the health of the New Zealand population. As part of its fulfilment of this role, the Ministry of Health has taken responsibility for ensuring that environmental health in New Zealand is monitored.

In 2001 the Ministry of Health contracted the Institute of Environmental Science and Research (ESR) to develop a core set of EHIs. This project resulted in the development of EHIs for New Zealand, using the DPSEEA framework and the criteria identified above (Phillips et al 2001; Khan 2002; Phillips et al 2005). The project involved an audit of currently available data related to environmental health and, as a result, a number of potential EHIs were identified. Pilot studies were carried out in Auckland (North Island) and Marlborough (South Island) regions to test the indicators in 2003 (Khan et al 2003).

Based on this work, ESR produced annual EHI reports for New Zealand for the years 2005, 2006 and 2007. The set of environmental health issues in 2005 included air quality, water quality and road transport (Khan et al 2005), and was later expanded to include biosecurity in 2007 (Hambling and Slaney 2007). In 2008 the Ministry of Health produced an EHI report, which included additional sections on driving forces and pressures (Ministry of Health 2009).

The Centre for Public Health Research, Massey University, was contracted by the Ministry of Health to update the 2008 report and further develop the monitoring and reporting of EHIs.

Purpose of this report

The report presents key indicators for environmental health in New Zealand. It fulfils an important purpose in drawing together data from a wide variety of sources (including government and non-government agencies) to present an overview of environmental health issues in New Zealand. The key overall purpose of the report is to provide robust scientific evidence to assist with decision-making and action on environmental health issues in New Zealand.

The specific objectives of the report are consistent with the key objectives for environmental health indicators identified during the development of the DPSEEA framework (Briggs 1999). The objectives are to:

- monitor trends in the state of the environment
- monitor trends in environment-related health effects
- compare regions to identify areas in need
- monitor and assess the effectiveness of policies and interventions
- raise awareness of environmental health issues
- investigate links between the environment and health.

The report will be of interest to the Ministry of Health and other central government agencies such as the Ministry for the Environment, Ministry of Transport, New Zealand Transport Agency, Department of Building and Housing, and Ministry of Agriculture and Forestry, as well as public health units, DHBs, the wider health sector, regional councils, TAs, and the general public.

Scope of this report

This report focuses in depth on three key environmental health issues: air quality, water quality and biosecurity.

Air quality is an important aspect of environmental health in New Zealand. Air pollutants include particulate matter and toxic gases such as nitrogen dioxide, sulphur dioxide, ozone, carbon monoxide and hydrocarbons. The sources of outdoor air pollution include home heating, vehicle emissions, industrial processes, power stations, and natural sources such as pollen, sea salt, soil, volcanoes and forest fires (Kjellström 2004). Indoor air quality is affected by tobacco smoke, fuels used for cooking and heating, and wall materials (Kjellström 2004). Human health effects from poor air quality include respiratory problems, particularly in the young and old, and in people with pre-existing medical problems. In 2001 a study found that air pollution accounted for 1079 cases of premature mortality in New Zealand (Fisher et al 2007).

Water quality is another important environmental health issue in New Zealand. Water (including drinking and recreational water, both marine water and freshwater) can become contaminated with toxins, excessive nutrients, and human and animal wastes (Cromar and Fallowfield 2004). Contamination of drinking-water and recreational water can lead to health problems, including enteric diseases (McBride et al 1998; Cromar and Fallowfield 2004).

Biosecurity is an emerging issue for New Zealand. Globalisation is increasing the number of tourists and vessels visiting New Zealand each year, which increases the risk of a border incursion of a pest or disease with the potential for impacting on health. In particular, arboviruses (those diseases carried by insects such as mosquitoes and ticks), which include malaria and dengue fever, could have a potentially large impact if the vector became established in New Zealand. This link makes biosecurity an important environmental health issue to monitor on an ongoing basis.

Environmental health issues not included in the report include housing, occupational health, noise, sanitation, waste management, food safety and radiation. Furthermore, the biosecurity section has focused on vector-borne disease, and has not included venomous biting insects and animals.

For each environmental health issue in the report, the indicators cover the different aspects of the DPSEEA framework: driving forces, pressures on the environment, state of the environment, human exposure to the environment, human health effects, and actions currently being taken to address the environmental health issue. The indicators are broadly consistent with those ESR selected as part of the scoping study in 2001 (Phillips et al 2001) and in later EHI reports (eg, Khan 2002; Hambling and Slaney 2007).

For each indicator, key analyses are presented, using the most recently available data at the time of publication. Results are presented for analyses at the national level and, where possible and appropriate, examine time trends and regional differences. The results presented are descriptive only, and should not be used to infer causal associations between exposure and health effects.

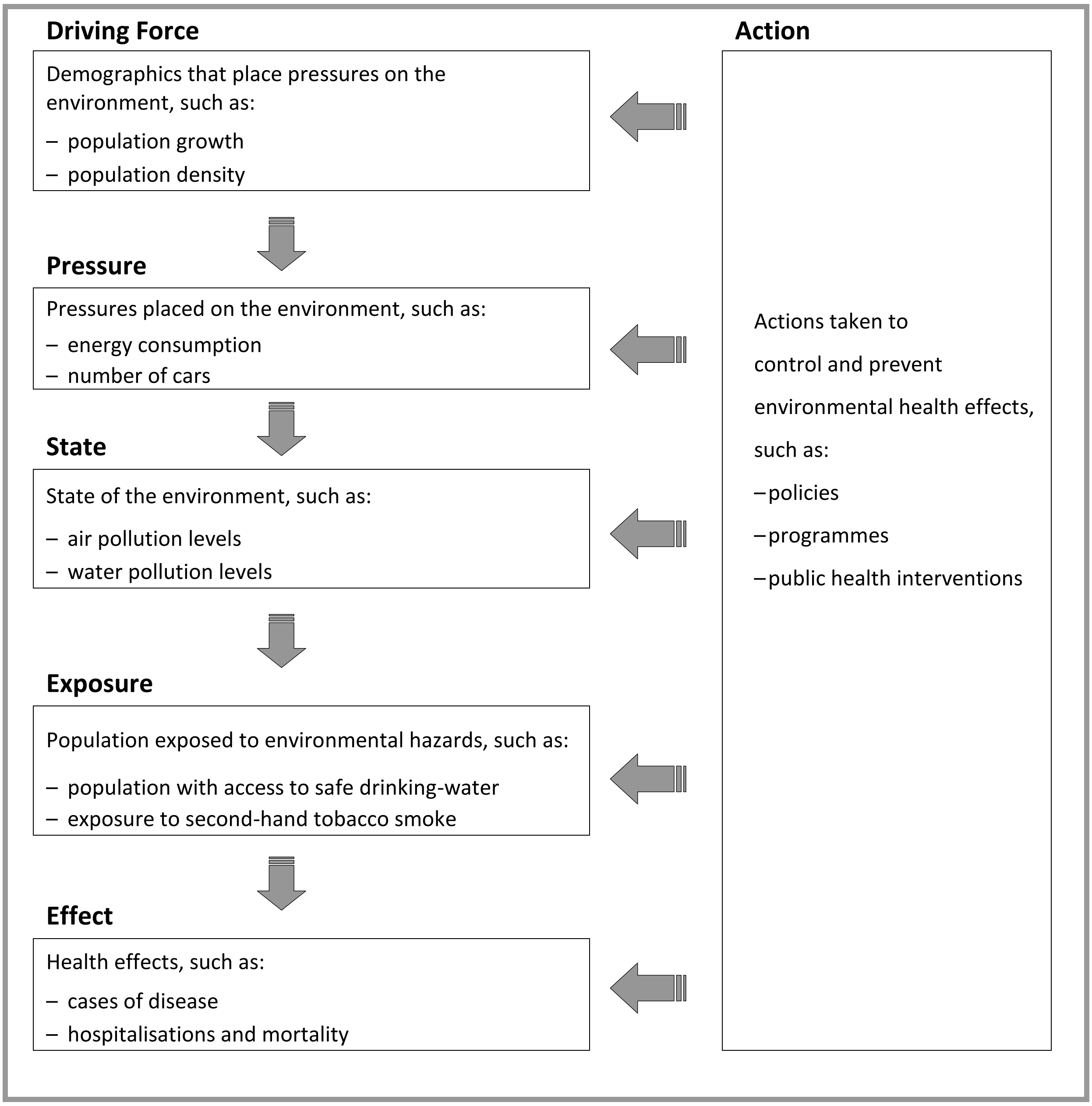
Chapter 2: Data and Methods

This chapter provides an overview of the DPSEEA framework, the indicators included in the report, data sources and methodology.

Framework for environmental health indicators

This report presents the environmental health indicators using the Driving Force–Pressure–State–Exposure–Effect–Action (DPSEEA) framework developed by the WHO (Briggs 1999). Figure 2 outlines the conceptual flow of the framework. The paragraphs below describe the individual components of the DPSEEA framework in more detail.

Figure 2: The DPSEEA framework for environmental health indicators



Source: Adapted from Corvalán et al (1999)

Driving forces: Driving forces have been defined broadly as the general socioeconomic activities that put pressures on the environment (Kjellström and Corvalán 1995), such as population growth. Corvalán et al (1999, pp 657–8) have also defined them more specifically:

> Driving forces create the conditions in which environmental health hazards can develop or be averted or that are generated by large numbers of people in their pursuit of the basic necessities of life (food and shelter) or in their appropriation and use of consumer goods. Driving forces include policies that determine trends in economic development, technology development, consumption patterns, and population growth.

Pressures: As a result of the driving forces, there are specific pressures placed on the environment. These pressures generally include key aspects of human habitation and the exploitation of the environment (Briggs 1999). Pressures can arise from all economic sectors, including energy production, manufacturing, agriculture, forestry, transport, service industries and tourism (Briggs 1999; Corvalán et al 1999). Examples of pressures include energy production and consumption.

States: The pressures on the environment can in turn affect the state of the environment. The state of the environment can include aspects such as the availability and quality of natural resources, the levels of environmental pollution in the air, soil, water and plants, and the frequency of natural hazards (Briggs 1999; Corvalán et al 1999). It may be affected at different geographical scales, from the local level (eg, waterways) to the global level (eg, climate change) (Briggs 1999).

Exposures: The term 'exposures' refers to when people are exposed to environmental hazards, which may, in turn, affect their health. To be classified as exposed, people must be present at both the time and place where the hazard occurs (Briggs 1999; Corvalán et al 1999; Phillips et al 2001). For pollutants in the environment, people may be exposed via ingestion, inhalation, and/or absorption through the skin.

Effects: Exposure to environmental hazards can have health effects. These effects can vary in severity, from subclinical problems to illness or morbidity and, in the most serious cases, death (Briggs 1999). Depending on the type of hazard, the level of exposure, incubation period and number of people exposed, health effects can vary in their type, intensity and scale (Briggs 1999; Corvalán et al 1999).

Actions: Actions include the policies, programmes and public health interventions that are taken to control and prevent environmental health effects (Corvalán et al 1999; Phillips et al 2001). Actions can relate to all other levels of the DPSEEA framework, to affect change of driving forces, pressures, state of the environment, exposures and health effects (Figure 2). Corvalán et al (1999, p 657) note:

> … although exposure to a pollutant or other environmentally mediated health hazard may be the immediate cause of ill health, the 'driving force' and 'pressures' leading to environmental degradation may be the most effective point of control of the hazard.

As a result, actions in the DPSEEA framework may not be purely in the realm of health, but may also cover domains such as the environmental and social policy (Corvalán et al 1999).

Selected indicators

Figure 3 presents the list of the indicators for each environmental health issue (ie, air quality, water quality and biosecurity) included in the report and their place in the DPSEEA framework.

The driving force and pressure indicators can apply to one or more of the environmental health issues, and therefore separate chapters have been included for each one: driving forces in Chapter 3 and pressures in Chapter 4. For each environmental health issue, the indicators for states, exposures and effects are discussed in individual chapters: air indicators in Chapter 5, water indicators in Chapter 6 and biosecurity indicators in Chapter 7.

Figure 3: Outline of environmental health indicators included in this report

Driving force

- **Population change**
- **Population density**
- **Number of passenger arrivals to New Zealand**

	Air quality indicators	Water quality indicators	Biosecurity indicators
Pressure	• Energy consumption • Number of vehicles • Average age of vehicle fleet • Proportion of households using wood or coal fires to heat home	• Number of livestock and dairy cattle	• Amount of overseas cargo arriving in New Zealand
State	• Exceedances of National Environmental Standards for Air Quality	• Exceedances of water quality guidelines for recreational marine and freshwater beaches	• Distribution of potential disease-vector species in New Zealand
Exposure	• Proportion of non-smoking adults exposed to second-hand smoke indoors	• Population with access to safe drinking-water	• Overseas outbreaks of notifiable diseases
Effect	• Respiratory disease (hospitalisations and mortality)	• Rate of water-borne disease	• Vector-borne disease notifications

Actions
(applying to all appropriate indicators)

Data sources

The data presented in the report are the latest available at the time of publication from the following agencies:

- Ministry of Health
- Institute of Environmental Science and Research Ltd (ESR)
- Ministry for the Environment
- Statistics New Zealand
- Ministry of Economic Development
- MAF Biosecurity New Zealand (MAF BNZ)
- Ministry of Transport
- World Health Organization.

Further information about these agencies is available in Appendix C. Detail about the data and data source is given in each particular indicator section.

Data presentation

Where possible, data are presented nationally for a number of years to show the trends over time, and for geographic regions such as territorial authorities.

Data sources

Limitations for individual datasets are included with the indicator. All data in this publication are subject to the limitations placed on them by the source data provider.

Rates

For many of the health effects, rates have been calculated as the proportion of the population of interest associated with the indicator. Rates have generally been expressed as per 100 (percent) or per 100,000 population.

Age-standardised rates

For many of the health effects, age-standardised rates have been presented. Standardising for age enables a valid comparison between places with different age structures. Age-standardised rates have been directly age-standardised to the WHO world standard population (Ahmad et al 2000), and generally expressed as per 100,000 population.

Denominators

The denominators used for calculating population rates were derived from census population data from Statistics New Zealand, matching the year of the data. For DHB analyses, interpolated mid-year populations have been used as the denominator populations.

Confidence intervals

For most rates for health effects, 95% confidence intervals have been included to indicate the range within which one can believe with 95% certainty the true value lies. When the 95% confidence intervals of two rates do not overlap, the difference in the rates is said to be statistically significant.

In the report, the use of 'significant' with reference to data indicates statistical significance.

Time trend analysis

Where possible and appropriate, data have been shown over time to provide important trend information. For time trends of health effects, age-standardised rates have been used.

Regional analysis

Data for many indicators have been presented at the following regional levels:

- DHBs
- territorial authorities
- designated airshed (urban area) as gazetted by the Ministry for the Environment in 2005 on behalf of regional councils and unitary authorities.

Within a single environmental health issue (eg, air quality), an effort has been made to keep the level of geography consistent across indicators. This consistency has not always been possible, as data often come from a variety of sources and agencies, and therefore have been collected for a variety of purposes and are sometimes available only at certain regional breakdowns. Data are also not always available for every region; for example, many analyses in this report have not included the Chatham Islands even though it operates as a unitary authority under the Chatham Islands Council Act 1995.

Maps showing boundaries and names of TAs and DHBs are provided in Appendix A. Additionally, tables presenting demographic data about TAs, DHBs and airsheds are provided in Appendix B.

Map classification scheme

Quintiles have been used to group the numbers, percentages and/or rate values on the maps. That is, the data have been ranked and divided into five groups containing equal numbers of territorial authorities. The darkest colour represents numbers, percentages and/or rates that are 'better' in terms of pressures on the environment, state of the environment, and health outcomes (eg, low population density, low coal and wood use as a source of heating, high percentage of population with access to compliant drinking-water and low rates of water-borne disease); conversely, the lightest colour represents numbers, percentages and/or rates that are 'worse' (eg, high population density, high coal and wood use as a source of heating, high percentage of population with access to non-compliant drinking-water and high rates of water-borne disease). However, quintiles have not been used for the exceedance rates from samples taken at monitored recreational beaches: these are based on predefined guideline categories.

Key points for interpreting results

This report aims to assist understanding of the complex relationship between the environment and health by representing this relationship through set indicators. However, the results should be interpreted with some caution.

The analyses are descriptive only and it is not possible to determine causation. For example, many other factors not considered in this report may have played a role. Some possible influences are access to health services, living standards including housing, individual behaviours and lifestyle factors such as smoking, diet, and exercise.

Some indicators have been selected based on an association between the environment and health shown in epidemiological studies, although these associations may only hold for certain groups of the population (for example, the young and old). Any such limitation has been noted where appropriate.

Results at a regional level can be subject to error known as 'ecological fallacy'. This error can be described as inappropriately assigning the values of an aggregate group to an individual (Longley et al 2001). For example, if the average income of people living in a region is $35,000, this does not mean that everyone in that region has an income of $35,000.

Although results for many of the indicators (particularly the state variables) have been presented at a regional level, actual exposure may differ for individuals. For example, some individuals within a territorial authority may be less exposed to air pollutants than others. For many indicators, such as air quality, it is very difficult to measure the exact exposure and dose for individuals. When interpreting the state indicators, it is also important to remember that health effects can be short term (acute) or long term (chronic or latent), and may not be apparent for many years following the initial exposure.

Glossary

Term	Definition
95% confidence interval	A measure that indicates the accuracy of an estimate; it is the range within which one can believe with 95% confidence the true value lies.
Age-standardised rates	Rates that have been adjusted to take account of differences in the age distribution between different groups. The standard population used in these analyses is the WHO world population (Ahmad et al 2000).
Ambient air	Outdoor air; air in the surrounding environment.
Arboviruses	Viruses transmitted by arthropods, such as mosquitoes and ticks.
District Health Board (DHB)	A body responsible for the provision of health services in its area. There are 20 DHBs in New Zealand.
Endemic	Regularly found or usually present in a particular area.
Exposure	Amount of a factor that a population is exposed to (which can include aspects such as duration, frequency, concentration).
Incubation period	The time between exposure to an infectious disease and the onset of symptoms.
Incursion	Sudden entry (eg, by a mosquito) into a place, particularly across a border.
Inversion (air)	A temperature inversion, for example where a layer of warm air traps another cooler layer of air below it. This can also result in a layer of air pollution being trapped in the cool layer of air (Ministry for the Environment 2007).
PM_{10}	Particulate matter with a diameter of 10 micrometres (µm) or less (1 µm = 0.000001 m).
$PM_{2.5}$	Fine particulate matter with a diameter of 2.5 micrometres (µm) or less (1 µm = 0.000001 m).
Regional council	A regional council listed in Part 1 of Schedule 2 of the Local Government Act 2002. That schedule lists the regional councils of New Zealand and their Gazette notices following their establishment in 1989. There are 12 regional councils and 5 unitary authorities (including Chatham Islands Council) in New Zealand.
Reticulated water	Water supplied through a distribution network of pipes.
Territorial authority (TA)	The second tier of local government in New Zealand, below regional councils. There are 73 TAs in New Zealand.
Unitary authority	A TA (district or city) that also performs the functions of a regional council. New Zealand has four unitary authorities.

Vector	An animal or insect that carries disease.
Zoonotic disease	An infectious disease that can be transmitted from animals to humans, or from humans to animals.

Chapter 3: Driving Forces

Driving forces have been defined broadly as the socioeconomic activities that put pressures on the environment (Kjellström and Corvalán 1995). On local, national and international scales, these factors underpin the overall state of the environment, and ultimately can affect the health of the population.

Overview of indicators

The following key indicators of driving forces were selected:

- driving force: population change
- driving force: population density
- driving force: number of passenger arrivals to New Zealand.

Driving force indicator: Population change

Indicator	Rate of population change

Relevance of indicator

Population change is driven by the birth rate, the mortality rate and immigration. An increase in population can have positive environmental health outcomes through economic development and growth and possible increased funding for programmes, such as those dealing with environmental issues and sustainable development (Kerr 1997).

However, negative effects may also arise from population growth. Rapid population growth without the provision of local infrastructure and services, such as sanitation and water supply, can place heavy demands on the environment. Such demands in turn may have negative effects on aspects of environmental health and ecosystems, including air pollution, poor drinking-water quality, an increase in vector-borne disease, and waste management and sanitation issues (Briggs 1999).

This potential for negative outcomes highlights the need for appropriate services and urban planning as towns and cities grow, to ensure sustainable growth and adequate provision and management of services.

Data source

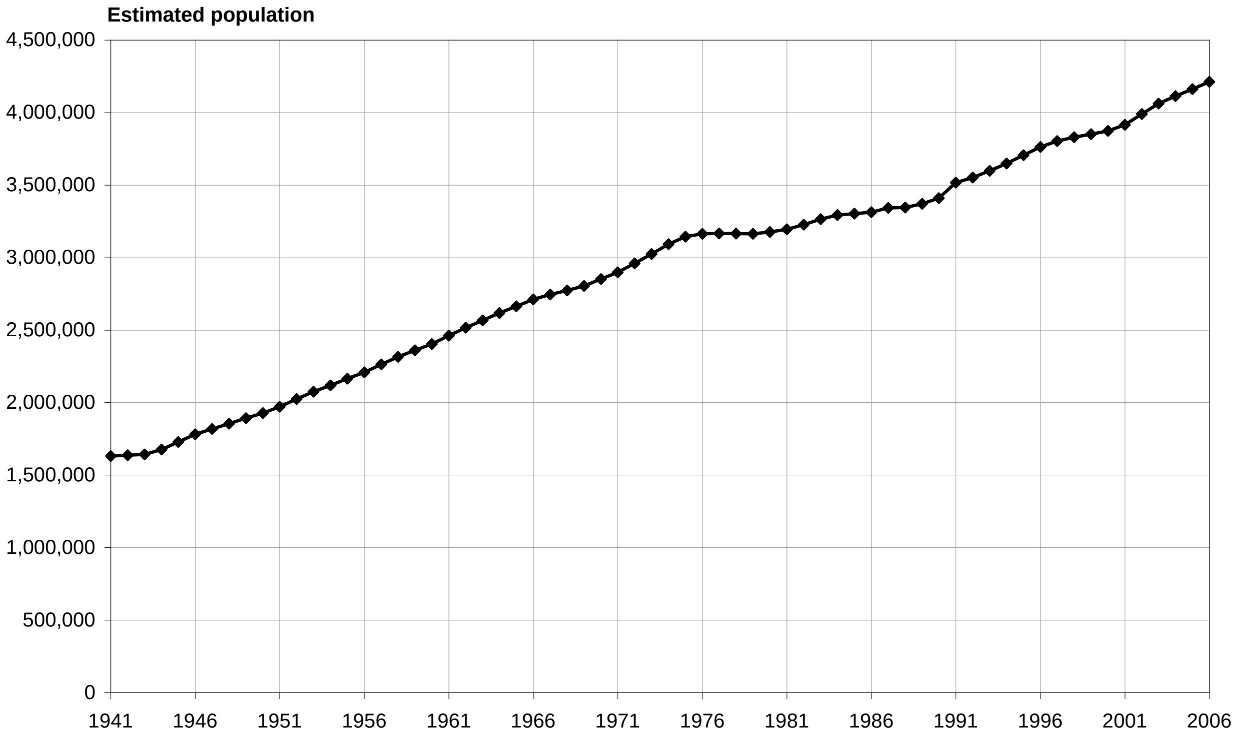
The data source for the indicator is the Census of Population and Dwellings, carried out every five years by Statistics New Zealand. The first part of the indicator examines the increase in the estimated resident population over time, based on the Census usually resident population, with adjustments for under-reporting, multiple reporting and residents who were temporarily overseas on Census night. The data for 2001 to 2006 were revised by Statistics New Zealand using data from the 2001 and 2006 Censuses.

The second part of the indicator examines the change in the usually resident population in each TA from 1996 to 2006. The section presents the data as the percentage change in population over the 10-year period. It should be noted that the estimated resident population (presented in the first part of the indicator) is not directly comparable with the Census usually resident population (in the second part) due to the post-Census adjustments. For additional information on TA populations from the 1996 and 2006 Censuses, see Appendix B.

Results

Figure 4 shows that the total estimated population in New Zealand has grown considerably over the past 50 years. In 1951 the estimated population size was approximately 2 million people, but it had more than doubled by 2006, to over 4 million people. The rate of increase over that time has been fairly consistent.

Figure 4: Estimated population in New Zealand, 1941–2006



Note: Year to 31 December.
Source: Statistics New Zealand

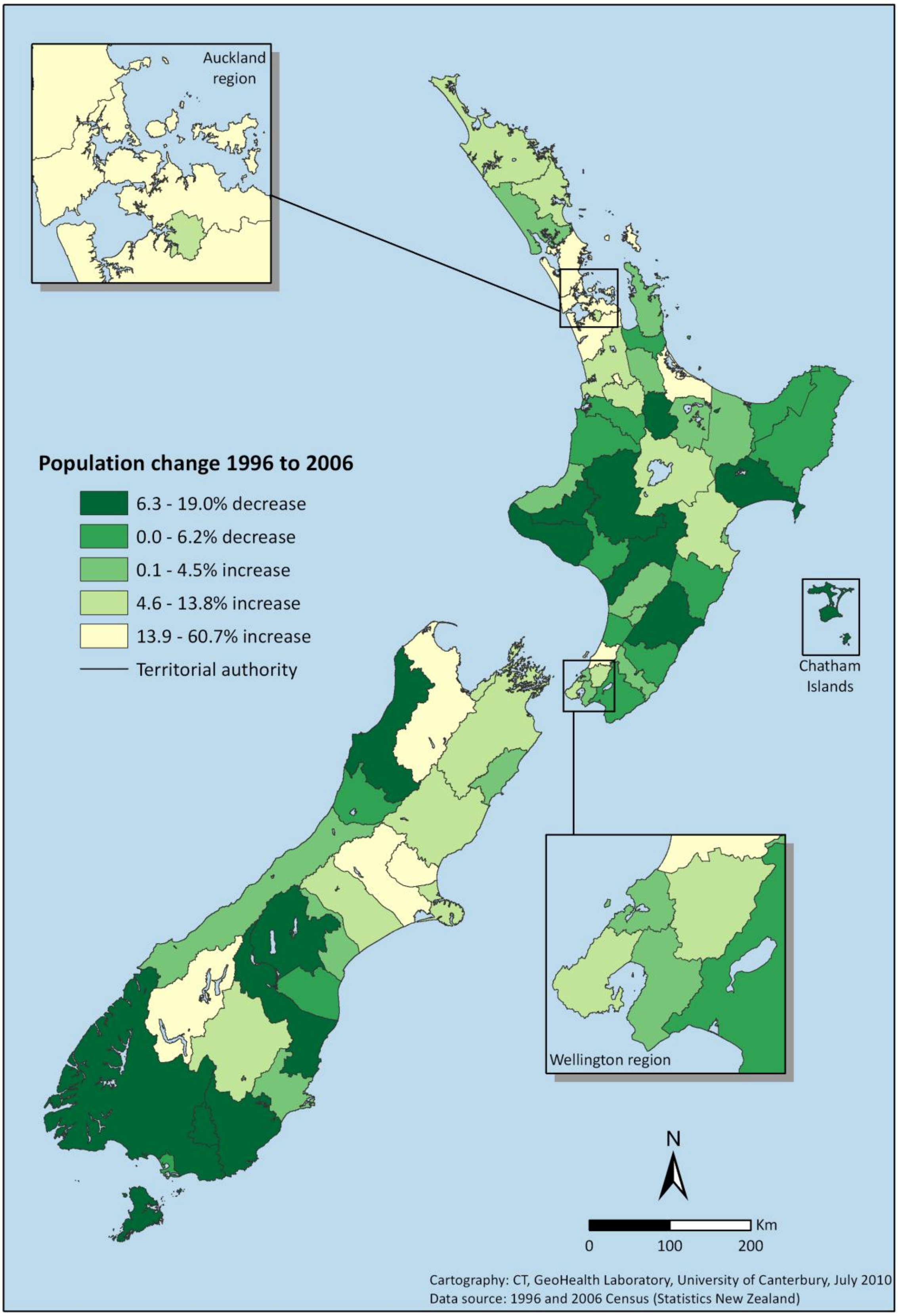
The size of the usually resident population overall increased by 11.3% from 1996 to 2006, although there were substantial geographical differences. Figure 5 shows the change in the usually resident population between 1996 and 2006, by TA. The greatest population increases were seen in TAs in the South Island, such as in:

- Queenstown-Lakes District 60.7%
- Selwyn District 35.8%
- Waimakariri District 32.4%
- Tasman District 17.5%.

In the North Island, the greatest increases were in:

- Rodney District 34.7%
- Tauranga City 33.2%
- Manukau City 29.4%
- Franklin District 23.2%.

Figure 5: Map of population change in New Zealand 1996–2006, by TA, percentage change (%)



Driving force indicator: Population density

Indicator	Usually resident population per square kilometre, by TA

Relevance of indicator

Population density is an important driving force for environmental health, as it can affect the environment and ecosystems in both positive and negative ways. High population density can promote sustainable development if planned for appropriately. For example, high density areas often benefit from better provision of services such as public transport systems and reticulated water supplies.

However, high population density may also indicate that there is a heavy burden on the surrounding environment. Rapid changes in population density may also place pressures on the local infrastructure and services (Briggs 1999). Furthermore, in some cities, the large number of people in high density areas may lead to more traffic on the roads, which can increase air pollution.

Data source

The indicator examines the population density in 2006 by TA measured as the number of people per square kilometre (people/km^2). The data source is the usually resident population by TA, from the 2006 Census of Population and Dwellings.

Results

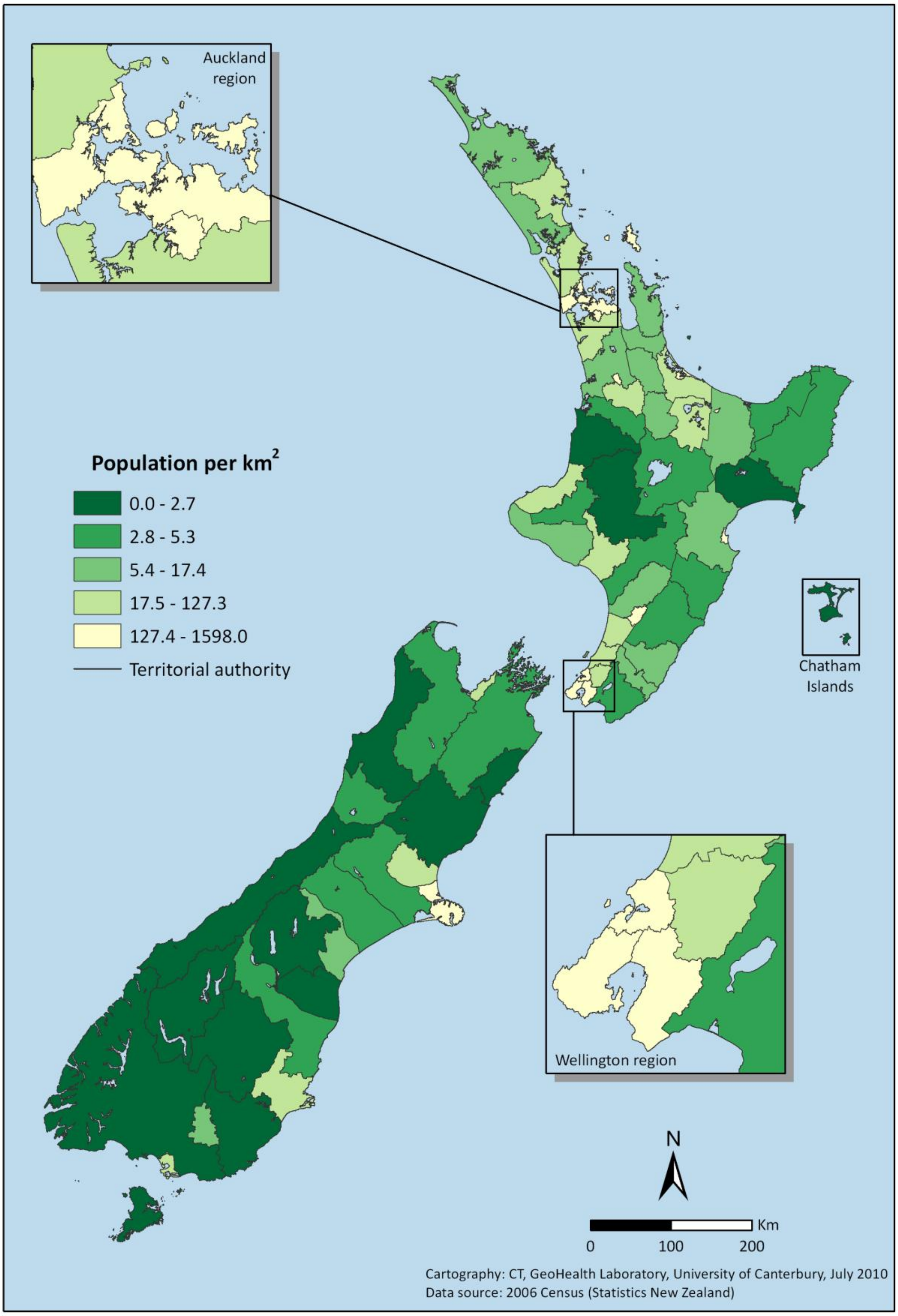
Although New Zealand has an overall population density of 15 people per square kilometre, the density varies markedly as a large amount of the land is covered in national parks, and the population concentrated in cities and towns.

Figure 6 presents the population density by TA for 2006. In general, the highest population densities were in the main urban areas. The three most densely populated TAs were:

- North Shore City 1594 people per km^2
- Hamilton City 1319 people per km^2
- Wellington City 619 people per km^2.

To a certain extent, these results are dependent on the land area size and urban nature of the TA, as well as where administrative boundaries are located.

Figure 6: Map of population density by TA, 2006, people per square kilometre



Driving force indicator: Number of passenger arrivals to New Zealand

Indicator	Annual number of passenger arrivals to New Zealand

Relevance of indicator

The number of people entering New Zealand is relevant to environmental health for a number of reasons. An increase in the number of people entering New Zealand can heighten the biosecurity risk by increasing the potential for the introduction of pests and disease into the country.

Furthermore, tourists to New Zealand increase the pressure on the environment by placing additional pressure on local infrastructure and services. Tourism can also have benefits, such as encouraging economic activity, which can lead to increased funding of environmental programmes.

Data source

The indicator presents the annual number of passenger arrivals to New Zealand from 1961 to 2009 (Statistics New Zealand 2010c). The data record arrivals to, and departures from, New Zealand for the following groups:

- short-term overseas visitors (overseas residents arriving for a stay of less than 12 months)
- short-term New Zealand-resident visitors (New Zealand residents who had been overseas for less than 12 months)
- permanent residents (which includes overseas residents intending to stay more than 12 months, and New Zealand residents returning after being overseas for more than 12 months).

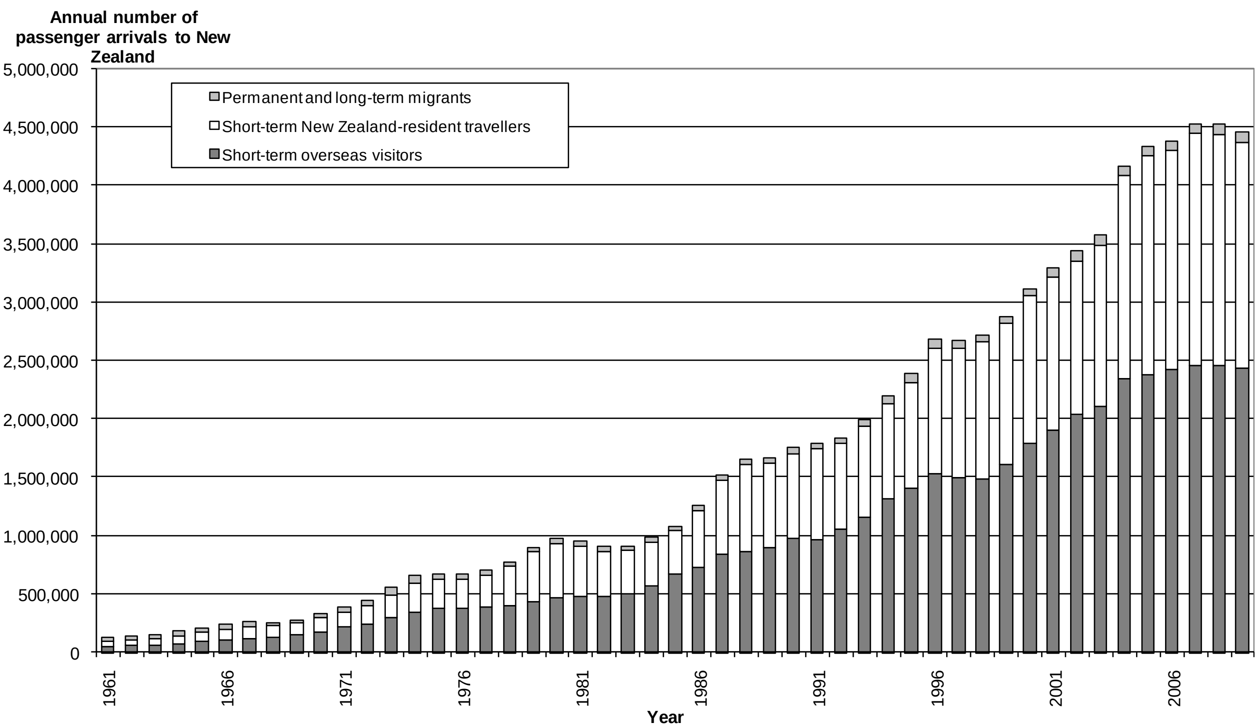
In general, when interpreting these data, a similar number of people were leaving New Zealand as were arriving, and therefore there was not necessarily an increase in overall population size due to these passenger arrivals.

The data take into account international air and sea passengers. The international airports in New Zealand are: Auckland, Hamilton, Wellington, Christchurch, Dunedin and Queenstown. The major seaports are: Auckland, Tauranga, Napier, Wellington, Christchurch (Lyttelton), Nelson and Dunedin.

Results

There has been a dramatic increase in the annual number of passenger arrivals to New Zealand over the past 50 years (Figure 7). The overall increase is mainly accounted for by short-term visitors, of whom the majority were overseas visitors. In 2009 an estimated 2.44 million short-term overseas visitors arrived in New Zealand, a decrease of 1.49% from 2008.

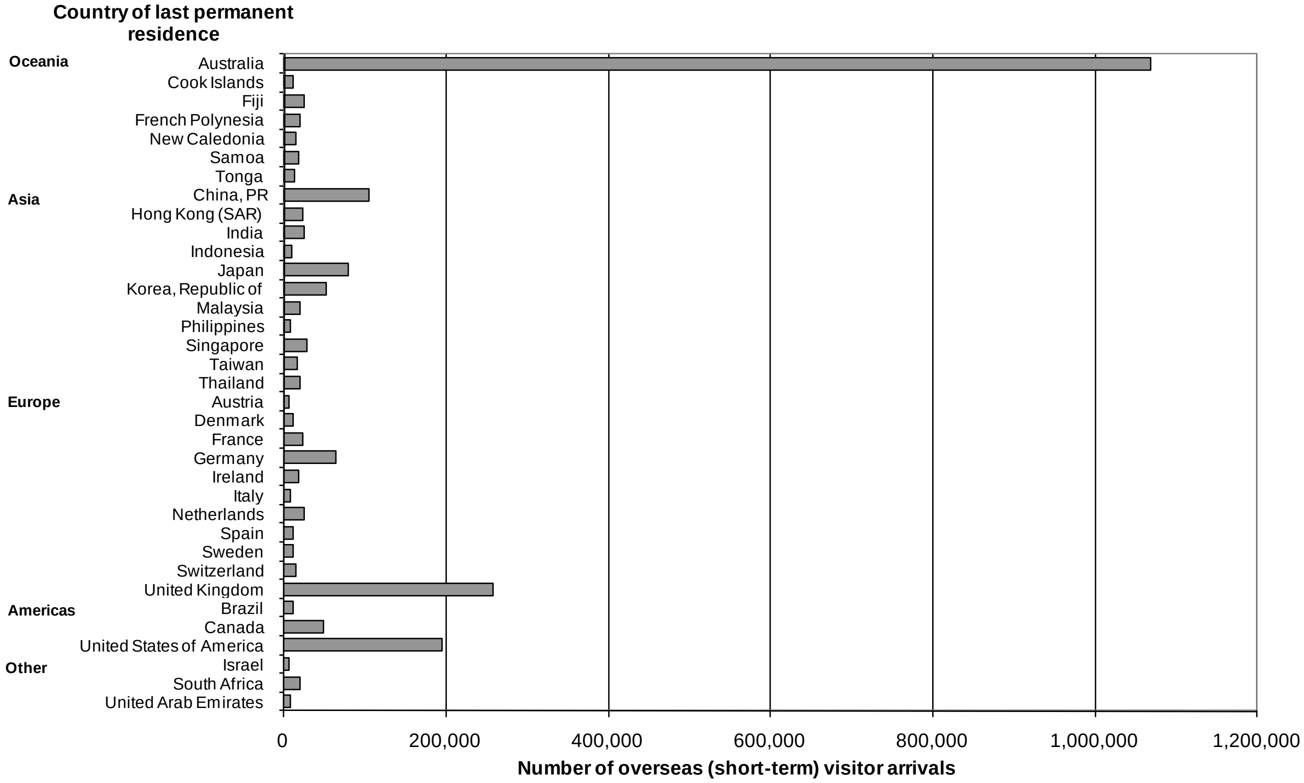
Figure 7: Annual number of passenger arrivals to New Zealand by type of visitor, 1961–2009



Notes: 'Short-term' means a length of stay of less than 12 months. Year to December.
Source: Statistics New Zealand (2010c)

In 2009 the main countries of origin for visitors were: Australia, United Kingdom and the United States of America (Figure 8). Additionally, there were over 100,000 visitors from China, approximately 85,000 from Japan (over 100,000 in 2008) and approximately 55,000 visitors from Korea (80,000 in 2008).

Figure 8: Number of short-term overseas passenger arrivals by country of last permanent residence, 2009



Notes: 'Short-term' means a length of stay of less than 12 months. Year to 31 December.
Source: Statistics New Zealand (2010c)

Actions relating to driving force indicators

This report has identified population growth and tourism (eg, the number of passenger arrivals) as major driving forces of environmental health in New Zealand. A number of policies and strategies address these issues by encouraging sustainable future development.

Population growth is the result of natural population growth, immigration and internal migration. In particular, immigration and migration policies can influence the number of temporary and permanent overseas visitors and residents. For example, the Immigration Act 2009 (and its amendments) controls how many immigrants may arrive in New Zealand. Decisions are made based on the current state of the economy, labour market, social development, health, education, law and order, housing, transport and other infrastructure (Department of Labour 2010).

A large driver of the number of passenger arrivals to New Zealand is tourism. Several strategies promote tourism, develop tourism research and policies and educate tourists on New Zealand:

- Asia Pacific Economic Cooperation (1999)
- Australian Standing Committee on Tourism
- New Zealand Tourism Strategies 2010 and 2015 (developed in 2001 and 2007 respectively).

Discussion

Overall themes have emerged from the driving force indicators, particularly around population growth, and increased numbers of people entering the country.

The New Zealand population has more than doubled in size over the past 50 years. In the last 10 years, population increases have been seen more in some areas than in others, particularly in the Auckland region, Bay of Plenty and some areas in the South Island, including Queenstown.

Over the past 40 years, there has been a massive increase in the number of passengers arriving to New Zealand, much of it due to tourism. Although not necessarily indicating a rapidly growing overall New Zealand population, it does indicate that tourism could be placing pressures on the environment and that, with the large numbers of people entering the country, biosecurity is increasingly important as a means of keeping out unwanted pests and diseases.

With the continuing ease of travel, these factors will continue to place pressures on the environment. Therefore, the challenge will be to prevent potentially negative effects arising from increased tourism and the rapidly increasing populations in some urban centres in New Zealand. Strategies for sustainable growth will play an important role in mitigating or preventing these effects.

Chapter 4: Pressures

As part of the DPSEEA framework, pressures were defined as being crucial aspects of human habitation, as well as exploitation of the environment (Briggs 1999). Pressures can arise from a wide range of sectors, including tourism, energy production, manufacturing, service sectors, agriculture and forestry.

In New Zealand, pressures are placed on the environment due to driving forces such as population growth, which can affect the quality of the environment. For example, air quality can be affected by pollutants emitted through energy consumption, through home heating, and through the use of vehicles. Water quality of rivers, groundwater, lakes and coastal environments can be affected by agricultural land use. Pressure can be placed on biosecurity efforts by large volumes of cargo and large numbers of people entering the country.

Overview of indicators

This chapter examines the following pressures, and how they relate to other aspects in the DPSEEA framework:

- energy consumption
- number of cars per person
- average age of vehicle fleet
- proportion of households using wood or coal fires to heat the home
- number of livestock
- amount of imported cargo entering New Zealand.

Pressure indicator: Energy consumption

Indicator	Total energy consumed in New Zealand, by sector

Relevance of indicator

New Zealand has a variety of energy sources, including renewable sources (eg, hydro-electricity, geothermal energy, biogas, and wind and solar power) as well as non-renewable sources of energy (eg, fossil fuels like coal, oil and gas). The consumption of energy is a major source of air pollution, as the burning of fossil fuels releases particulate matter (such as PM_{10}) and gases, which can have negative effects on health (Kjellström 2004). Furthermore, the use of fossil fuels adds to carbon dioxide in the atmosphere, contributing to greenhouse gases and potentially climate change, which has the potential to affect health.

Data source

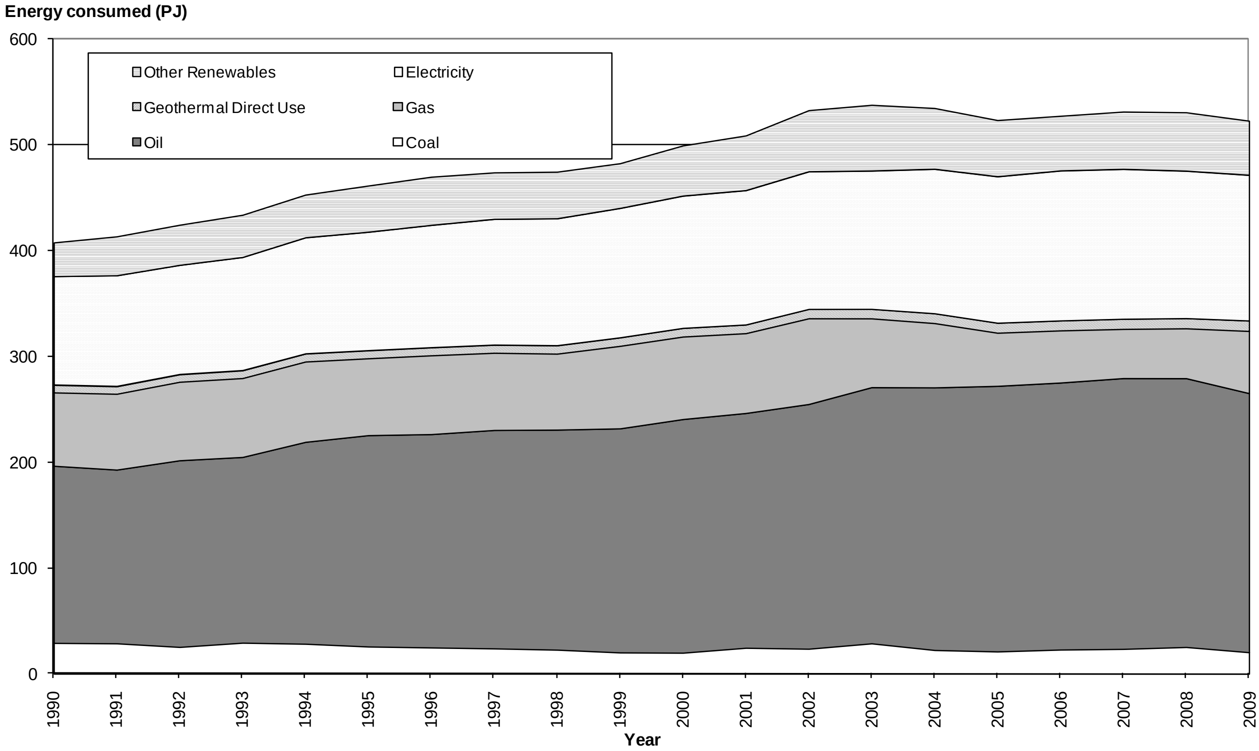
The indicator examines consumption of energy in New Zealand, by fuel type and sector, for the years 1990–2009. These data are available from the Ministry of Economic Development (2010), as part of the Energy in Brief publications. Energy consumed is defined as the amount of energy consumed by final users, and does not include energy used or lost while generating more energy, or bringing energy to final users (Ministry of Economic Development 2008). Energy is measured in petajoules (PJ = 1×10^{15} J).

Results

Energy consumption rose continuously from 1990 to 2003, decreased between 2003 and 2005, and dropped further between 2007 and 2009 (Figure 9). The main type of energy consumed is oil, although electricity also represents a large proportion of energy used.

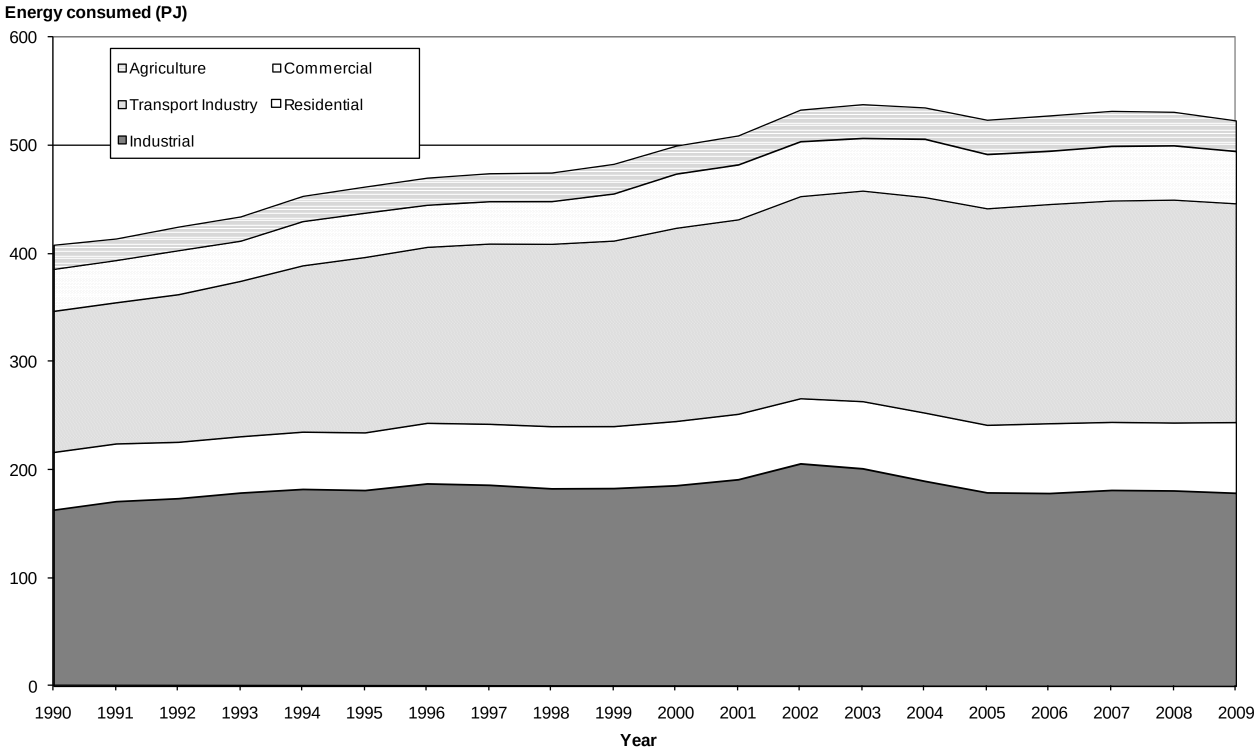
Industrial use of energy accounts for about a third of total energy consumption in New Zealand (Figure 10). Another third is accounted for by the transport sector. A drop in fuel consumption in the transport sector is primarily responsible for the overall reduction in consumption in 2009 and, among the fuels used, it was gas that saw the biggest drop in consumption.

Figure 9: New Zealand total energy consumed, by fuel type, 1990–2009



Source: Ministry of Economic Development (2010)

Figure 10: New Zealand total energy consumed, by sector, 1990–2009



Source: Ministry of Economic Development (2010)

Pressure indicator: Number of vehicles

Indicator	Number of vehicles in New Zealand

Relevance of indicator

Vehicle use has a major impact on the environment and potentially therefore on health. For example, vehicle emissions caused by the burning of petrol and diesel release greenhouse gases (carbon dioxide), carbon monoxide, particulate matter (PM_{10}) and other gases, which can all lead to health problems (Kjellström 2004).

Data source

The indicator presents the number of vehicles in New Zealand by year. These data are sourced from the Ministry of Transport's online database (Ministry of Transport 2010) and are updated periodically.

For the indicator, five categories of vehicles are used:

1. 'light passenger' vehicles, which include passenger cars and vans
2. 'light commercial' vehicles, which include the following if under 3500 kg: goods vans, trucks, utilities, buses and motor caravans
3. 'trucks', which include the following if over 3500 kg: goods vans, trucks, utilities and motor caravans
4. 'motorcycles', which include motorcycles and mopeds
5. 'buses', which include buses over 3500 kg.

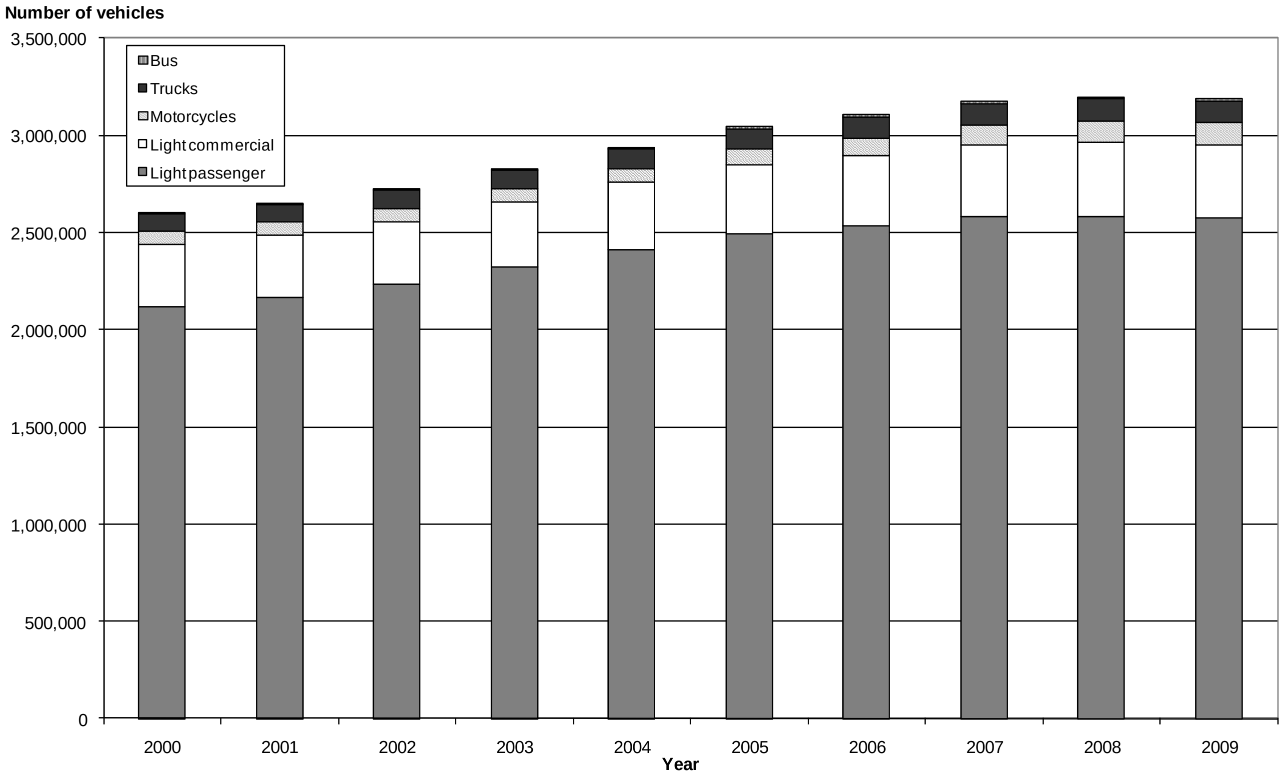
The number of light vehicles per 1000 people in New Zealand is also compared with other countries, as reported in *The New Zealand Vehicle Fleet* (Ministry of Transport 2010).

Results

The number of vehicles in New Zealand continued to increase between 2000 and 2008, but decreased slightly in 2009 (Figure 11). The reduction in vehicle numbers included the first decrease in light passenger vehicle numbers (approximately 10,000 fewer than 2008) since 2000. Light passenger vehicles (passenger cars and vans), as in all previous years, made up the large majority of these vehicles. The 8450 buses comprised only a very small proportion (less than 0.3%) of the total number of vehicles in 2009.

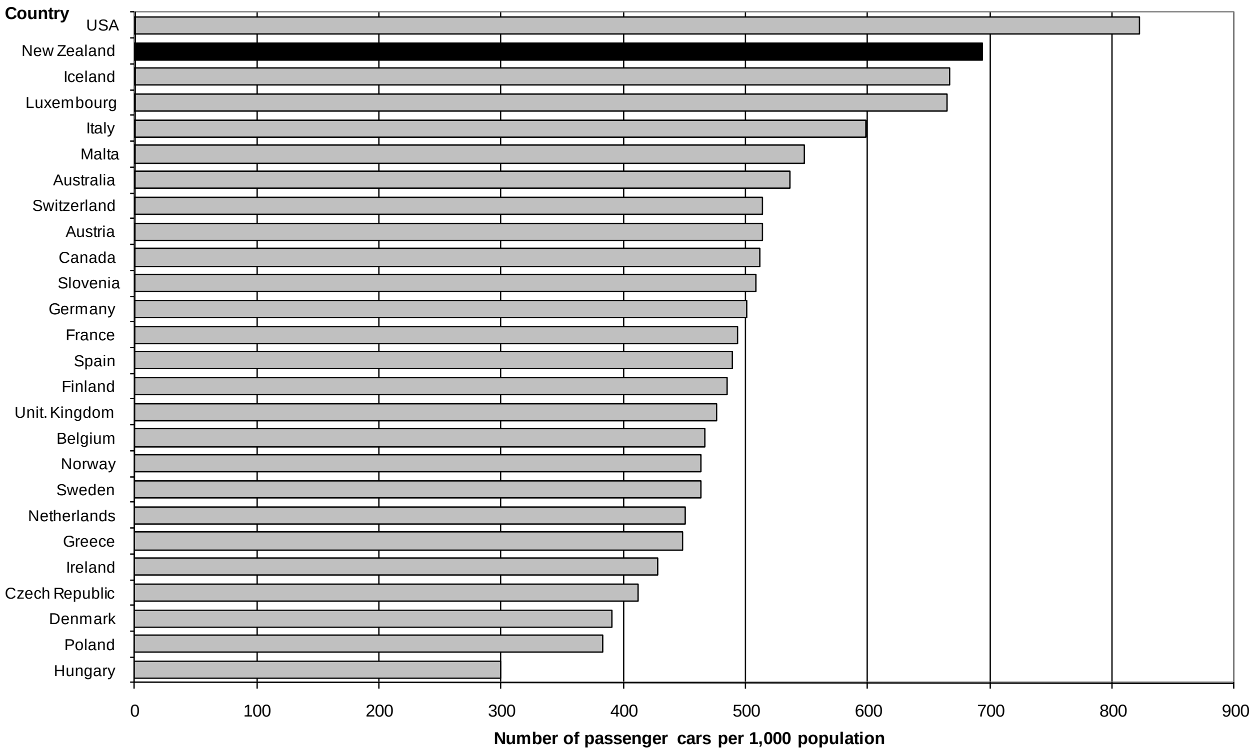
Internationally New Zealand has a very high rate of light vehicles per population at 694 light vehicles for every 1000 people. In 2007–2008, only the USA had higher rates of passenger cars per population (Figure 12).

Figure 11: Number of vehicles in New Zealand, by vehicle type, 2000–2009



Source: Ministry of Transport (2010)

Figure 12: Number of light vehicles per 1,000 population, comparison of countries, 2007–2008



Source: Ministry of Transport (2010)

Pressure indicator: Average age of vehicle fleet

Indicator	Average age of vehicle fleet in New Zealand

Relevance of indicator

The average age of a country's vehicle fleet is an indicator of the efficiency of the vehicles on the road. Older cars tend to be less efficient and have more emissions. These emissions include carbon dioxide, carbon monoxide and particles (PM_{10}), particularly from diesel vehicles (Kjellström 2004). Furthermore, vehicle age is often related to vehicle safety, with newer cars having better safety features.

Data

The indicator presents the average age of vehicles in New Zealand by type for the years 2000 to 2009. The data are sourced from the report *The New Zealand Vehicle Fleet* (Ministry of Transport 2010), published annually by the Ministry of Transport.

For this indicator, the five categories of vehicles used are the same as for the previous indicator 'Number of vehicles in New Zealand'.

The average age of vehicles in New Zealand is also compared with other countries with high levels of motorisation and similar patterns of development to New Zealand, as reported in *The New Zealand Vehicle Fleet* (Ministry of Transport 2010).

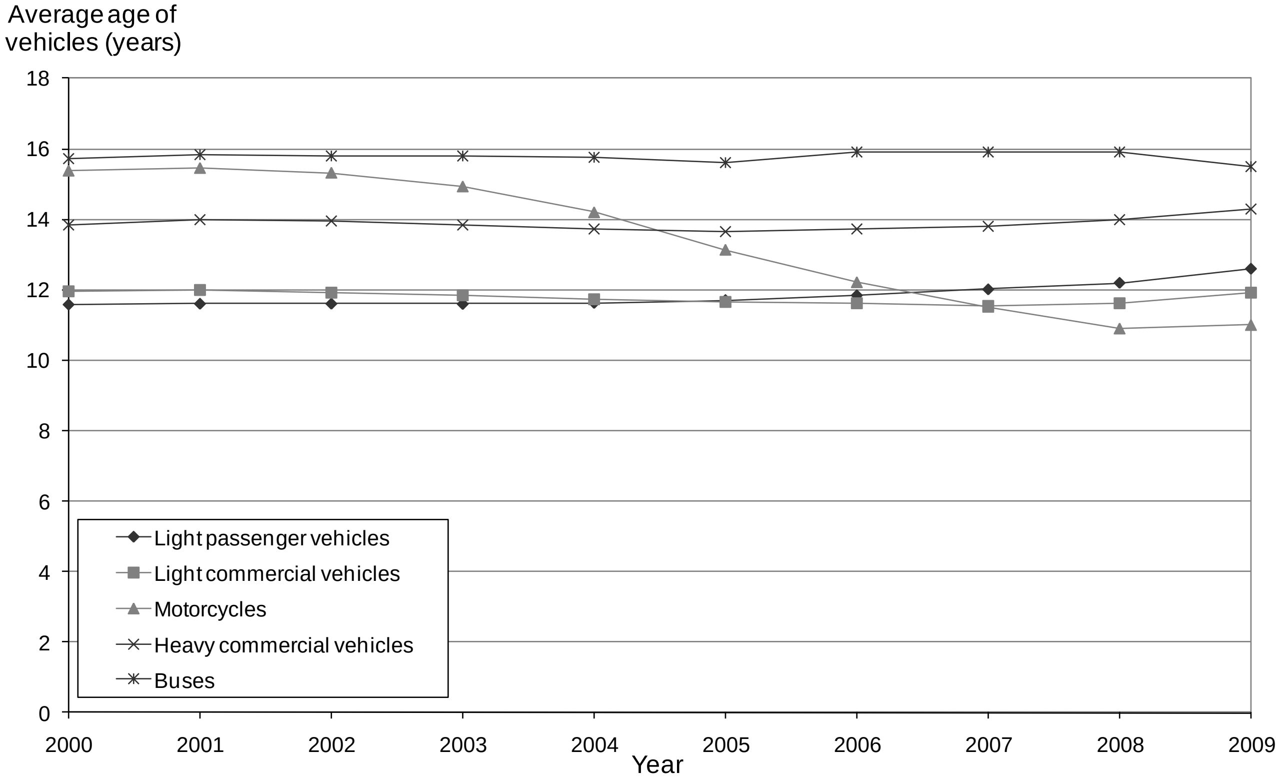
Results

The average age of all types of New Zealand vehicles is between 11 and 16 years; for light passenger and commercial vehicles it is approximately 12 years, for heavy commercial vehicles about 14 years, and for buses approximately 16 years (Figure 13). The pattern has not changed substantially in the past nine years.

The average age of motorcycles has decreased from 15 years in 2000 to about 11 years in 2008.

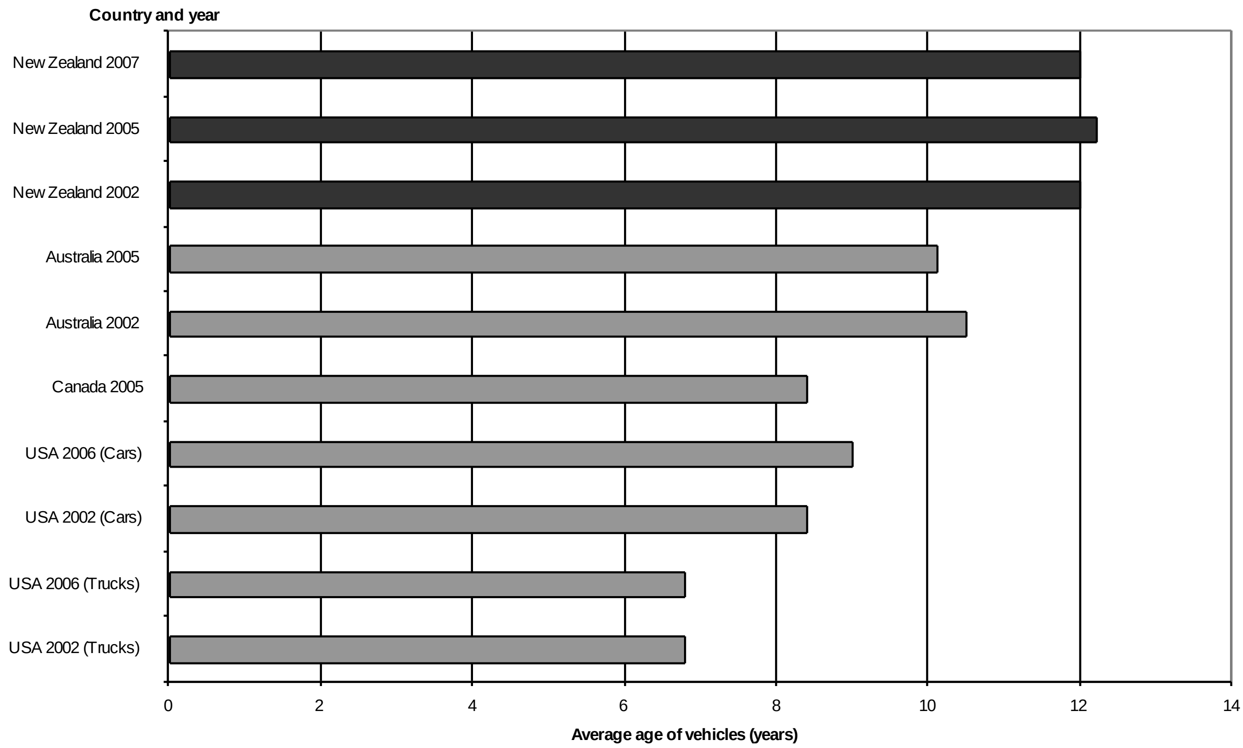
The latest available international data show New Zealand has an older vehicle fleet than the other countries in the comparison (Figure 14). Between 2002 and 2007, the average age of vehicles in New Zealand was approximately 12 years, compared with about 10 years in Australia, and 8–9 years in Canada and the USA.

Figure 13: Average age of vehicle fleet in New Zealand (years), by vehicle type, 2000–2009



Source: Ministry of Transport (2010)

Figure 14: Average age of vehicle fleet (years), international comparisons, 2002–2007



Notes: The average age refers to the mean age of the vehicle fleet. An exception is the United States, where vehicle ages are given as medians, and are therefore lower than the expected average ages for vehicles (Ministry of Transport 2008).

Source: Ministry of Transport (2008)

Pressure indicator: Use of wood and coal for domestic heating

Indicator	Proportion of households that use wood or coal fires as a source of fuel for heating

Relevance of indicator

Home heating through the use of wood or coal fires is a major source of air pollution in most towns and cities of New Zealand, with emissions considered to be as toxic as other sources of air pollution (Naeher et al 2007). Wood and coal fires emit carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter and other organic compounds, including polycyclic aromatic hydrocarbons (Fisher et al 2007). Studies have shown that coal fires emit 58–75% more PM_{10} pollution than wood burners (Ministry for the Environment 2005).

In New Zealand, air pollution from wood-burning domestic fires mostly occurs in winter and in particular locations such as Nelson, Alexandra and Christchurch (Fisher et al 2007). In Christchurch, conditions such as low-level temperature inversions, calm weather, and the burning of wood as the main heat source can result in a number of elevated air pollution days, particularly during winter (Scoggins 2004). The Health and Air Pollution in New Zealand (HAPiNZ) study estimated there was an increase of 4.8% in the national average mortality rate associated with air pollution (Fisher et al 2007). Using wood or coal fires as a source of fuel for heating can also lead to poor air quality within the dwelling.

Data source

The data were sourced from Statistics New Zealand Censuses for the years 1996, 2001 and 2006. Data were collected on the fuel types used to heat occupied private dwellings, and multiple fuel types could be selected (eg, electricity, gas, coal and wood).

Data are presented for the proportion of dwellings in each TA that reported using wood and/or coal as a fuel for heating their dwelling. Results for wood and coal are presented separately.

Results

In the 2006 Census, 39.0% of all dwellings recorded wood as a source of home heating, compared with 46.9% in 1996 (Table 1). The proportion of dwellings using coal as a source for heating nearly halved over the same period, from 12.5% in 1996 to 6.7% in 2006.

The following sections focus primarily on the use of wood and coal as fuels for home heating, as these are some of the main sources of air pollution.

Table 1: Percentage of dwellings using certain fuel types for home heating, 1996, 2001 and 2006

Fuel type	1996	2001	2006
Electricity	74.3%	69.0%	71.4%
Wood	46.9%	42.8%	39.0%
Bottled gas	21.5%	27.1%	26.4%
Mains gas	11.2%	12.9%	12.6%
Coal	12.5%	8.9%	6.7%
Solar power	0.7%	0.9%	1.0%
No fuels used in this dwelling	1.8%	2.7%	2.3%
Other fuel(s)	0.9%	1.0%	2.0%
Not elsewhere included	3.8%	4.2%	4.5%

Notes: Dwellings refers to private occupied dwellings. Multiple fuel types could be reported; total response fuel types have been reported in the table, which means that percentages will not add to 100.0%.

Source: Statistics New Zealand (2010d)

Wood as a source of fuel for heating dwellings by territorial authority

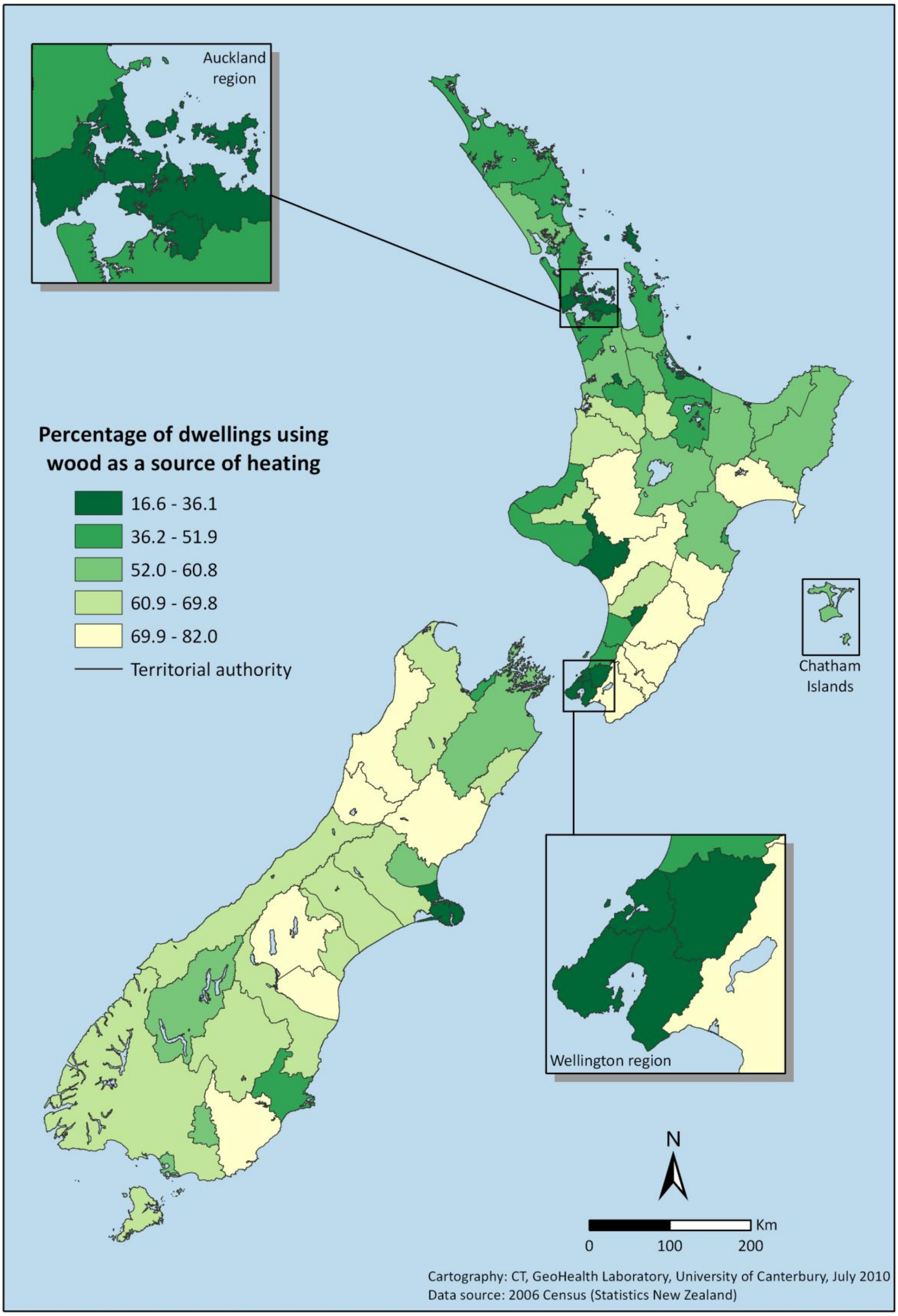
Generally, TAs in rural areas had the highest proportions of dwellings using wood as a source of heating (Figure 15). At least 70% of households in Wairoa, Central Hawke's Bay, Ruapehu, Rangitikei, Tararua, Masterton, Carterton, South Wairarapa, Buller, Grey, Hurunui, Mackenzie, Waimate and Clutha used wood as a source of heating.

TAs in urban areas generally had the lowest proportions of wood-burning dwellings. The lowest proportion was in Hamilton City (16.6%). The following TAs had less than 30% of households using wood as a source of heating: North Shore City, Auckland City, Manukau City, Hamilton City, Tauranga City, Palmerston North City, Lower Hutt City and Wellington City. In Christchurch City, 31.6% of the dwellings used wood as a fuel source for heating, compared with 44.0% in Nelson City.

From 1996 to 2006, the proportion of dwellings using wood as a fuel source for home heating declined nationally from 46.9% to 39.0%. However, in nine TAs there were increases: New Plymouth, Stratford, South Taranaki, Whanganui, Manawatu, Palmerston North City, Horowhenua, Carterton and South Wairarapa.

Overall, 63 TAs had a decrease in the proportion of houses using wood as a source of heating. The greatest decreases were in: North Shore City, Waitakere City, Auckland City, Manukau City, Waipa, Tauranga City, Kaikoura, Waimakariri, Christchurch City and Selwyn.

Figure 15: Percentage of dwellings using wood as a source for heating, by TA, 2006



Source: Statistics New Zealand (2010d)

Coal as a source of fuel for heating dwellings by territorial authority

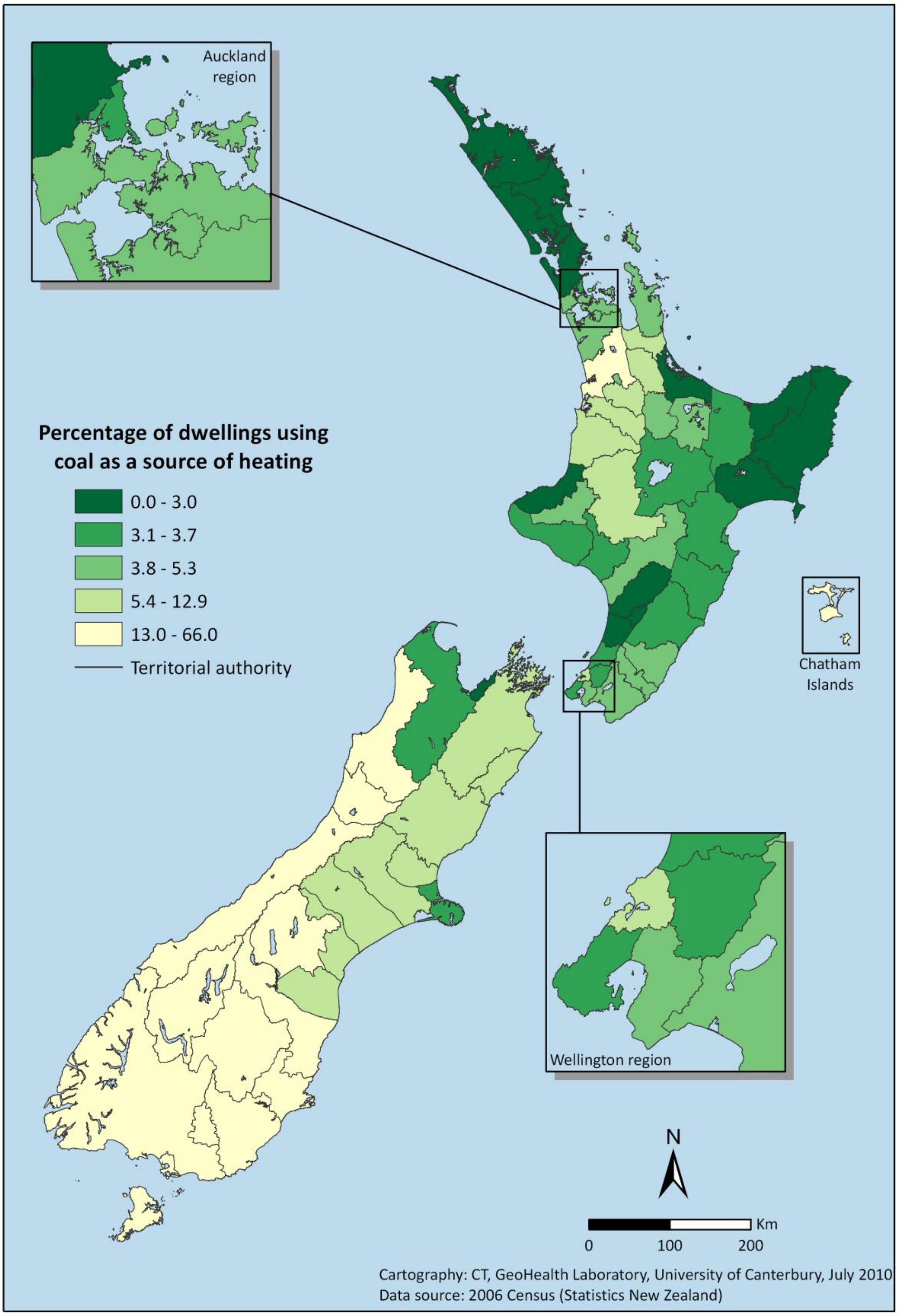
In 2006 fewer New Zealand dwellings used coal as a source of heating (6.7%) than wood (39.0%).

TAs in the South Island generally had a much higher use of coal as a source of fuel for home heating (Figure 16). The following TAs had over 40% of households using coal as a source of heating: Buller, Grey (6.0%), Westland, Clutha, Southland, Gore and Invercargill City.

Overall, 47 TAs had 5% or fewer dwellings using coal as a fuel source for heating the home. The majority in this category were in the North Island.

From 1996 to 2006 the national proportion of households using coal as a source of heating decreased from 12.5% to 6.7%. All TAs recorded a decline with the largest decreases in: Waikato, Christchurch City, Selwyn, Ashburton, Timaru, Waimate, Waitaki, Central Otago, Queenstown-Lakes and Southland.

Figure 16: Percentage of dwellings by TA using coal as a source for heating, 2006



Source: Statistics New Zealand (2010d)

Pressure indicator: Number of livestock

Indicator	Total number of livestock in New Zealand

Relevance of indicator

In New Zealand, livestock (ie, animals such as cattle, sheep and deer farmed for agricultural purposes) has long played a very important role in the economy. However, agricultural use of the land can have a major effect on the environment, particularly from the run-off of effluent into water sources, which can affect water quality (Cromar and Fallowfield 2004).

Dairy cows may have additional effects on the environment. For example, the conversion of land to dairy farming requires a large amount of water for irrigation. It is estimated that dairy farms require 420 litres of water per day per hectare, as compared with 95 litres for intensive livestock and dairy support, 60 litres for lifestyle land use, and 21 litres for non-irrigated hill country (Morgan et al 2002). As a result of dairy farming, irrigation and the run-off of nitrates used to fertilise the grass may affect water supply levels and quality. Furthermore, dairy cows produce methane (CH_4), a greenhouse gas that is thought to contribute to climate change.

Data source

Data on the number of livestock in New Zealand were sourced from annual Agricultural Production Surveys and five-yearly Agricultural Production Censuses (Statistics New Zealand 2010b). The last Agricultural Production Census was carried out in 2007, and the last Agricultural Production Survey was carried out in 2009.

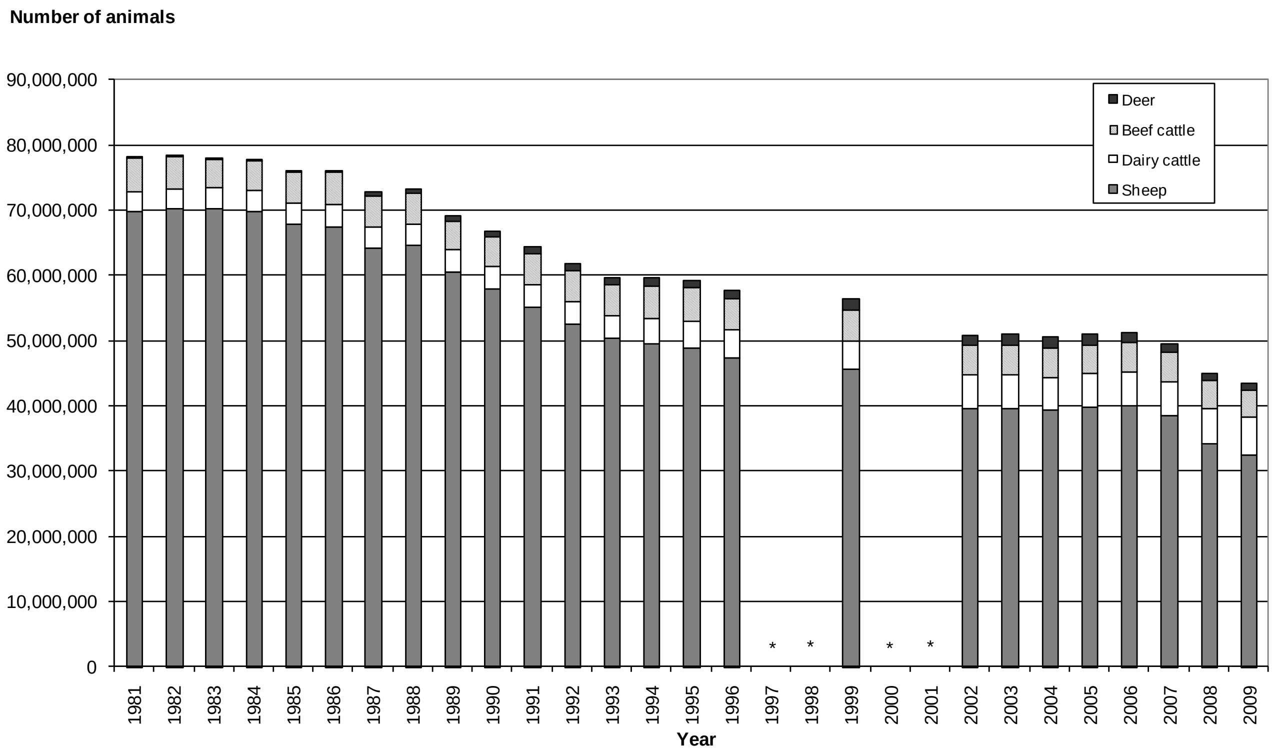
Livestock numbers are presented by regional council and TA for 2009. For the purposes of this report, livestock only includes the main categories of cattle, sheep and deer. Regional livestock densities are not included in this analysis.

Results

Livestock numbers

Livestock numbers have decreased since the 1980s, with the largest decrease occurring for sheep although they still comprise the majority of the livestock numbers (Figure 17). There has been a considerable decline in sheep numbers during 2008 and 2009.

Figure 17: Number of livestock by type in New Zealand, 1981–2009

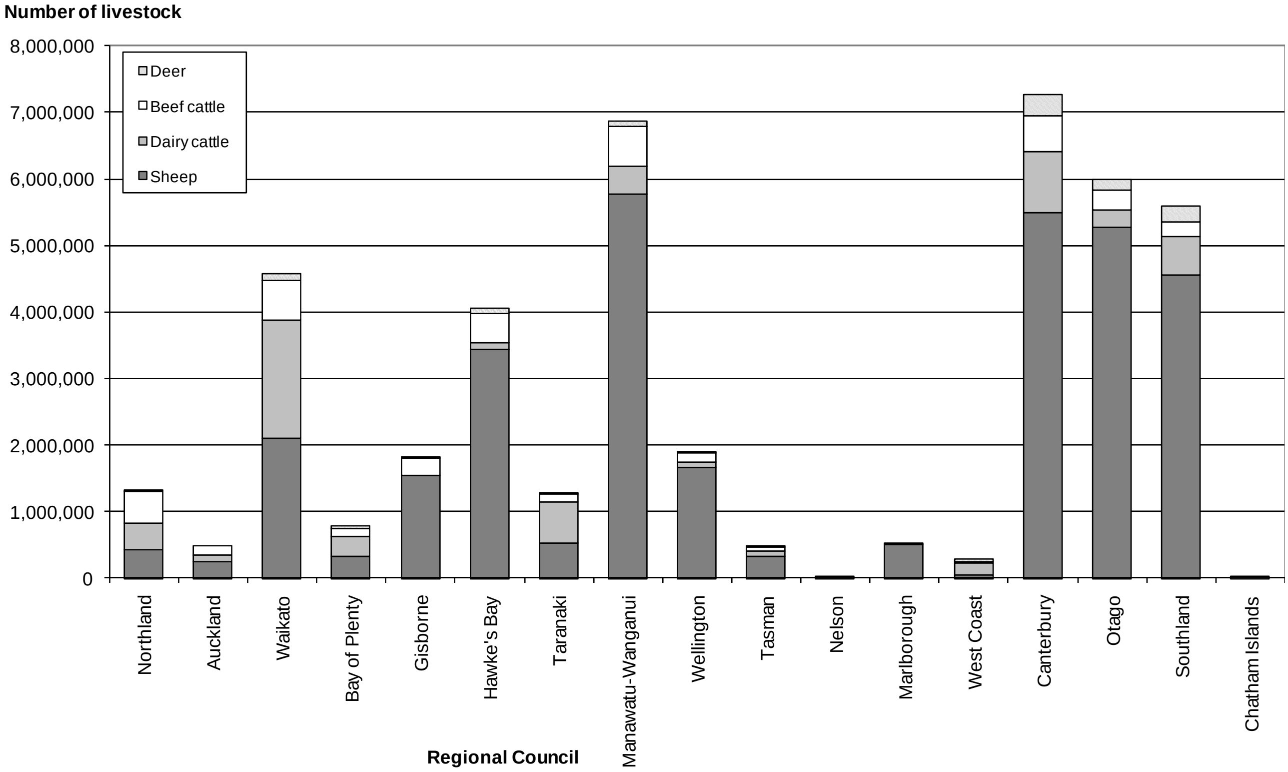


Notes: An asterisk (*) indicates that data were unavailable for that year. Livestock only includes dairy cattle, beef cattle, deer and sheep. Year to 30 June. Numbers for 2008 and 2009 are based on agricultural production sample surveys, and are therefore subject to sample bias.

Source: Statistics New Zealand (2010b)

There are large numbers of livestock (primarily sheep) in the Manawatu-Whanganui, Canterbury, Otago and Southland Regional Councils (Figure 18). The Waikato Regional Council has the largest number of dairy cattle.

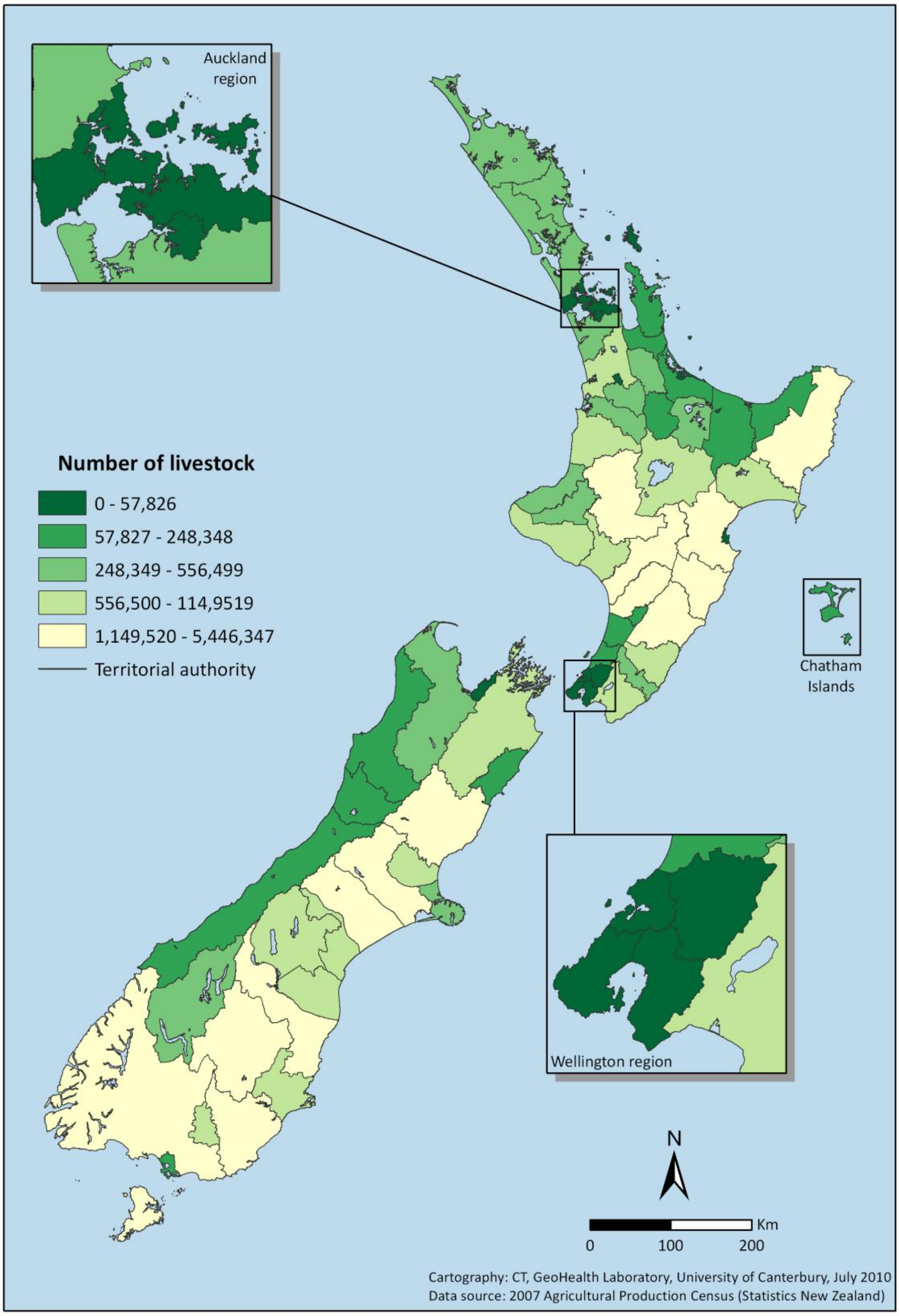
Figure 18: Number of livestock in New Zealand by regional council, 2009



Note: Year to 30 June.
Source: Statistics New Zealand (2010b)

The highest numbers of livestock are located in the TAs of the central North Island, Canterbury and Southland areas (Figure 19).

Figure 19: Number of livestock by TA, 2009

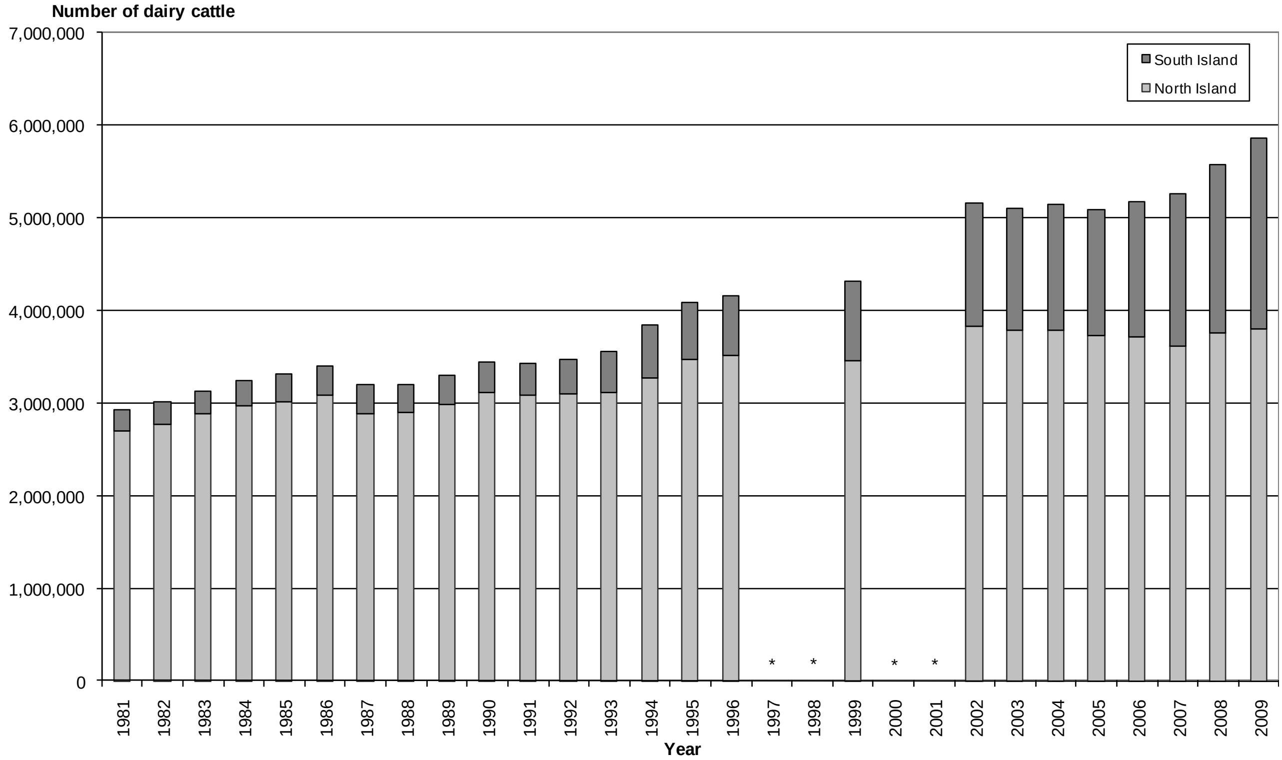


Source: Statistics New Zealand (2010b)

Dairy cattle numbers

Over the past 20 years, there has been a considerable increase in the number of dairy cattle in the South Island (Figure 20). The number in the North Island declined slightly between 2002 and 2007, but increased during 2008 and 2009.

Figure 20: Number of dairy cattle in New Zealand, 1981–2009

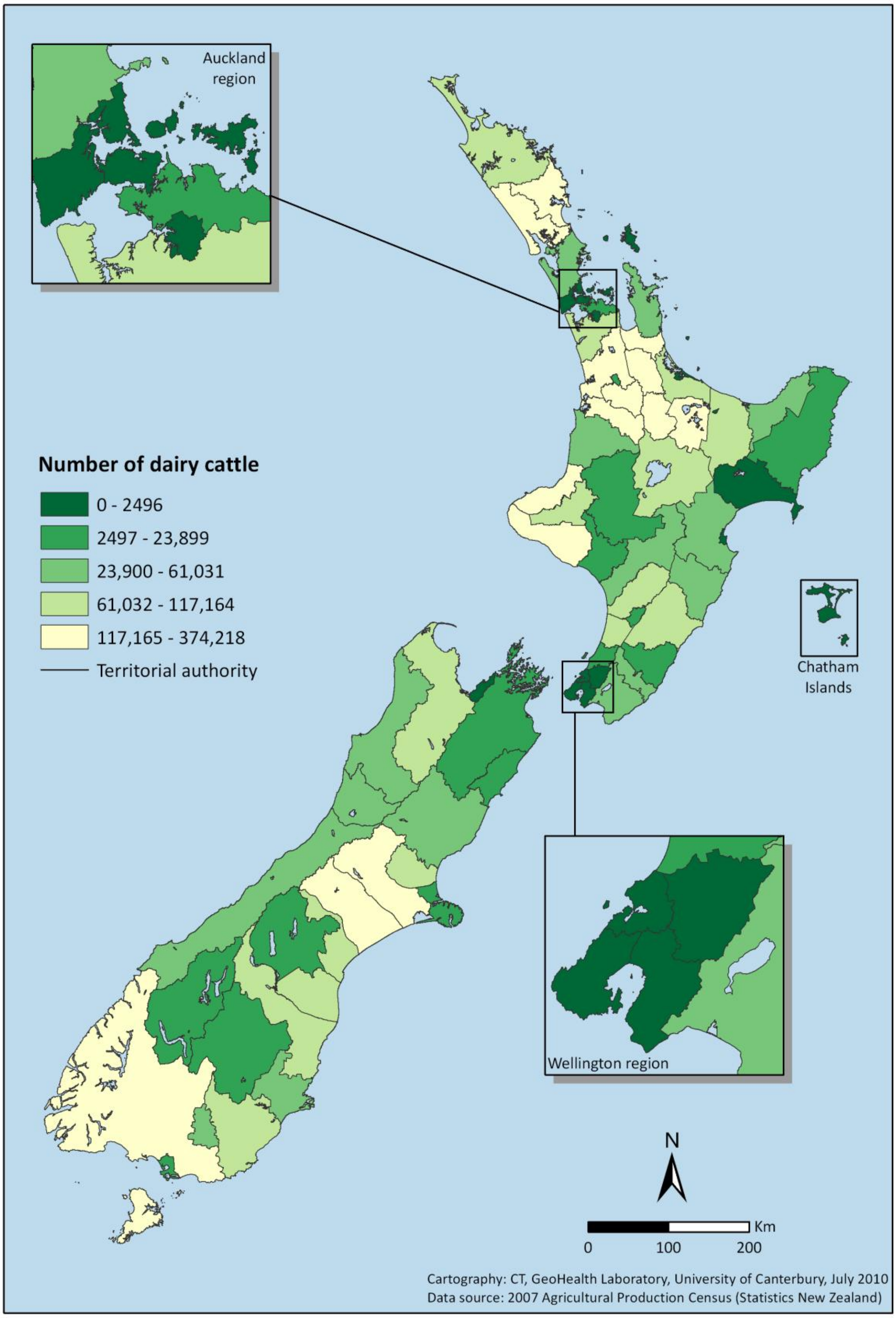


Notes: An asterisk (*) indicates that data were unavailable for that year. Year to 30 June. The 2008 and 2009 Agricultural Production Surveys are sample surveys and therefore estimates are subject to sample error.

Source: Statistics New Zealand (2010b)

Dairy farming is carried out predominantly in TAs in Northland, Waikato, Bay of Plenty, Taranaki, Mid Canterbury and Southland (Figure 21).

Figure 21: Number of dairy cattle, by TA, 2009



Source: Statistics New Zealand (2010b)

Pressure indicator: Amount of imported cargo

Indicator	Amount of imported cargo entering New Zealand

Relevance of indicator

Increases in the amount of cargo coming into New Zealand can increase the risk of a biosecurity breach from harmful pests and disease. The level of risk depends on a number of variables, including the amount of cargo being imported, country of origin, and the port of destination within New Zealand. However, the risk can be mitigated to a certain extent by risk profiling, and level of risk by pathway and quantity.

Data source

Data on the amount of cargo unloaded at New Zealand ports were sourced from the New Zealand Customs Service and Statistics New Zealand, as part of the annual release of statistics (Statistics New Zealand 2010a). In the analysis, overseas cargo imports exclude certain items such as large one-off imports of transport equipment (ie, aircraft), goods imported for use by foreign armed forces, and passenger baggage (Statistics New Zealand 2010a).

Data about the number of sea containers imported into New Zealand from 2002 to 2009 were obtained from Ministry of Agriculture and Forestry's Biosecurity New Zealand (MAF BNZ).

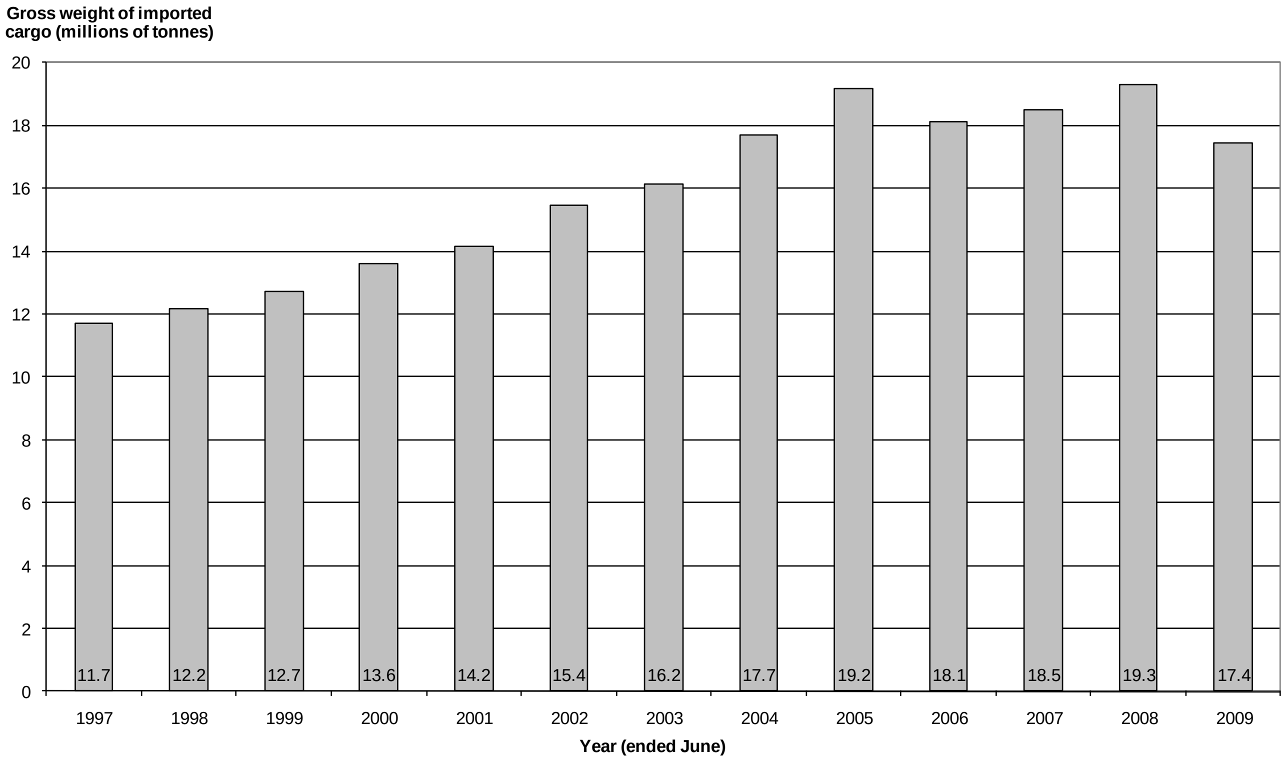
Results

Imported cargo

The gross tonnage of cargo imported into New Zealand increased steadily from 1997 to 2005 and then, with the exception of 2008, the following years have remained lower than the 2005 peak (Figure 22).

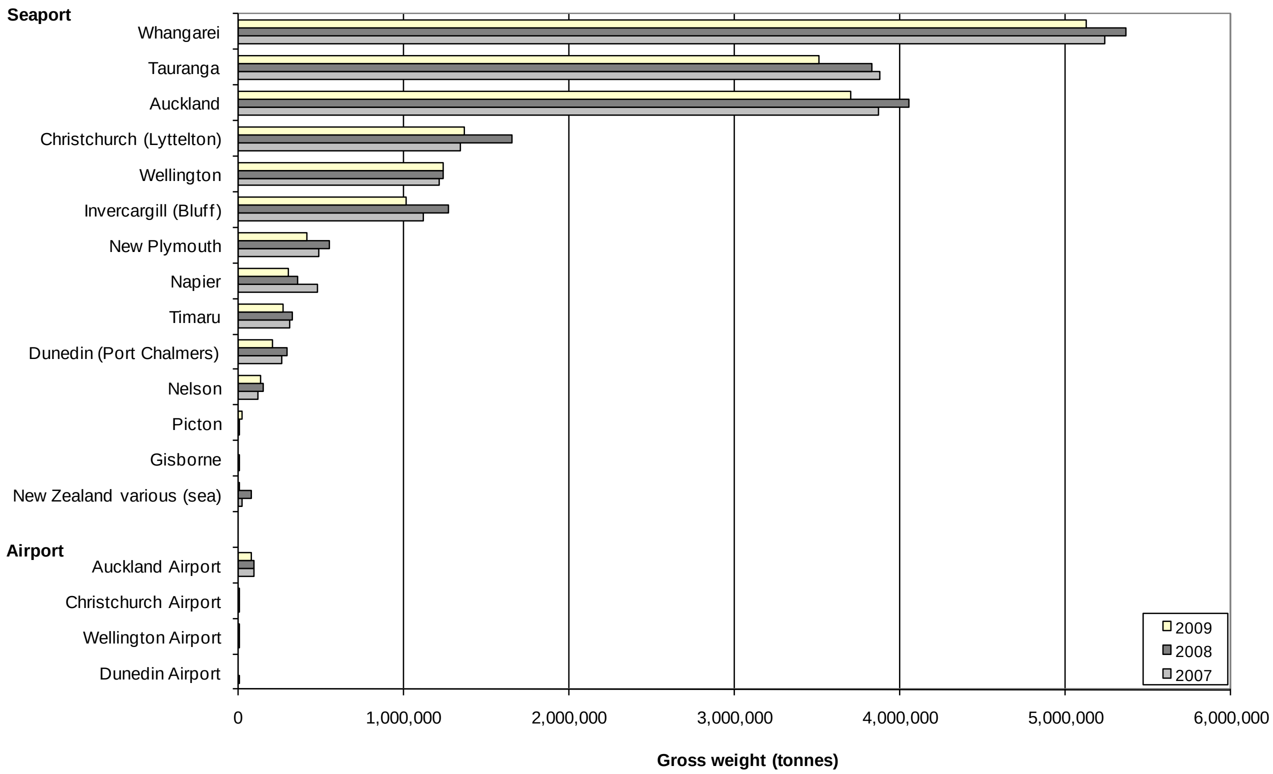
Figure 23 presents the imported tonnage of cargo between 2007 and 2009 (year ended June), by seaport and airport. During this period, almost all tonnage of imports entered New Zealand via seaports, with the majority entering at the ports of Whangarei, Tauranga and Auckland. Cargo tonnage arriving by air was handled mainly by Auckland International Airport, with small amounts arriving at Christchurch, Wellington and Dunedin international airports (Figure 23).

Figure 22: Gross weight of imported cargo into New Zealand, by year, 1997–2009 (millions of tonnes)



Note: Year ended 30 June.
Source: Statistics New Zealand (2010a)

Figure 23: Gross weight of imported cargo into New Zealand, by seaport and airport, 2007–2009 (tonnes)

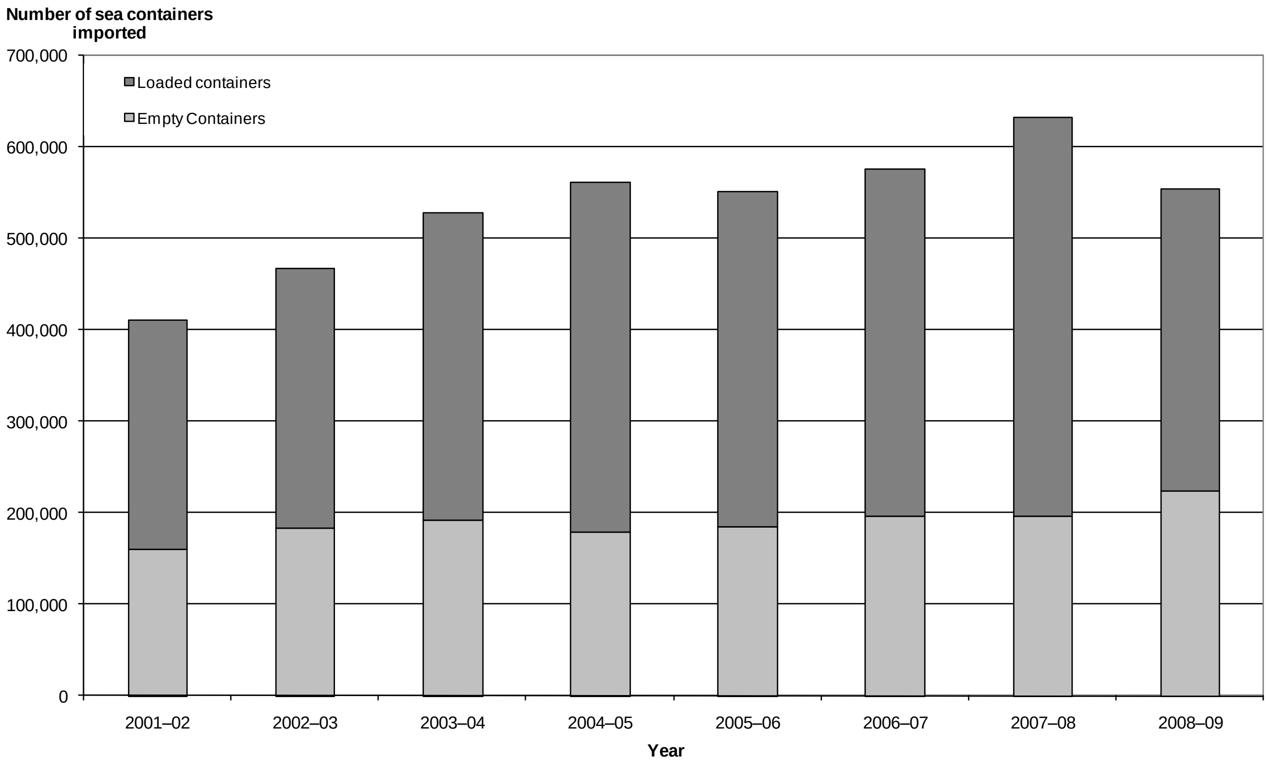


Note: Year ended 30 June
Source: Statistics New Zealand (2010a)

Number of sea containers

The number of sea containers imported into New Zealand increased from 2001/02 to 2006/07, peaked in 2007/08 and declined in 2008/09 (Figure 24). Most of the increase was in loaded containers, which made up the majority of sea containers imported into New Zealand in 2008/09, although to a lesser extent than in the previous four years.

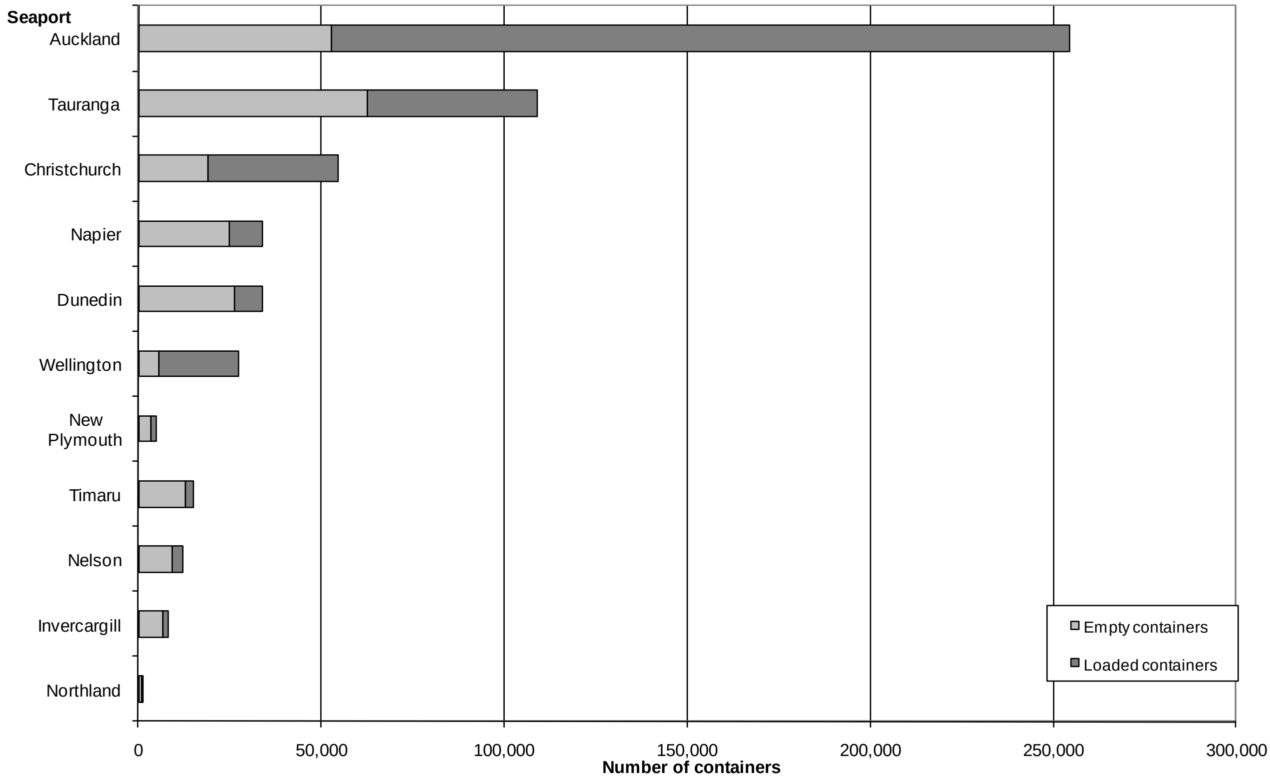
Figure 24: Number of sea containers imported into New Zealand, by type, 2001/02 to 2008/09



Note: Year to June.
Source: MAF BNZ (2010c)

Over two-thirds of all sea containers imported into New Zealand in 2008/09 arrived at either Auckland (46% of all containers) or Tauranga (24% of all containers) (Figure 25).

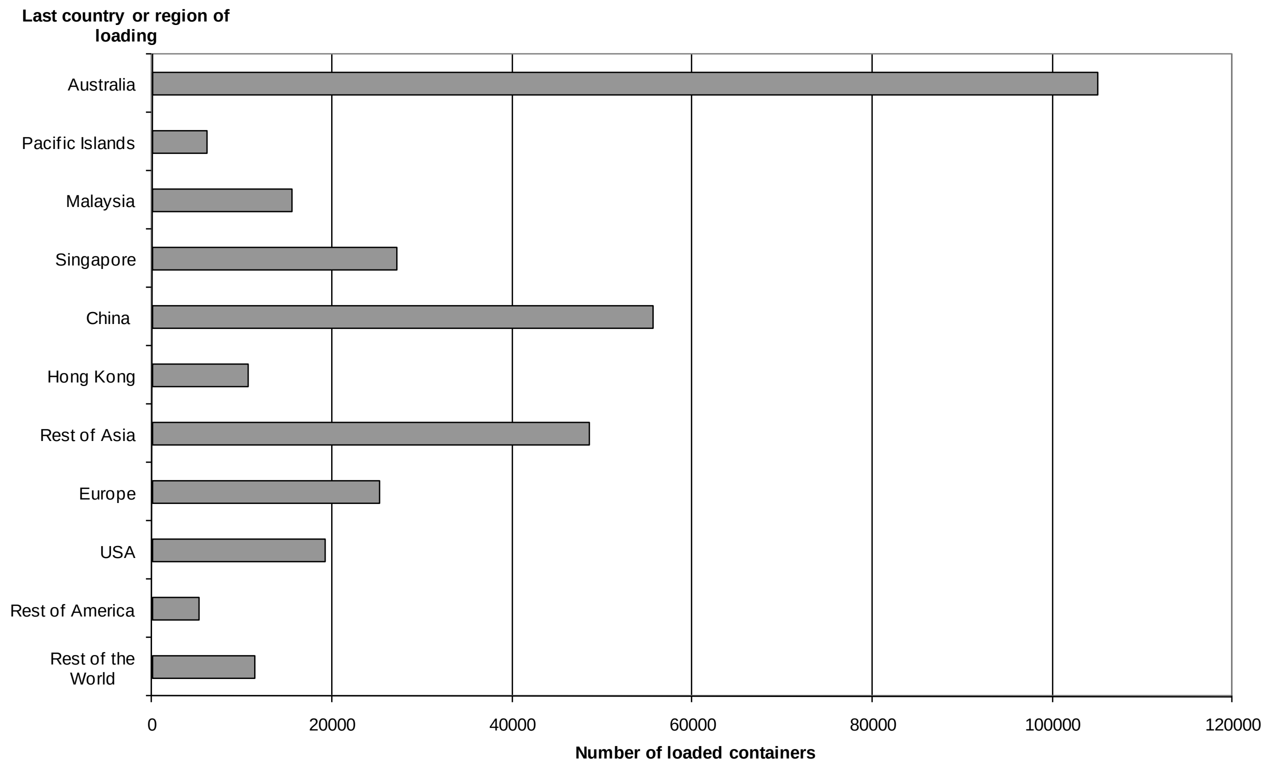
Figure 25: Number of sea containers imported into New Zealand, 2009, by port



Note: Year to June.
Source: MAF BNZ(2010c)

In 2008/09, just under one-third of all sea containers imported into New Zealand arrived from Australia. Over 50% of sea containers arrived from Asia (includes Malaysia, Singapore, China, Hong Kong and the rest of Asia), an increase of 10% from 2007 (Figure 26).

Figure 26: Number of sea containers imported into New Zealand, 2009 (year to June), by last country or region of loading



Note: Year to June.
Source: MAF BNZ (2010c)

Actions relating to pressure indicators

Pressures on the environment include energy consumption, increasing numbers of cars, and the large amount of cargo arriving in New Zealand. These pressures can, in turn, affect environmental health exposures such as air quality and biosecurity. The New Zealand Government has recognised the impacts of these pressures and has created several mitigation policies.

Strategies for energy efficiency and conservation

Energy strategies in New Zealand provide guidance for sustainable energy use. For instance, the National Energy Efficiency and Conservation Strategy, released in 2001, is the Government's action plan to promote energy efficiency and conservation, and the use of renewable energy sources (Ministry of Economic Development 2008). The strategy aims to reduce electricity demand, address energy use in transport, buildings and industry, and promote greater consideration of sustainable energy in the development of land, settlements and energy production.

Introduced in 2006, the New Zealand Energy Strategy sets a strategic direction for the energy sector to contribute to New Zealand's future prosperity and sustainability. It provides direction on energy security and climate change issues and specifically responds to the challenges of providing enough energy to meet the needs of the growing economy and population, by maintaining a secure supply yet reducing greenhouse gas emissions (Ministry of Economic Development 2007). One target is to produce 90% of electricity in New Zealand from renewable resources by 2025.

The New Zealand Government also funds several energy-saving strategies. On 1 July 2009 the New Zealand Insulation Fund (known as Warm Up New Zealand: Heat Smart) replaced ENERGYWISE™ Interest subsidies and Grants Schemes. The fund is delivered by the Energy Efficiency and Conservation Agency and continues to contribute to the Agency's goal of 'warm dry healthy homes, improved air quality and reduced energy costs'. It has been allocated $323 million in Crown funding (including $100 million from Vote: Health) to deliver 180,500 insulation retrofits and/or clean heat retrofits over a period of four years. For low-income homes, the target is 15,000 insulation and 5000 clean heat retrofits each year. The intention is to insulate the ceiling and under the floor, and to install a clean heating device (a heat pump, a fluid gas heater, or an efficient and clean wood/pellet burner).

Other initiatives include Smarter Homes, operated by the Department of Building and Housing and created in a joint initiative with the Ministry for the Environment, Consumer, Beacon Pathway Ltd and URS. This initiative aims to ensure that homes are built to be warmer, drier, healthier and more comfortable (Climate Change New Zealand 2008). Multiple programmes promote energy efficient workplaces, encourage the use of renewable technologies (eg, solar heating), and provide incentives for saving energy.

Transport strategies

Other initiatives aimed at addressing environmental pressures and human health and safety includes the New Zealand Transport Strategy 2008, which encourages sustainable transport. The strategy aims to halve per capita greenhouse gas emissions from domestic transport by 2040 and improve the emissions technology of new and used vehicles (Ministry of Transport 2008). It outlines measures for reducing road deaths, injuries, and exposure to noise and air pollution.

Dairy cattle and water quality strategies

The Dairying and Clean Streams Accord aims to achieve clean, healthy water in dairying areas, by excluding stock from waterways and reducing discharges of dairy effluent (Ministry for the Environment 2007). The accord was signed by Fonterra, the Ministry of Agriculture and Forestry, the Ministry for the Environment and regional councils in May 2003.

Discussion

The main pressures on environmental health that have been covered in this chapter are the increases in:

- energy consumption
- numbers of vehicles, and age of vehicle fleet
- numbers of dairy cows in the South Island (although the numbers of livestock are decreasing overall)
- tourism and imports.

These pressures can affect the quality of the environment. For example, pollutants emitted through home heating, energy consumption and the use of vehicles, can affect air quality. Agricultural land use and the use of fertilisers can affect water quantity and quality of groundwater, rivers, lakes and coastal environments. Insects and pests can enter the ecosystem through increasingly large volumes of imported cargo and humans entering the country, which may carry diseases. Trends have shown that some pressures are continuing to increase, and therefore may require planning to promote sustainability of the environment and to protect human health.

Energy consumption

The amount of energy consumed in New Zealand has continued to rise since the 1980s. Renewable energy sources comprised just over 36% of all energy consumed each year from 2004 to 2008. The majority of energy was consumed by the industrial sector and 'unallocated' users, of which the majority were likely to be private vehicles. About 10% of the total energy consumed was accounted for by the transport industry.

Vehicles

The increase in consumption of energy appears to have been driven, in part, by the large numbers of vehicles on the road. In addition to the effects from the consumption of energy and production of greenhouse gases, there are further environmental impacts from high vehicle numbers, particularly on air quality. These impacts are compounded by the old age of the vehicles, which tend to be less efficient and have higher rates of emissions.

Home heating

Another key source of air pollution in New Zealand is home heating – in particular, wood and coal burners. While the national proportion of houses with wood burners is still relatively high (around 40%), there has been a considerable decrease over time in the proportion of homes using wood and coal as a source of heating.

Livestock

Although livestock numbers have decreased over the past 20 years, the number of dairy cows in the South Island has increased rapidly. It will be important to continue monitoring the effect of livestock on the quantity and quality of water sources.

Imports

Imports to New Zealand have on the whole increased over the last 13 years, which has augmented the risk of harmful pests and diseases entering New Zealand. The greatest increase occurred between 1997 and 2005, when the annual imported cargo tonnage increased by over 60%. From 2005 to 2009 the increase attenuated to some extent, with numbers stabilising. The risks associated with these new pests and diseases will vary geographically, according to both the region of origin of imported cargo and the port of arrival.

This chapter has shown that there are a number of pressures on the environment, which must continue to be monitored in order to mitigate or minimise any negative effects.

Chapter 5: Air Quality and Health

Air quality is a critical environmental health issue, as clean air is essential to life and development. Air pollution has been linked to a wide range of health effects, including by exacerbating respiratory and cardiovascular conditions (American Thoracic Society 1996, 2000) and causing restricted activity days (eg, air pollution causing breathing problems which prevent work attendance) (Fisher et al 2007).

Ambient air pollution encompasses a number of pollutants, including:

- coarse particulate matter (PM_{10}) and fine particulate matter ($PM_{2.5}$), which can penetrate deep into the lungs
- carbon monoxide (CO), which is highly correlated with particulates and can affect the blood's ability to carry oxygen
- nitrogen dioxide (NO_2), which can exacerbate asthma
- sulphur dioxide (SO_2), which can cause sore eyes and throat
- ozone (O_3), which can cause breathing difficulties
- benzene, which is a carcinogen (Fisher et al 2007; Ministry for the Environment 2007).

The sources of air pollution can be domestic, vehicular, industrial and natural (including wind-blown dust). However, the key pressure on air quality in New Zealand is domestic heating, with high levels of particulate matter due to household wood and coal burning (Ministry for the Environment 2010a). In Auckland, population growth is increasing the number of vehicles on the road, which also contributes to poor air quality (Ministry for the Environment 2010c). In general, the concentration of pollutants in the air can be influenced by pollution sources, location, topography, time of day, weather conditions, wind patterns, season and specific emission types and levels.

The Health and Air Pollution in New Zealand (HAPiNZ) study showed a correlation between increased levels of air pollution and adverse health effects (Fisher et al 2007). The study estimated that, in 2001, air pollution from domestic, vehicular and industrial sources such as PM_{10} and CO accounted for 1079 cases of premature mortality, 1544 cases of chronic obstructive pulmonary disease and 703 extra hospitalisations for respiratory and cardiac problems for those over 30 years old. The study also estimated an increase of 4.8% in the national average mortality rate due to air pollution. The annual cost of air pollution in New Zealand due to health effects and mortality was estimated to be $1.14 billion (Fisher et al 2007).

The National Environmental Standards for Air Quality were introduced in 2004 (and revised in 2005) under the Resource Management Act 1991. These standards set national thresholds for concentrations of five air pollutants: CO, NO_2, O_3, PM_{10} and SO_2 (Table 2). The standards are consistent with the WHO's global guidelines published in 2006, based on extensive scientific evidence on the human health effects associated with air pollution (WHO 2006b). However, it should be noted that research has yet to identify thresholds below which adverse effects do not occur, and therefore these standards cannot fully protect human health (WHO 2006b).

Table 2: National Environmental Standards for Air Quality in New Zealand

Contaminant	Threshold concentration	Averaging period for measurements	Duration of permissible excess
Carbon monoxide (CO)	10 mg/m^3	8-hour running average	One 8-hour period in any 12-month period
Nitrogen dioxide (NO_2)	200 µg/m^3	1-hour average	9 hours in any 12-month period
Ozone (O_3)	150 µg/m^3	1-hour average	Not to be exceeded
Particulate matter (PM_{10})	50 µg/m^3	24-hour average	One 24 hour period in any 12-month period
Sulphur dioxide (SO_2)	350 µg/m^3	1-hour average	9 hours in any 12-month period
	570 µg/m^3	1-hour average	Not to be exceeded

Source: Resource Management (National Environmental Standards Relating to Certain Air Pollutants, Dioxins, and Other Toxics) Regulations 2004

The main indicator for air quality in New Zealand is PM_{10}, as local research has suggested that the greatest health effect for air pollutants is the long-term exposure to particulate matter (Fisher et al 2007). For this report, PM_{10} monitoring data have been presented for 2009 for 40 monitored airsheds throughout New Zealand. PM_{10} is highly correlated with other air pollutants, which may also have health effects. In the report, monitoring data for CO, NO_2 and SO_2 have also been presented for the main centres in New Zealand where available.

When considering the health effects from air pollution, indoor air pollution must also be considered, as humans are estimated to spend 80% of their time indoors, including in the home and workplace (Public Health Advisory Committee 2002). Indoor air pollution is associated with exacerbation of respiratory conditions, as well as allergic reactions (Public Health Advisory Committee 2002). Causes of indoor air pollution include second-hand tobacco smoke, NO_2 from unvented gas appliances, dust mite allergens and poor quality housing (Public Health Advisory Committee 2002). Children are particularly susceptible to respiratory morbidity due to second-hand smoke in the home (Neas et al 1994; Mommers et al 2005). For this reason, this report includes an indicator on exposure to second-hand smoke in the home.

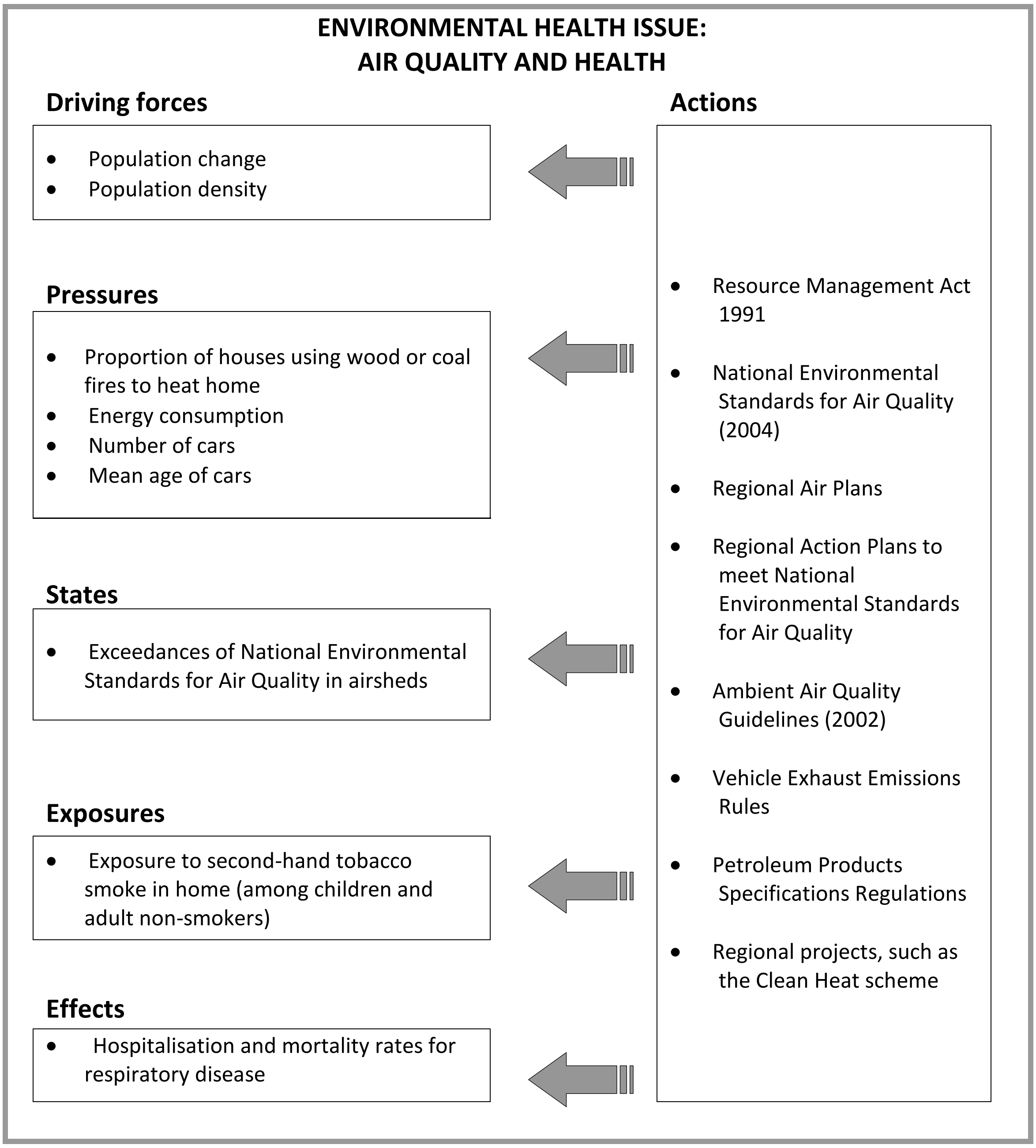
Overview of indicators

The following key indicators for the environmental health issues of air quality and health were selected:

- state: exceedance of the National Environmental Standards for Air Quality
- exposure: exposure to second-hand tobacco smoke in the home (among children and adult non-smokers)
- effects: respiratory hospitalisations and mortality

Figure 27 shows how these indicators fit into the DPSEEA framework, and illustrates the related driving force and pressure indicators. It should be noted that the current report can only identify areas of interest, possible areas for further research, and the actions that are currently being taken to improve air quality. It does not fully investigate the complex relationships among sources of air pollution, air quality and health.

Figure 27: The DPSEEA framework for air quality environmental health indicators



State indicator: Exceedance of National Environmental Standards for Air Quality

Indicator Exceedance of National Environmental Standards for Air Quality for particulate matter (PM_{10}), carbon monoxide (CO), sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) in airsheds

Relevance of indicator

The indicator examines exceedances of National Environmental Standards for Air Quality, for four air pollutants: PM_{10}, CO, NO_2 and SO_2. The national environmental standards for these pollutants are consistent with the 2005 WHO global guidelines, which are based on robust epidemiological research in order to protect human health (WHO 2006a).

Particulate matter with a diameter of less than 10 micrometres (PM_{10}) can penetrate far into the human lung. Most poor air quality in New Zealand is caused by high winter levels of PM_{10} from coal and wood used in home heating (Ministry for the Environment 2010a). Auckland also experiences high levels of PM_{10} from road transport (Ministry for the Environment 2007). Particulates are also produced from atmospheric reactions of SO_2, nitrogen oxides and organic compounds (Cromar et al 2004), and natural sources such as dust, pollen, ash, sea salt and soil particles (Fisher et al 2007).

Short-term and long-term exposures to PM_{10} have predominantly been associated with the exacerbation of respiratory and cardiovascular conditions (WHO 2006a). In New Zealand, a $10 \mu g/m^3$ increase in daily PM_{10} levels, after a one-day lag, was associated with a 1% increase in all-cause mortality and a 4% increase in respiratory mortality among people aged over 30 years (Hales et al 2000). Furthermore, each $10 \mu g/m^3$ increase in annual average PM_{10} concentration was associated with a 4.3% increase in annual mortality for people aged over 30 years (Kunzli et al 2000; Fisher et al 2002). Population groups most affected by PM_{10} include children with asthma and elderly people with respiratory and cardiovascular disease (Fisher et al 2007).

The New Zealand National Environmental Standards for Air Quality set a maximum 24-hour PM_{10} threshold concentration of $50 \mu g/m^3$, while the national guideline sets a guideline annual average value of $20 \mu g/m^3$ for PM_{10}. These concentrations are consistent with WHO guidelines. However, health effects have been shown at low concentrations only just above background (natural sources) levels (WHO 2003b, 2006a).

In addition, other air pollutants such as NO_2, SO_2 and CO may contribute to poor air quality. Sources of NO_2 that are related to human activities include the combustion of fossil fuels (coal, oil and gas) and commercial manufacturing. NO_2 is often found with a number of other air pollutants. Studies have suggested that NO_2 is a toxic gas with health effects at a concentration of $200 \mu g/m^3$ or greater (WHO 2006a). For this reason, the WHO guideline (and New Zealand national environmental standard for NO_2) has been set at a one-hour maximum concentration of $200 \mu g/m^3$.

Short-term exposure to high concentrations of SO_2 has been shown to have health effects such as respiratory symptoms, particularly for asthmatics. The National Environmental Standards for Air Quality have set a maximum concentration of 350 μg/m^3 for SO_2.

CO is also associated with health effects ranging from respiratory, neurobehavioral effects at low concentration (10 ppm) to unconsciousness and death after prolonged or acute exposure to high concentration of CO (> 500 ppm). It has a maximum concentration of 10 mg/m^3 per eight hours according to the National Environmental Standards for Air Quality.

Data source

Regional councils and unitary authorities are required to monitor ambient air quality in airsheds, to ensure they comply with the National Environmental Standards for Air Quality. The data presented were obtained from the Ministry for the Environment, which is responsible for collating the national data.

Airsheds are defined as populated areas that are known or likely to breach air quality standards, and are gazetted for the purposes of managing air quality. This report presents data on PM_{10} levels from 44 monitored airsheds across the country (Ministry for the Environment 2010a). PM_{10} data have been presented in three ways:

- the annual maximum 24-hour concentration of PM_{10} for each airshed (to indicate short-term exposure levels)
- the annual number of exceedances of the threshold level of PM_{10} (50μg/m^3) for each airshed
- the annual average PM_{10} concentration for each airshed (to indicate long-term exposure levels).

For the PM_{10} monitoring presented, some airsheds include a number of towns or cities. The Auckland airshed includes the Auckland urban area, North Shore and Whangaparaoa. The Otago 1 airshed includes Alexandra, Arrowtown, Clyde, Cromwell, Naseby, Ranfurly and Roxburgh. The Mosgiel airshed (Otago 2) includes South Dunedin, Green Island, Mosgiel, Milton and Palmerston. The Dunedin airshed (Otago 3) includes North Dunedin, Central Dunedin, Port Chalmers, Balclutha, Waikouaiti and Oamaru.

This report presents data on the population living within airsheds that exceeded the National Environmental Standards for Air Quality for PM_{10}. Further population data for airsheds are provided in Appendix B.

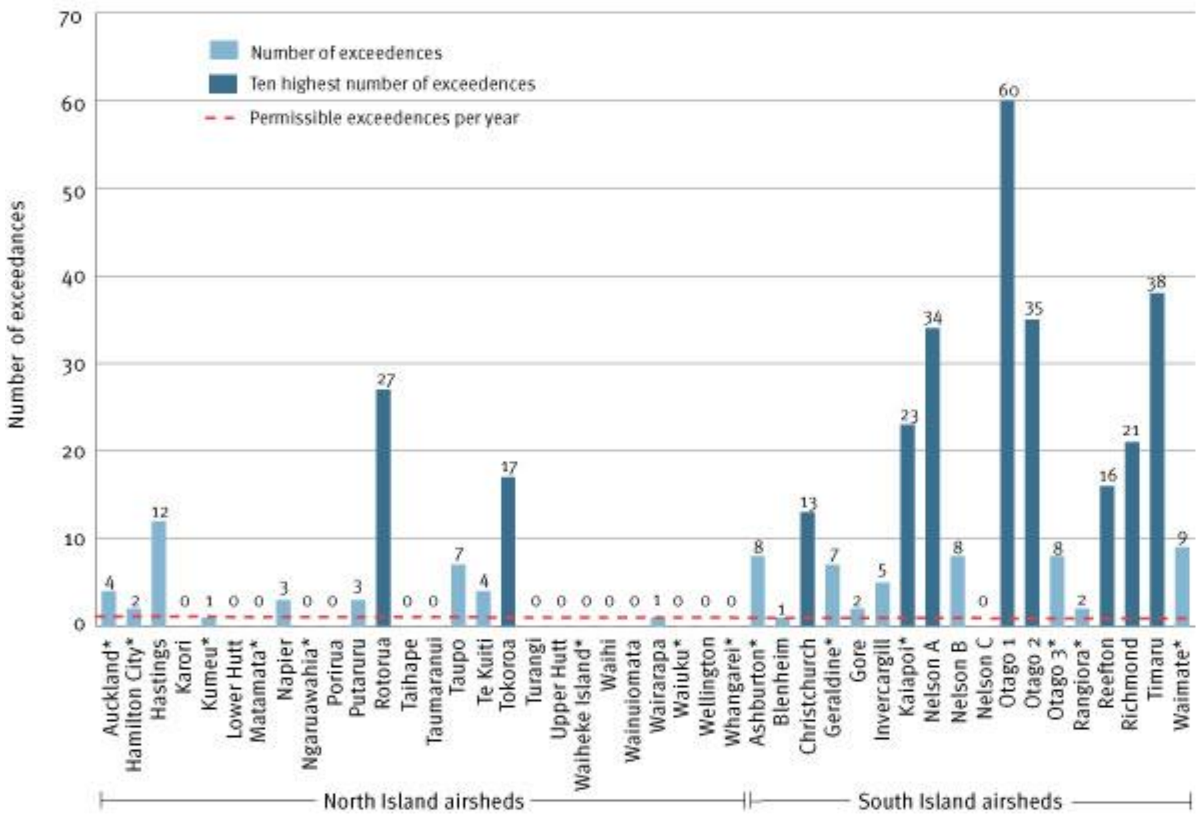
Where available, monitoring data have also been presented for NO_2, SO_2 and CO at specific monitored sites in Auckland, Hamilton, Wellington and Christchurch.

Results

Particulate matter (PM_{10})

Overall, nine of the 26 airsheds in the North Island, and 17 of the 18 South Island airsheds breached the PM_{10} standard in 2009 (four more airsheds than in 2008) by exceeding the PM_{10} standard more than once in the year (Figure 28). In 2009 the Otago 1 airshed exceeded the national standard for PM_{10} most often (60 exceedance days), which was less than 2008 (91 exceedance days) but up from 51 in 2005 and 2006 and 55 in 2007. Timaru (38), Rotorua (27), Otago2 (35) and Nelson A (34) airsheds also exceeded the national standard frequently in 2009.

Figure 28: Number of exceedances of the National Environmental Standards for Air Quality for PM_{10}, 2009

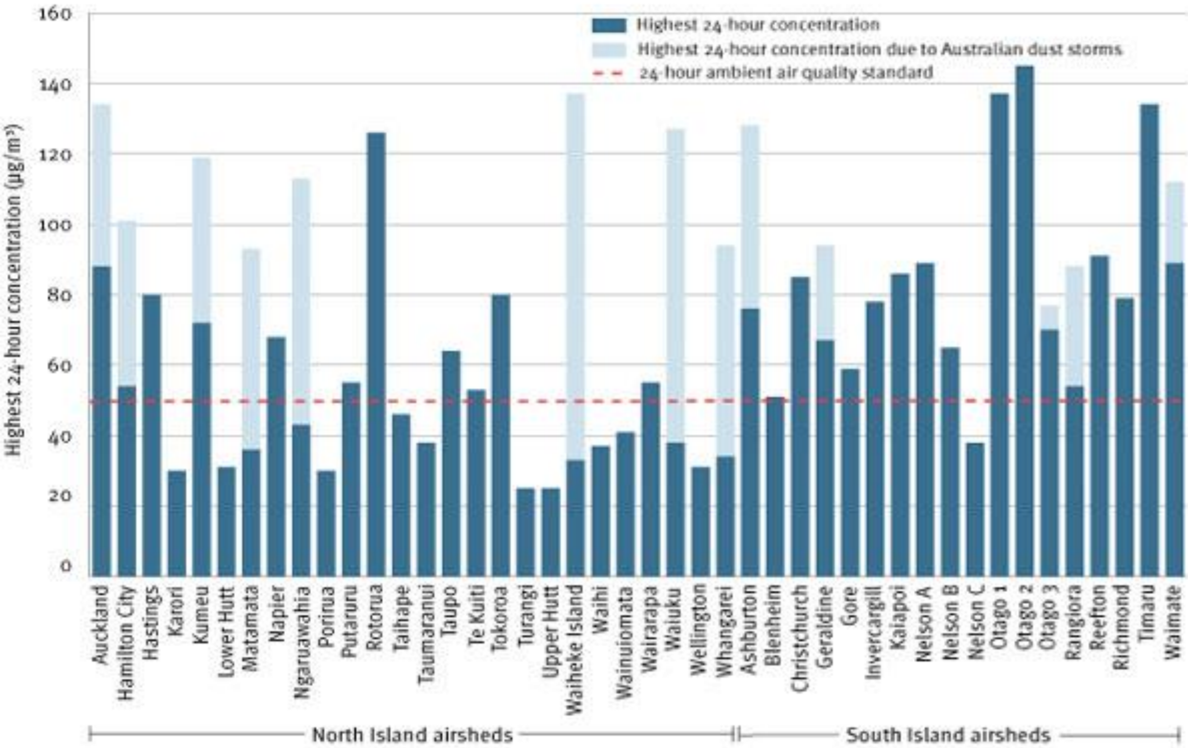


Note: The broken line represents the maximum number of exceedance days allowed (one day per year) under the National Environmental Standards for Air Quality.

Source: Ministry for the Environment (2010a)

Figure 29 presents, for each of the 44 monitored airsheds, the maximum 24-hour PM_{10} concentration in 2009. Twenty-eight of the 44 monitored airsheds recorded a maximum 24-hour PM_{10} concentration exceeding the national environmental standard of 50 µg/m³. The highest recorded 24-hour concentration of PM_{10} was 145 µg/m³ in the Mosgiel (Otago 2) airshed, almost more than three times the national environmental standard.

Figure 29: Maximum PM_{10} levels (24-hour concentration) in airsheds, 2009

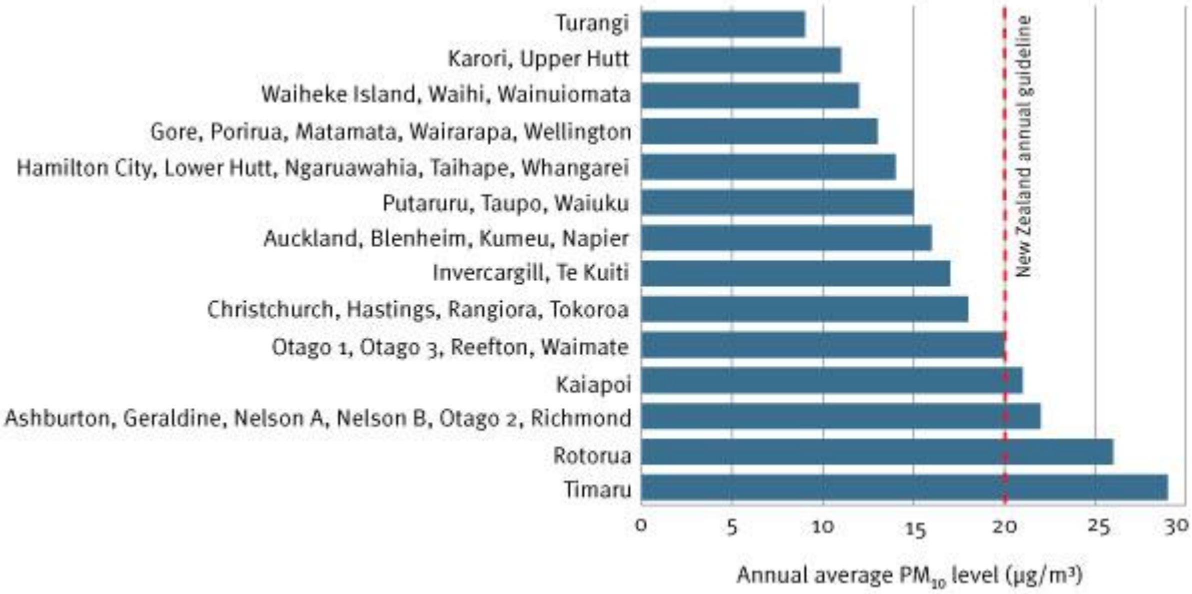


Note: The broken line represents the maximum highest 24 hour concentration of PM_{10} (50 μg/m^3) allowed under the National Environmental Standards for Air Quality. Under the standards, airsheds may exceed the PM_{10} standard once a year.

Source: Ministry for the Environment (2010a)

Figure 30 presents the average annual PM_{10} levels in 2009 for 42 of the 44 monitored airsheds that were able to monitor an annual average for PM_{10}. The annual guideline level of 20 μg/m^3 was exceeded in one airshed in the North Island (Rotorua - 26 μg/m^3) and in 8 airsheds in the South Island (Nelson A (22 μg/m^3), Nelson B (22 μg/m^3), Richmond (22 μg/m^3), Kaiapoi (21 μg/m^3), Ashburton (22 μg/m^3), Geraldine (22 μg/m^3), Timaru (29 μg/m^3) and Otago 2 (22 μg/m^3)), amounting to three less airsheds than in 2008.

Figure 30: Annual average PM_{10} levels in airsheds, 2009



Notes: An asterisk (*) indicates that there were insufficient valid data for averaging. The horizontal broken line represents the average annual concentration of PM_{10} (20 $\mu g/m^3$) allowed under the ambient air quality guidelines.

Source: Ministry for the Environment (2010a)

Data about the estimated usually resident population living within the airshed in 2006 have been included to indicate the population exposed. For more data about the population living in airsheds, see Appendix B.

Table 3 shows that the Otago 1 airshed had the highest number of days of exceedance. However, the Auckland airshed had the largest population living in an airshed that had breached the National Environmental Standards for Air Quality for PM_{10}, followed by the Timaru airshed.

Table 3: Airsheds exceeding National Environmental Standards for Air Quality for PM_{10}, 2009, and usually resident population in airsheds, 2006

Airshed	Number of days of PM_{10} exceedance	Highest 24-hour concentration of PM_{10} ($\mu g/m^3$)	Annual average PM_{10} concentration ($\mu g/m^3$)	Estimated usually resident population, 2006
Auckland	4	134	16	1,159,860
Hamilton	2	101	14	129,249
Putaruru	3	55	15	3760
Rotorua	27	126	26	45,600
Tokoroa	17	80	18	13,020
Te Kuiti	4	53	17	4420
Taupo	7	66	15	18,800
Napier	3	68	16	33,140
Hastings	12	80	18	26,350
Wairarapa	1	55	13	35,420
Nelson A	34	89	22	9030
Nelson B	8	65	22	20,160
Richmond	21	79	22	12,410
Blenheim	1	51	16	22,570
Reefton	16	91	20	1020
Rangiora	2	88*	18	11,500
Kaiapoi	23	86	21	8360
Christchurch	13	85	18	334,170
Ashburton	8	128*	22	13,780
Geraldine	7	94*	22	2380
Timaru	38	134	29	25,420
Waimate	9	112*	20	3066
Otago 1	60	137	20	14,220
Dunedin	8	77*	20	75,420
Mosgiel	35	145	22	50,430
Gore	2	59	13	7638
Invercargill	5	78	17	41,810

Source: Ministry for the Environment; Statistics New Zealand

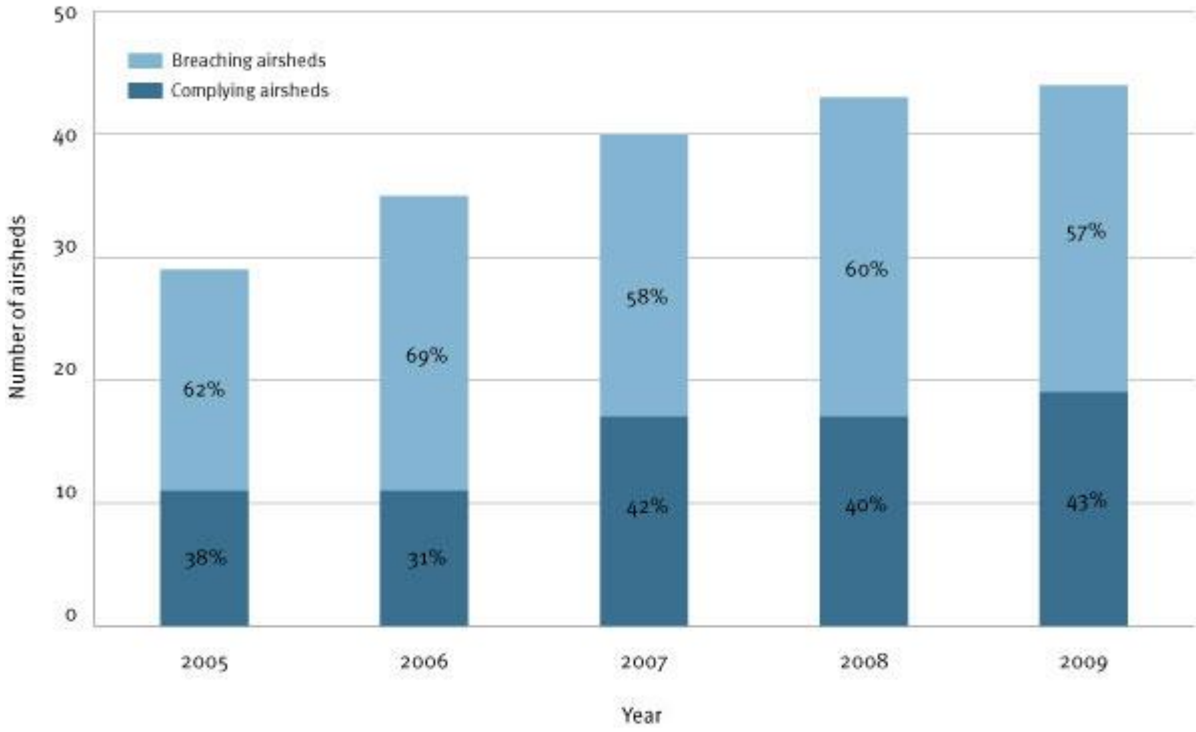
* The highest 24-hour average value for this airshed was due to transboundary pollution from Australian dust storms. The exceedance due to this event has not been included in this table.

Overall, 13 DHBs had at least one airshed exceeding the National Environmental Standards for Air Quality for PM_{10} in 2008:

- Waitemata (Auckland airshed)
- Auckland (Auckland airshed)
- Counties Manukau (Auckland airshed)
- Waikato (Putaruru, Hamilton, Tokoroa and Te Kuiti airsheds)
- Lakes (Rotorua and Taupo airsheds)
- Hawke's Bay (Napier and Hastings airsheds)
- Wairarapa (Wairarapa airshed)
- Nelson-Marlborough (Nelson A, Nelson B, Richmond and Blenheim airsheds)
- West Coast (Reefton airshed)
- Canterbury (Rangiora, Kaiapoi, Christchurch and Ashburton airsheds)
- South Canterbury (Geraldine, Waimate and Timaru airsheds)
- Otago (Otago 1, Dunedin and Mosgiel airsheds) and Southland (Invercargill and Gore airsheds).

Figure 31 shows that the proportion of airsheds breaching the PM_{10} standard was higher in 2008 (60%) than in 2009 (57%), but lower than in 2005 and 2006. For all years, fewer than half of the airsheds complied with the PM_{10} standard.

Figure 31: Compliance with the PM_{10} standard, 2005–09



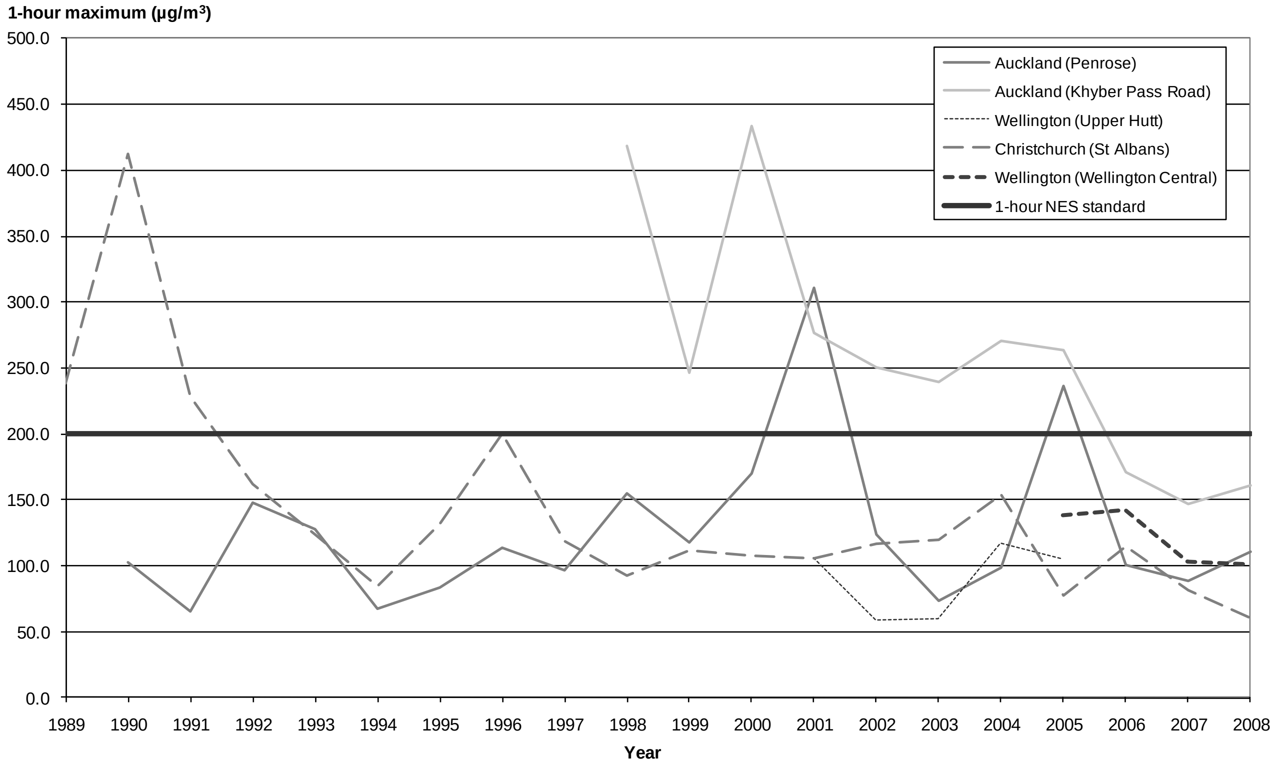
Source: Ministry for the Environment (2010a)

Nitrogen dioxide (NO_2)

Figure 32 presents the one-hour maximum levels of nitrogen dioxide at sites in Auckland, Wellington and Christchurch, and compares each one with the national environmental standard of 200 μg/m^3 (measured as a one-hour average). The standard may be exceeded nine times per year.

The maximum levels have fluctuated over time, but they have decreased in Christchurch (St Albans) since 1991 and in Auckland (Khyber Pass Road) since 2000. However, in 2001 and 2005 the maximum one-hour NO_2 concentration at one Auckland site (Penrose) increased sharply, exceeding the level set in the National Environmental Standards for Air Quality. Maximum one-hour NO_2 concentrations at the Auckland site of Khyber Pass Road consistently exceeded the national environmental standard up until 2005, after which levels dropped below the standard.

Figure 32: Nitrogen dioxide (NO_2) one-hour maximum levels in four monitored airsheds, 1989–2008

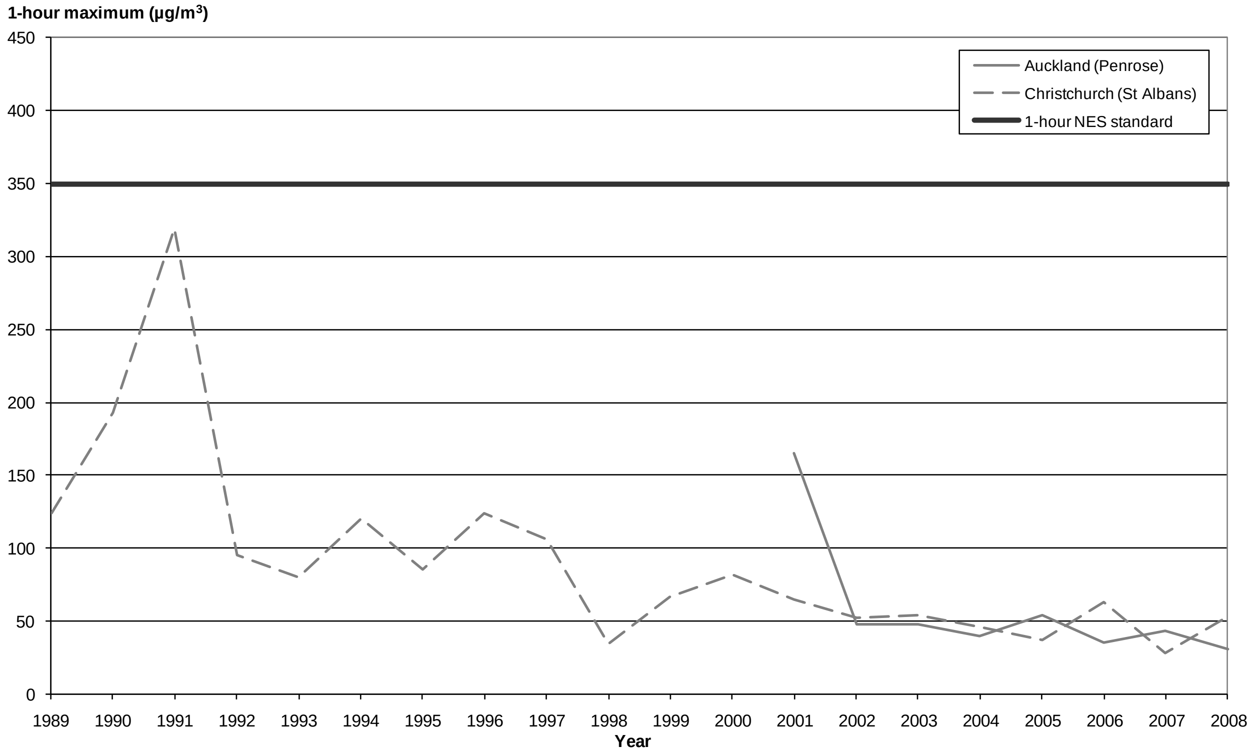


Source: Ministry for the Environment (2010b)

Sulphur dioxide (SO_2)

Figure 33 compares the one-hour maximum levels of sulphur dioxide at sites in Auckland and Christchurch with the national environmental standard of 350 µg/m^3 (measured as a one-hour average). Since 1991 the maximum levels of SO_2 in Christchurch have decreased considerably. The Auckland and Christchurch sites have consistently met the national environmental standard for SO_2.

Figure 33: Sulphur dioxide (SO_2) one-hour maximum levels in two monitored airsheds, 1989–2008



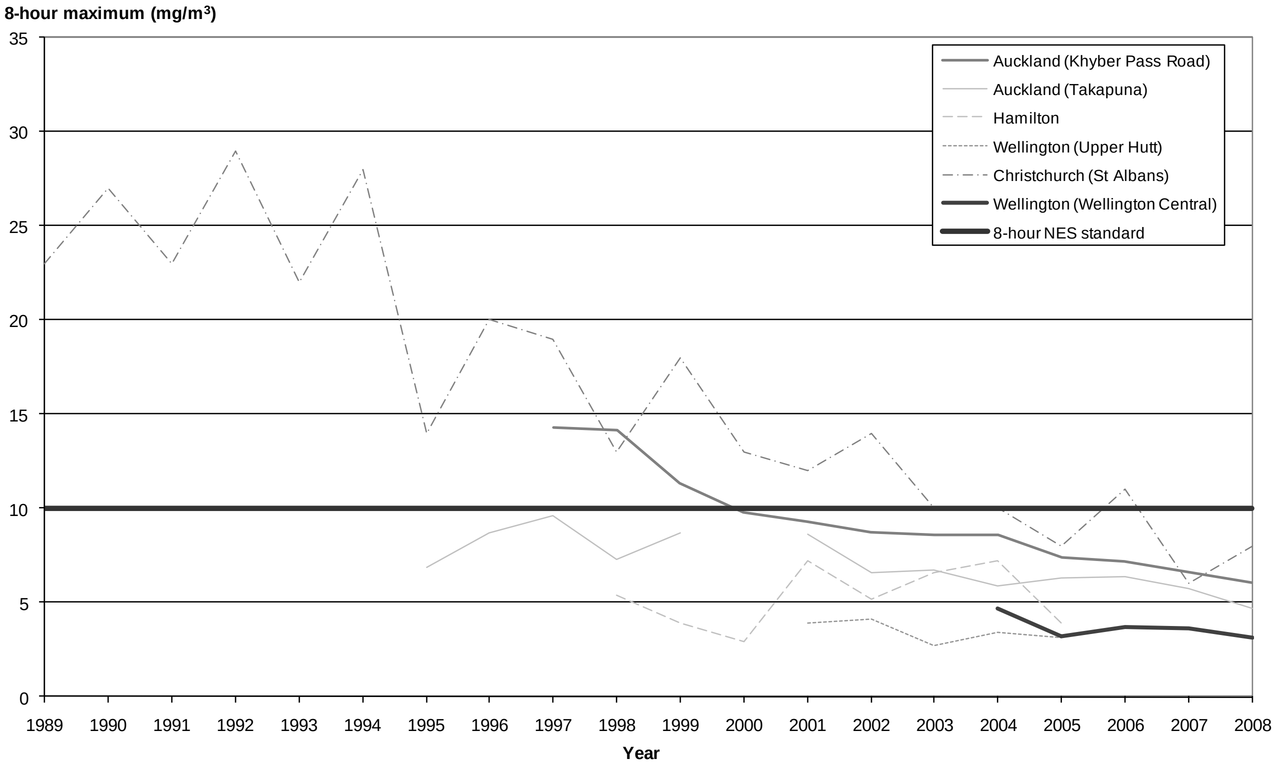
Source: Ministry for the Environment (2010b)

Carbon monoxide (CO)

Figure 34 compares the eight-hour maximum levels of carbon monoxide at sites in Auckland, Hamilton, Wellington and Christchurch with the national environmental standard of 10 mg/m^3 (measured as a running eight-hour average).

In 2008 all six sites met the national environmental standard for CO. Between 2003 and 2008 there has only been one exceedance (in the St Albans airshed in Christchurch in 2006) of the standard for CO.

Figure 34: Carbon monoxide (CO) eight-hour maximum levels in five monitored airsheds, 1989–2008



Source: Ministry for the Environment (2010b)

Exposure indicator: Exposure to second-hand tobacco smoke in the home

Indicator Proportion of children and non-smoking adults exposed to second-hand smoke in their house

Relevance of indicator

Indoor air quality is important as humans are estimated to spend approximately 80% of their time indoors (Public Health Advisory Committee 2002). A key source of indoor air pollution in New Zealand is exposure to second-hand tobacco smoke from either the air exhaled by the smoker or from the smoke burning at the end of the cigarette.

Exposure to second-hand smoke has health effects such as chest infections, severe asthma, ear infections, sudden infant death syndrome (SIDS) and premature death in children (US Department of Health and Human Services 2006). Studies have also shown that non-smoking adults who are exposed to second-hand smoke have an increased risk of lung cancer and ischaemic heart disease (US Department of Health and Human Services 2006).

Data source

The data are from the 2006/07 New Zealand Health Survey (NZHS) carried out from September 2006 to December 2007 (Ministry of Health 2008c). Data were collected on exposure to second-hand smoke in the home, among children (aged 0–14 years) and non-smoking adults (aged 15 years and over). Non-smokers were defined as adults who were not currently smoking tobacco (including ex-smokers) at the time of the survey.

Estimates have been provided by DHB area, but some DHBs were combined for analysis due to small sample sizes. Results are presented as prevalence estimates with 95% confidence intervals, and have not been adjusted for age, thereby reflecting the true burden of exposure.

Results

Overall, one in 10 children (9.6%) aged 0–14 years was exposed to second-hand smoke in their home in New Zealand. Additionally, one in 15 non-smoking adults in New Zealand was exposed to second-hand smoke in their home.

The DHB areas with exposure rates among children that were significantly higher than the national average were: Waikato and the combined area of Northland, Tairawhiti, Hawke's Bay, Lakes and Whanganui (Table 4).

DHBs with significantly lower rates than the national average were: Waitemata (for children), Auckland (for children and non-smoking adults) and Canterbury (for non-smoking adults).

Table 4: Exposure to second-hand smoke for children and non-smoking adults in their home, 2006/07, by DHB area, unadjusted prevalence

DHB area	Prevalence in children (0–14 years) (95% confidence interval)	Prevalence in non-smoking adults (15+ years) (95% confidence interval)
Northland, Tairawhiti, Hawke's Bay, Lakes and Whanganui	13.1 (10.2–16.1)	8.1 (6.1–10.0)
Waitemata	5.2 (3.0–7.4)	8.5 (6.4–10.7)
Auckland	5.4 (3.0–8.9)	4.9 (3.1–6.7)
Counties Manukau	7.8 (5.2–10.3)	9.3 (7.0–11.5)
Waikato	14.8 (10.8–18.8)	9.0 (6.5–11.5)
Bay of Plenty, Taranaki and MidCentral	11.8 (8.6–14.9)	8.5 (6.3–10.7)
Wairarapa, Hutt Valley and Capital & Coast	7.3 (4.5–10.2)	7.3 (5.0–9.6)
Canterbury	7.2 (4.3–11.4)	4.8 (3.0–6.6)
Nelson Marlborough, West Coast, South Canterbury, Otago and Southland	13.6 (8.6–18.6)	7.9 (5.2–10.6)
New Zealand	9.6 (8.6–10.6)	7.5 (6.9–8.2)

Notes: Data are based on direct survey estimates and could be confounded by different population characteristics in each DHB. Due to small sample size, some DHB areas have been combined.
Source: Ministry of Health (2008c)

People living in areas of higher socioeconomic deprivation had higher exposure to second-hand smoke than people in other areas. There were also significantly higher rates of second-hand smoke exposure among Māori compared with non-Māori. One in five Māori children were exposed to second-hand smoke in their home.

Effects indicator: Respiratory disease

Indicator	Hospitalisations for respiratory disease, rate per 100,000

Air quality is a key environmental health issue associated with respiratory disease. In developed countries, it is estimated that around 20% of lower and 12% of upper respiratory infections are caused by indoor and outdoor air pollution (Prüss-Üstün and Corvalán 2006). Furthermore, existing respiratory conditions can be exacerbated by short and long-term exposure to particulate and gaseous air pollution, especially among the young and old (Briggs 1999). Outdoor and indoor air pollutants are some of the main risk factors for chronic respiratory disease (Bousquet et al 2007).

It has been shown that short-term air pollution events can lead to an excess mortality rate, such as during the London smog of December 1952. More recently, studies have shown increases in respiratory mortality due to air pollution in certain cities (Dab et al 1996; Touloumi et al 1996). Other studies have indicated correlations between high exposure areas and high mortality rates from acute lung injury (Knox 2008). Furthermore, long-term exposure to black smoke and SO_2 has been associated with respiratory mortality (Elliott et al 2007; Beelen et al 2008). Certain population groups are at increased risk of death, including children (Gauderman 2006) and elderly people with respiratory disease (Cromar et al 2004).

A Christchurch study found an increase in respiratory hospitalisations after elevated air pollution days (McGowan et al 2002). The Health and Air Pollution in New Zealand (HAPiNZ) study of people aged 30 years and older estimated that there were 465 acute respiratory admissions in 2001 due to air pollution (Fisher et al 2007). The study also found that in Auckland, there was an estimated 35% increase in respiratory deaths per 10 μg/m³ increase in PM_{10} concentrations, among adults aged over 30 years (Fisher et al 2007).

The indicator examines the age-standardised hospitalisation and mortality rates for respiratory disease from 2000 to 2007. No adjustment has been made for confounding factors such as individual behaviour, smoking status and pollutant levels.

The spatial analysis of the indicator for children aged 0–4 years excludes the effect of smoking, as smoking is likely to contribute to the burden of respiratory disease in New Zealand among adults, but does not account for exposure to second-hand smoke.

Data source

Respiratory disease hospitalisations and mortality data were sourced from the National Minimum Dataset (NMDS) and New Zealand Mortality Collection respectively. The NMDS records national public and private hospital discharge information, and the Mortality Collection holds data on all mortality in New Zealand (Ministry of Health 2008b). Hospitalisation data were available for the years 2000–2007, and mortality data for 2000–2005. For this analysis, respiratory disease included ICD-10-AM codes J00–J99 (National Centre for Classification in Health 1998).

Age-standardised rates and age-specific rates are presented per 100,000 population. For DHB analyses, rates were calculated using the mid-year population estimates as the denominators. The analyses presented in this report only included cases that resided in one of the 20 DHBs.

Results

There were significant decreases in the age-standardised hospitalisation and mortality rates from 2004 to 2005, and a significant decrease in the age-standardised hospitalisation rate from 2006 to 2007 (Table 5).

Table 5: Annual respiratory hospitalisations and mortality among total New Zealand population, 2000–2007, age-standardised rate per 100,000

	Hospitalisations		Mortality	
Year	Number of hospitalisations	Age-standardised rate per 100,000 (95% confidence interval)	Number of deaths	Age-standardised rate per 100,000 (95% confidence interval)
2000	50,926	1,252 (1,241–1,262)	1,967	30.7 (29.4–32.1)
2001	53,108	1,286 (1,275–1,297)	2,341	35.1 (33.7–36.6)
2002	52,524	1,263 (1,252–1,274)	2,307	33.9 (32.6–35.3)
2003	53,448	1,268 (1,258–1,279)	2,352	34.0 (32.7–35.5)
2004	53,948	1,270 (1,259–1,280)	2,462	35.0 (33.7–36.4)
2005	52,167	1,241 (1,231–1,252)	2,147	30.5 (29.2–31.8)
2006	54,529	1,282 (1,271–1,292)	2,342	31.7 (NA)
2007	53,862	1,266 (1,255–1,277)	NA	NA

Notes: NA – data not available. Age-standardised to the WHO world standard population (Ahmad et al 2000).
Source: National Minimum Dataset and New Zealand Mortality Collection, Ministry of Health (2007)

Table 6 presents the age-specific (unadjusted) rates per 100,000 for hospitalisations for respiratory disease by age group for 2007. There rates of hospitalisations for respiratory disease were significantly higher among young children (aged 0–4 years) and older people (aged 65 years and over) than among any other age group.

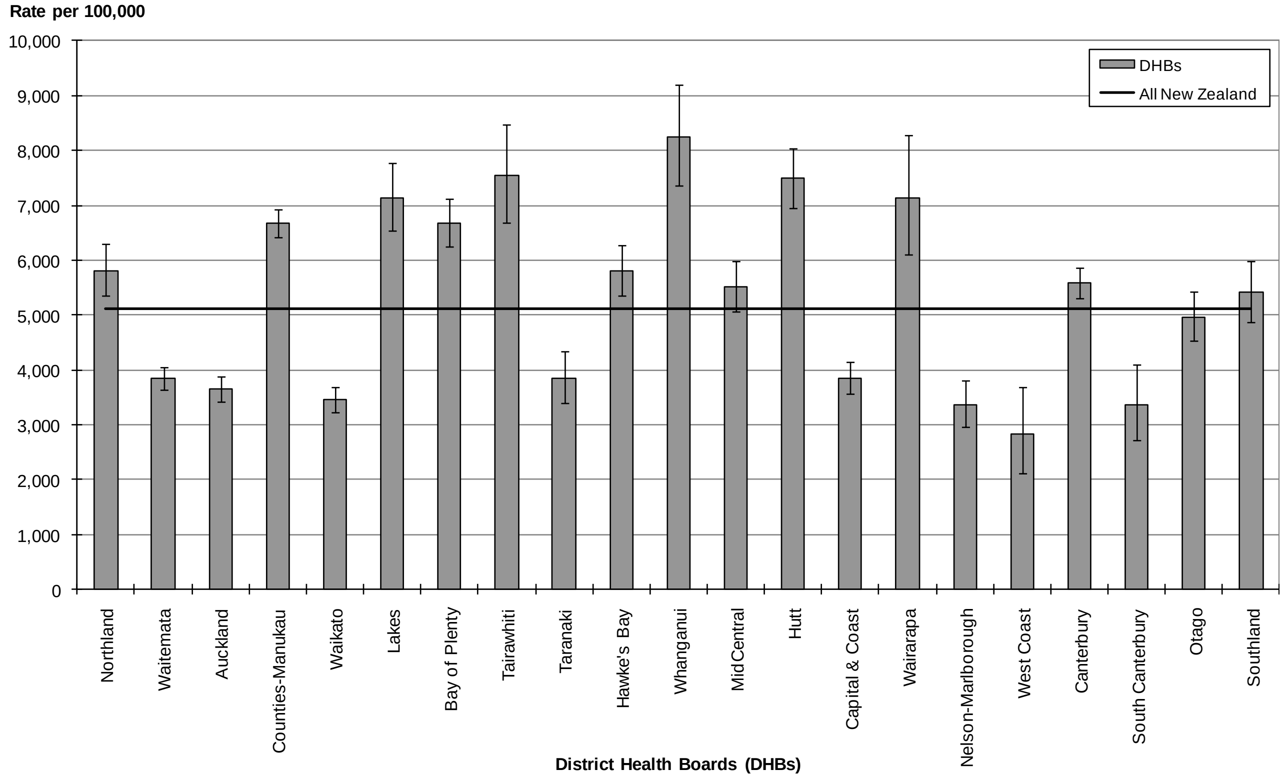
Table 6: Respiratory hospitalisations by age group, 2007, unadjusted rate per 100,000

Age group	Rate per 100,000 (95% confidence interval)
0–4 years	5120 (5036–5205)
5–14 years	882 (858–906)
15–44 years	534 (523–545)
45–64 years	814 (797–832)
65 years and over	3332 (3282–3383)

Source: National Minimum Dataset, Ministry of Health (2007)

DHBs with significantly high rates of respiratory disease hospitalisations for children aged 0–4 years in 2007 were: Northland, Counties Manukau, Lakes, Bay of Plenty, Tairawhiti, Hawke's Bay, Whanganui, Hutt, Wairarapa and Canterbury (Figure 35).

Figure 35: Respiratory hospitalisations among children aged 0–4 years, by District Health Board, 2007, unadjusted rate per 100,000



Source: National Minimum Dataset, Ministry of Health (2008b)

Actions relating to air quality and health indicators

This section outlines the actions that are relevant to addressing the environmental issue of air quality and health in New Zealand. In general, these actions focus on improving ambient air quality to prevent disease.

Resource Management Act 1991

The Resource Management Act 1991 (RMA) is at the core of environmental health legislation in New Zealand. Air quality management under the RMA is directly impacted by:

- the different approaches that regional councils/unitary authorities (eg, for discharges to air (section 15)) and TAs (eg, for the effects of land use and subdivision, which can also impact on air quality) have in managing air quality effects
- the need for regional councils/unitary authorities to comply with the National Environmental Standards for Air Quality.

For pollutants (and time averaging periods) not covered by the standards, the Ambient Air Quality Guidelines (Ministry for the Environment 2002) provide the minimum requirements for outdoor air quality to protect human health and the environment.

Ambient Air Quality Guidelines

Guideline values are the minimum requirements that outdoor air quality should meet to protect human health and the environment (Ministry for the Environment 2002). In New Zealand, the

Ambient Air Quality Guidelines were introduced in 1994 and updated in 2002 (Ministry for the Environment 2002).

The Ambient Air Quality Guidelines set guideline values for the following: carbon monoxide, PM_{10}, nitrogen dioxide, sulphur dioxide, ozone, lead, hydrogen sulphide, benzene, 1,3 butadiene, formaldehyde, acetaldehyde, benzo(a)pyrene, mercury, chromium and arsenic. These are health-based guideline values that aim to protect people's health and wellbeing (Ministry for the Environment 2002). Efforts should be made to manage air quality if levels exceed the values, for example by reducing emissions.

National Environmental Standards for Air Quality

Between October 2004 and September 2005 the National Environmental Standards for Air Quality introduced 14 standards comprising:

- five ambient air quality standards for CO, NO_2, O_3, PM_{10} and SO_2
- seven standards banning activities that discharge significant quantities of dioxins and other toxins into the air (October 2004)
- a design standard for new wood burners installed in urban areas (September 2005); the standard requires wood burners to meet an emission limit of less than 1.5 g/kg (grams of particulate per kilogram of wood burnt) and an efficiency rate of greater than 65%
- a requirement for landfills of over 1 million tonnes of refuse to collect the greenhouse gas emissions resulting from the refuse and to flare or use as fuel (October 2004).

Regional councils and local authorities are responsible for enforcing these standards and, in some cases, can impose stricter standards (Ministry for the Environment 2008a). As at December 2009, the Minister for the Environment had gazetted 71 airsheds for the purposes of managing air quality on behalf of regional councils and unitary authorities in the *New Zealand Government Gazette*. All gazetted airsheds, except one, have been gazetted for the purpose of managing PM_{10}. The exception is the Marsden Point airshed which is gazetted for the management of sulphur dioxide (SO_2). Forty-three airsheds are continuously monitored for PM_{10}.

Reducing air pollution from transport

Several transport initiatives have been implemented to reduce vehicle emissions in New Zealand, in particular focusing on improving the quality of fuel and vehicles.

- It has been illegal to sell leaded petrol since 1996 (Ministry for the Environment 1997).
- The Engine Fuel Specification Regulations 2008 (which replaced the earlier Petroleum Products Specifications Amendment Regulations 2003) specify the technical requirements for all fuels, including petrol and diesel supplied for retail sale. These regulations have reduced pollutants that are emitted from a vehicle, such as PM_{10} and benzene, and reduced aromatics and vapour pressure (Ministry for the Environment 2007).
- The sulphur content in diesel has reduced 60-fold since 2001 from 3000 parts per million to 50 parts per million (Ministry for the Environment 2006). The reductions in sulphur levels in diesel fuel supplies have also allowed vehicles built to the most recent and most stringent international emissions standards (Euro 4 and Euro 5 for example) to operate out on our roads.

Measures that have been or are currently being implemented include measures to:

- improve individual vehicle performance, such as introducing progressive emissions standards for vehicles first entering the vehicle fleet and prohibiting the modification of the emissions controls on vehicles imported since May 2008
- require a visible smoke check for all vehicles as part of the warrant or certificate of fitness inspection to target the very worst vehicles
- improve traffic conditions, such as measuring the effect of different traffic management techniques on traffic emissions from busy roads
- improve air quality, such as developing consistent methods to measure and monitor local air quality (Ministry for the Environment 2010a).

Regional actions to reduce air pollution

Since 2004 a number of initiatives have been implemented at the regional level to meet national environmental standards. All regional councils have a 24-hour response team that investigates public complaints about air quality.

The Clean Heat project offers households a free energy audit of their homes, and provides assistance to low-income homeowners to replace open fires and burners with cleaner heating options to upgrade housing insulation (Environment Canterbury 2006; Otago Regional Council 2006; Ministry for the Environment 2007; Tasman District Council 2007). The Nelson City Council and Tasman District Council operate a Good Wood Scheme, which encourages firewood suppliers to sell only dry wood, and the Smoke Patrol, which identifies excessively smoky fires and offers improvement advice (Ministry for the Environment 2007).

Other air quality improvement programmes for transport have been introduced on a local scale, often where environmental pressures are the highest. For example, the Auckland Regional Council has implemented transport-related projects, in response to large volumes of traffic (Ministry for the Environment 2007).

Discussion

Studies have shown that air pollutants can cause and/or exacerbate human health effects, including respiratory problems. Although New Zealand does not have a major air pollution problem by international standards, two-thirds of the population live in areas that can experience poor air quality (Ministry for the Environment 2010a and 2010b).

Driving forces and pressures on air quality

The main pressure on air quality in New Zealand is the type of heating used in homes, with wood and coal heating being the major contributors to air pollution (Ministry for the Environment 2010a). In part, this is driven by the New Zealand housing stock, which is generally not well insulated. Actions to improve housing stock, and in turn reduce the need for using solid fuel to heat homes, include retrofitting houses with insulation, improving building standards and installing cleaner home heating.

Exposure to poor ambient air quality

New Zealand has taken action to improve ambient air quality by introducing and implementing National Environmental Standards for Air Quality, which set thresholds for air pollutants and require public reporting of exceedances. Overall, the largest number of exceedances was reported for PM_{10} in 2008; however, 2008 was also the first year in which there were no breaches of the national environmental standard for CO, NO_2, SO_2 and O_3 at any monitoring sites since the standards were introduced in 2004.

On average in 2009, airsheds in the South Island had a higher number of days of exceeding the standard, and higher concentrations of PM_{10} on their maximum day, than North Island airsheds. In these South Island areas, household wood- and coal-burning is likely to have been the main contributor to air pollution, especially during winter. The proportion of homes using wood and/or coal for home heating was quite high in the South Island compared with the North Island in 2006, although overall these proportions have decreased over the past 10 years.

In the North Island, the Rotorua airshed had the second highest maximum PM_{10} concentration in New Zealand in 2008, and exceeded the PM_{10} standards on 36 days, five times the number of exceedance days recorded in 2007. In 2005 the two monitoring sites in Auckland exceeded the NO_2 levels. In addition, the Auckland airshed had a high number of exceedance days in 2007 (29 days) and a maximum of PM_{10} concentration that was over twice the maximum concentration allowed. In 2008, however, only three days of exceedances were recorded in this airshed, along with a maximum level of 14 $\mu g/m^3$ over the 50 $\mu g/m^3$ allowed concentration, around 10 $\mu g/m^3$ less than the previous year.

Exposure to indoor second-hand tobacco smoke

In addition to outdoor air pollutants, indoor air pollutants, such as indoor exposure to second-hand smoke, may contribute to negative health effects. Analyses showed that approximately one in 10 children aged 0–14 years (9.6%), and one in 15 non-smoking adults (7.5%), were exposed to second-hand tobacco smoke in their home in 2007. There were high rates for children's exposure in the Waikato DHB and the combined area of the Northland, Tairawhiti, Hawke's Bay, Lakes and Whanganui DHBs.

Health outcomes related to poor ambient and indoor air quality

In general, health effects resulting from air pollution will depend on the exposure of the population to air pollution, with the greatest health effects likely to arise from long-term exposure to air pollution. However, it is difficult to determine the exact contribution of air pollution to health outcomes. It was not possible in this report to determine the level of health effects caused by air pollution, due to the cross-sectional nature of the data. There are numerous causes and/or risk factors for diseases linked to air quality (such as smoking, lifestyle and behaviour factors, and occupational exposure), which are likely to influence results. Nonetheless, this report found some overall trends, and found that some population groups suffered from health effects related to air pollution, particularly in certain geographic areas and among the young and old.

One of the main health outcomes from air pollution is respiratory disease (Kjellström 2004). In recent years in New Zealand, there have generally been over 50,000 hospitalisations and over 2000 deaths each year due to respiratory disease.

New Zealand children aged 0–4 years had much higher hospitalisation rates for respiratory disease than other age groups. The rates for children were highest in the Northland, Counties Manukau, Lakes, Bay of Plenty, Tairawhiti, Hawke's Bay, Whanganui, Hutt, Wairarapa and Canterbury DHBs.

The results show a moderate relationship between ambient air quality and high hospitalisation rates for respiratory disease in children aged 0–4 years. The DHBs with significantly higher hospitalisation rates for respiratory disease in children aged 0–4 years, as well as having airsheds with exceedances in 2007, were:

- Counties Manukau (Auckland airshed)
- Lakes (Rotorua and Taupo airsheds)
- Hawke's Bay (Napier and Hastings airsheds)
- Canterbury (Rangiora, Kaiapoi, Christchurch and Ashburton airsheds).

There were no PM_{10} exceedances in 2007 in the airsheds within Hutt Valley DHB (Lower Hutt, Upper Hutt or Wainuiomata airsheds), Northland DHB (Kaitaia and Whangarei airsheds) or Wairarapa DHB (Wairarapa airshed), which also had high respiratory hospitalisation rates in 2007. With the exception of the Canterbury DHB, the hospitalisation rates for respiratory disease were generally not significantly higher in the South Island DHBs compared with the national average, although there were a higher number of PM_{10} exceedances in the South Island airsheds. In comparison with 2007, the number of PM_{10} exceedances increased for the majority of airsheds during 2008, but decreased in Auckland, a key airshed in terms of the size of the population potentially exposed. Respiratory hospitalisations and mortality for 2008 were not available at the time of publishing the current report.

For indoor air quality, DHB areas with significantly higher rates of exposure to second-hand smoke corresponded to a certain extent with areas with high rates of children's respiratory problems. For example, there were significantly higher age-standardised rates of respiratory hospitalisations in 2007 for children aged 0–4 years, in the DHBs of Northland, Lakes, Tairawhiti and Whanganui, which also had significantly high rates of exposure to second-hand tobacco smoke in the home.

Summary

Air pollution is a current, and potentially an increasing, environmental health concern in New Zealand, which may be having adverse health effects. Due to the high population density, the heaviest burden is likely to be in the major population centres, although exposure to air pollution can occur in most urban areas. A number of policies and programmes have been implemented to reduce air pollution levels, including the National Environmental Standards for Air Quality.

Chapter 6: Water Quality and Health

Clean and adequate water is essential for human health and wellbeing. While uncontaminated drinking and recreational water contributes to positive health, poor quality water has adverse health effects worldwide. Globally, an estimated 9.1% of the total disease burden and 6.3% of all deaths could be prevented by improved water, sanitation and hygiene (Prüss-Üstün et al 2008). The majority of the reduction in disease burden would occur in children aged 0–14 years, as they are the most vulnerable to diseases caused by contaminated or inadequate water (Prüss-Üstün et al 2008). The potential economic benefits of improved water quality are global health-care savings of an estimated US$7 billion a year for health agencies and US$340 million for individuals.

New Zealand enjoys relatively clean and plentiful freshwater and healthy offshore marine environments by international standards (Ministry for the Environment 2007). Additionally, this abundance makes water one of New Zealand's most valuable natural assets. For example, New Zealand has 425,000 km of rivers and streams, nearly 4000 lakes (Ministry for the Environment 2006), about 200 groundwater aquifers (White 2001) and nearly 15,000 km of coastline (Ministry for the Environment 2007). People use these resources on a daily basis, whether for recreational, industrial or domestic purposes, and therefore depend on having adequate quality water that is free of pathogens and other pollutants.

Driving forces such as population growth have placed increased pressures on water resources in New Zealand, through agricultural intensification and expansion and urban development. Increases in the amount of land used for agriculture (currently 40% of total land use) can increase the amount of nutrients, pathogens and sediment discharged into water (Ministry for the Environment 2007). Furthermore, the 86% of New Zealand's population who live in towns and cities also contribute pollutants to urban streams and, ultimately, to coastal receiving water (such as harbours and estuaries). Sources of urban pollutants include wastewater (including treated sewage) and stormwater (which can contain faecal matter, garden chemicals, detergents and other household chemicals).

The vast majority of the drinking-water supplied to the New Zealand population is through reticulated supplies (ie, piped water distribution). About half of New Zealand's drinking-water is pumped from the ground, and the other half comes from surface sources (Pricewaterhouse Cooper 2004). Water treatment plants can be used to remove actual or potential contaminants, such as bacteriological and protozoan contaminants, from the water.

Drinking-water quality is monitored primarily by health agencies. Requirements for drinking-water quality are currently regulated by the Resource Management Act 1991, the National Environmental Standards for Sources of Human Drinking Water, the Health Act 1956 as amended by the Health (Drinking Water) Amendment Act 2007 and the Drinking-water Standards for New Zealand 2005 (revised 2008).

Recreational water quality is monitored in New Zealand primarily by regional councils and Crown Research Institutes. Concentrations of *Escherichia coli* (*E. coli*) are measured in freshwater, and *Enterococci* in marine and estuarine water. Guidelines are set by the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (Ministry for the Environment and Ministry of Health 2003).

Water resources that are not monitored or that fail to meet guidelines can have adverse effects for people who consume or come into contact with them. For instance, infectious, enteric (gastrointestinal) diseases are caused by the ingestion of pathogens that usually originate from the faeces of infected humans and animals and are often transmitted through contaminated water (Ball 2006). The three main types of water-borne agents that cause gastroenteritis are pathogenic bacteria (eg, *Campylobacter, Salmonella, Shigella, Yersinia* and toxigenic *E. coli*), protozoa (eg, *Giardia* and *Cryptosporidium*) and viruses (eg, enteroviruses and noroviruses).

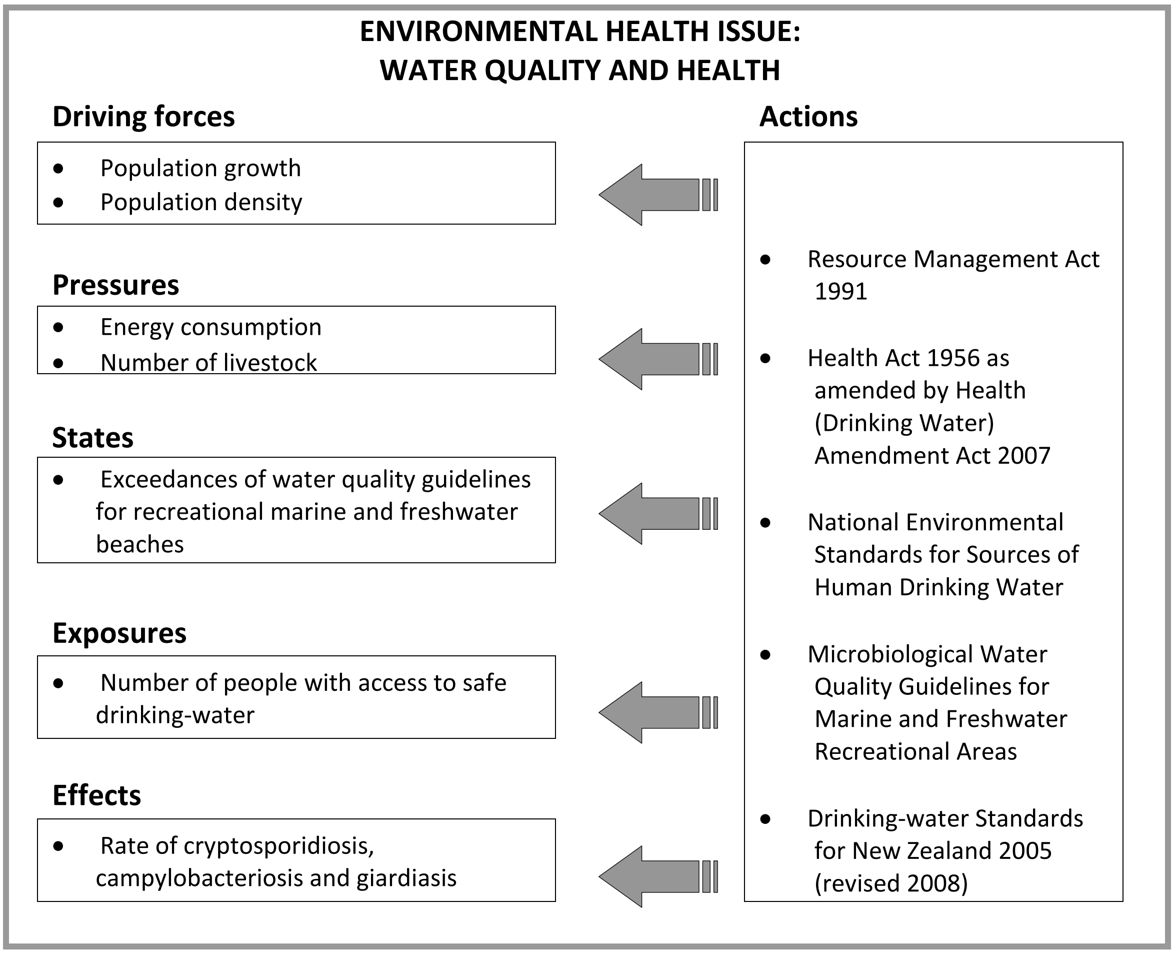
Overview of indicators

The following key indicators for water quality in New Zealand were selected:

- state: exceedances of water quality guidelines at recreational marine and freshwater beaches
- exposure: estimated number of people with access to safe drinking-water
- effects: number of notifications of water-borne illnesses.

Figure 36 demonstrates how these indicators fit into the DPSEEA framework, and illustrates the related driving force and pressure indicators.

Figure 36: The DPSEEA framework for water quality environmental health indicators



State indicator: Exceedances of guidelines at recreational marine and freshwater beaches

Indicator Number of exceedances of water quality guidelines at recreational marine and freshwater beaches

Relevance of indicator

Recreational contact with polluted water, for example through swimming, can have health effects such as water-borne diseases. Water-borne diseases are caused by ingesting pathogens, which can originate from animal or human faeces, and can be transmitted through drinking-water or recreational water (Ball 2006). In New Zealand, guidelines have been set for water quality at recreational marine and freshwater beaches to protect human health, as part of the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (Ministry for the Environment and Ministry of Health 2003). The bacterial group *Enterococci* are used to index faecal pollution in recreational marine water (including coastal and estuary waters), while the bacterium *E. coli* is used to indicate the presence of faeces, and therefore an increased risk of water-borne infection in recreational freshwater (including rivers and lakes). Councils monitor coastal and freshwater beaches during the swimming season, usually from November to March (Ministry for the Environment 2007). This section examines the number of exceedances of guideline levels of these indicators at marine and freshwater beaches in New Zealand.

Contamination of recreational freshwater and marine water is mainly caused by discharged human sewage and animal and livestock effluent from agricultural and urban areas. Faecal contamination of waterways is generally correlated with rainfall events, which cause much higher levels of run-off. In general, coastal beaches are less likely than freshwater beaches to have higher background levels of bacteria and longer-lasting contamination events, as faecal pollution is more rapidly diluted and dispersed by currents and large volumes of water at the coast (Ministry for the Environment 2007).

Studies have shown that human exposure to recreational marine water contaminated with *Enterococci* can have health effects, including eye, ear, nose and throat symptoms and respiratory and gastrointestinal illnesses (Corbett et al 1993; Harrington et al 1993; McBride et al 1998; WHO 2003a). Epidemiological studies have found that adverse health outcomes in swimmers and surfers were associated with high concentrations of *Enterococci* at marine beaches in New Zealand (McBride et al 1998) and in Australia (Corbett et al 1993; Harrington et al 1993). Exposure to contaminated freshwater (indicated by high levels of *E. coli*) can have adverse health effects, including gastrointestinal and respiratory diseases (Ministry for the Environment and Ministry of Health 2003).

Data source

Data for the indicator were collected by regional, district and city councils, and provided in aggregated form by the Ministry for the Environment (2010c). Water quality is monitored at recreational marine and freshwater beaches during the swimming season, generally between November and March and usually on a weekly basis. Samples of water are tested to ensure they comply with the guidelines in the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (Ministry for the Environment and Ministry of Health 2003). At marine and estuary beaches, the maximum guideline level of *Enterococci* is 280 *Enterococci* per 100 millilitres, while at freshwater beaches, the maximum guideline level of *E. coli* is 550 *E. coli* per 100 millilitres of water. If levels of *Enterococci* and/or *E. coli* breach these action (high alert) levels, councils co-ordinate with health authorities to mitigate health risks and ensure public awareness by restricting access to recreational and/or drinking-water sources.

The indicator presents the number of beaches that fall into one of four water quality categories, according to the proportion of samples taken that were compliant with the guidelines. The categories and exceedance thresholds are consistent with those used by the Ministry for the Environment (2007):

- 95 to 100% of samples at the beach complied with guidelines, indicating that the water quality is suitable for swimming 'almost all the time'
- 90 to 95% of samples at the beach complied with guidelines
- 75 to 90% of samples at the beach complied with guidelines
- 0 to 75% or more of samples at the beach complied with guidelines, indicating that water quality is 'often unsuitable for swimming'.

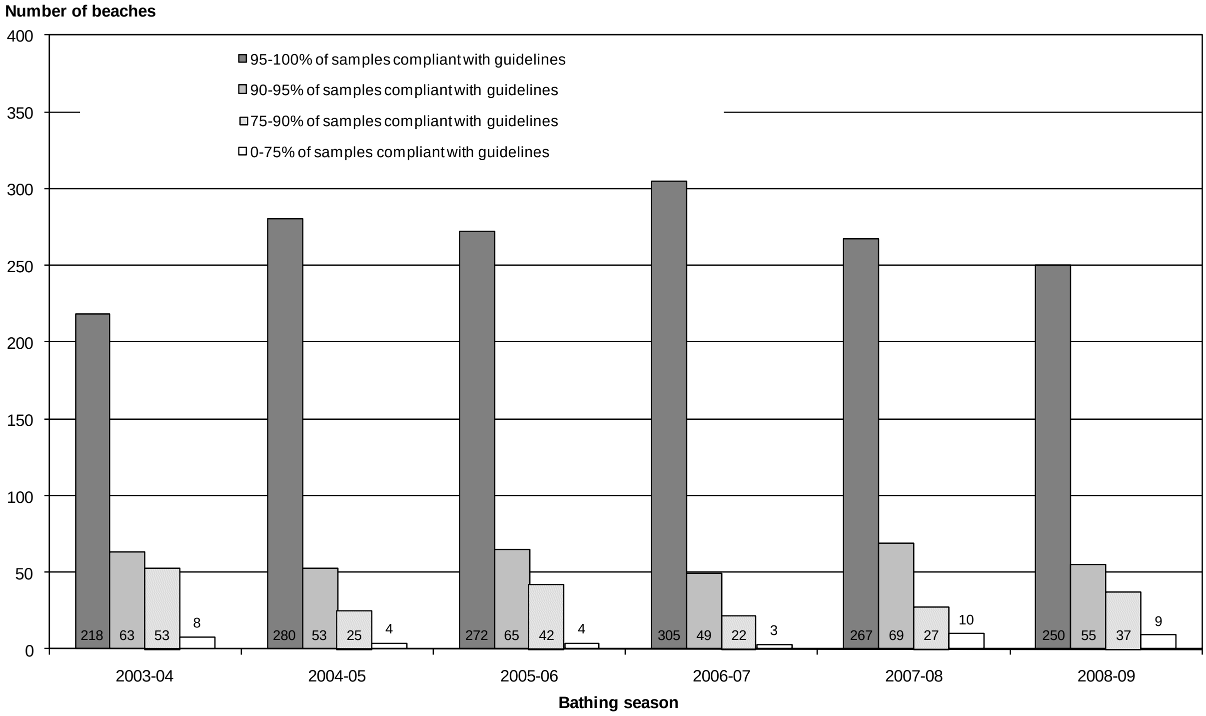
Some regional councils did not monitor sites in the 2008–2009 summer, as they rotate their monitoring programmes on a biannual basis, or conducted targeted water quality investigations (Ministry for the Environment 2010c). In addition, some beaches were insufficiently sampled, as they had fewer than 10 samples over the time period.

Results

Marine beaches

From the 2003–2004 to the 2006–2007 bathing seasons there was an increase in the number of recreational marine beaches that were monitored in New Zealand, from 342 to 379 (Figure 37). From 2007–2008 to 2008–2009 the number of marine beaches being monitored steadily decreased, from 373 to 351.

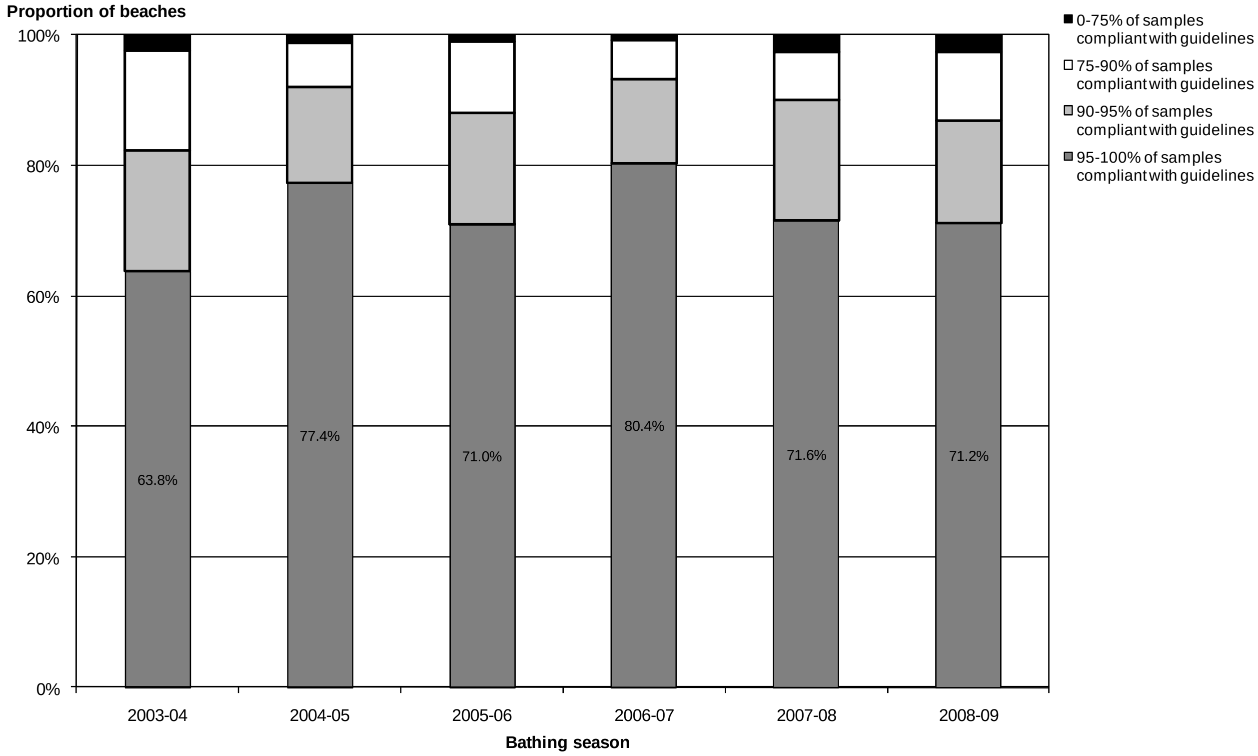
Figure 37: Number of recreational marine beaches exceeding guidelines for *Enterococci*, 2003–2004 to 2008–2009



Source: Ministry for the Environment (2010d)

Between the 2003–2004 and the 2006–2007 bathing seasons there was an overall increase in the proportion of monitored beaches suitable for swimming 'almost all of the time' (with 95% to 100% of samples complying with guidelines), from 63.8% to 80.4% (Figure 38). After this period, the proportion of beaches that were suitable for swimming 'almost all of the time' declined to a small extent, from 80.4% in 2006–2007 to 71.2% in 2008–2009.

Figure 38: Proportion of recreational marine beaches exceeding guidelines for *Enterococci*, 2003–2004 to 2008–2009

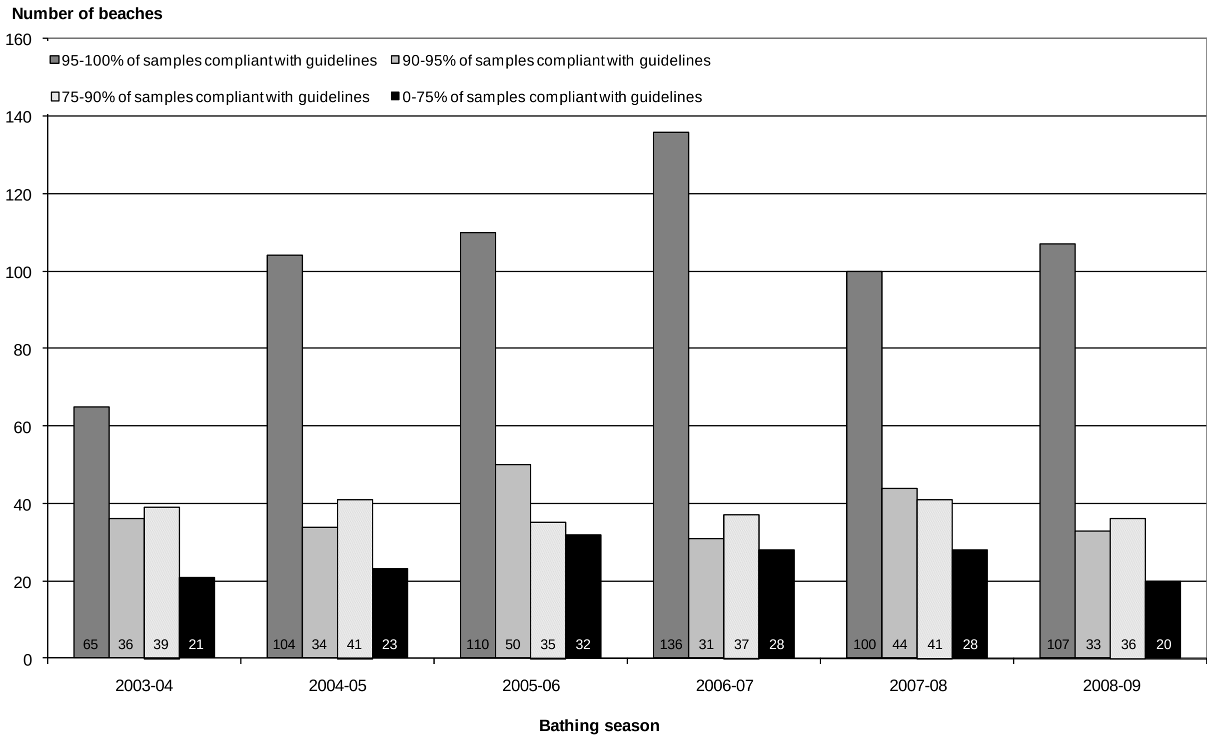


Source: Ministry for the Environment (2010d)

Freshwater beaches

Between the 2003–2004 and the 2006–2007 bathing seasons the number of monitored freshwater beaches increased from 161 to 232, and then decreased in subsequent years (Figure 39).

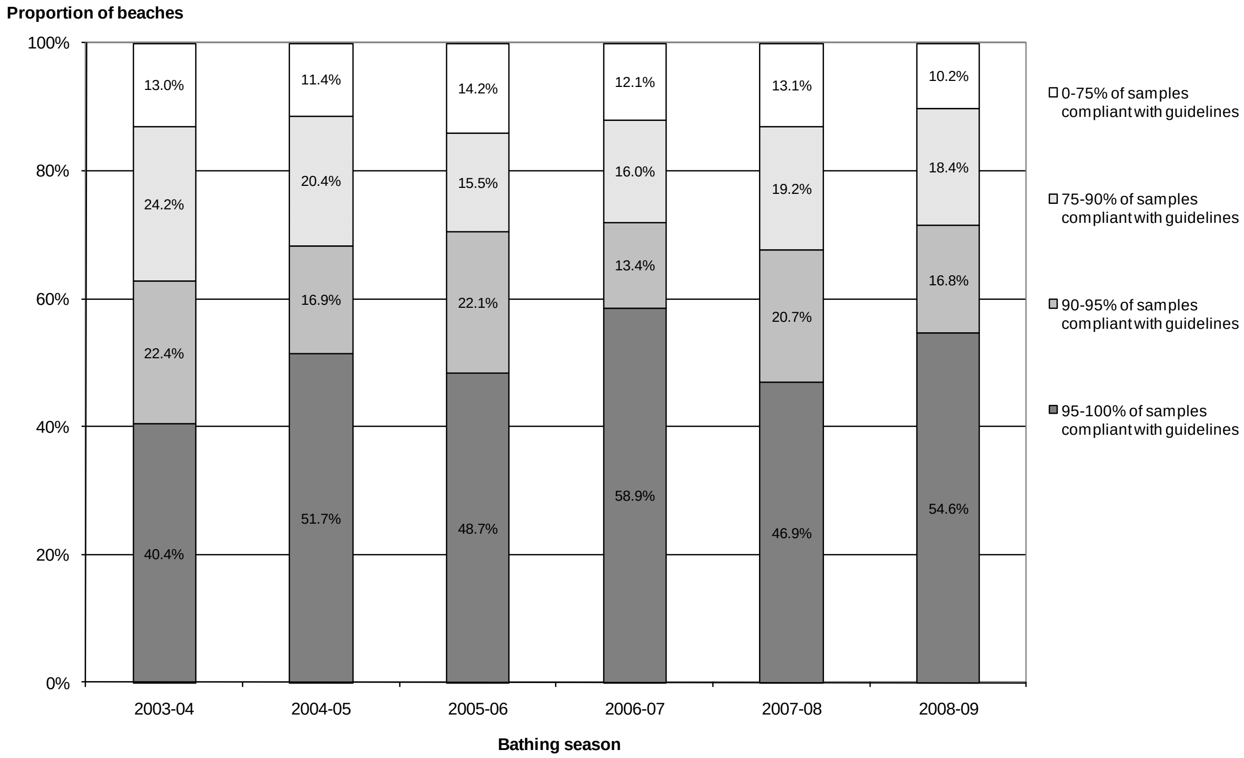
Figure 39: Number of recreational freshwater beaches by *E. coli* exceedance levels, 2003–2004 to 2008–2009



Source: Ministry for the Environment (2010d)

The proportion of freshwater beaches suitable for swimming 'almost all the time' (ie, 95% to 100% of samples complying with guidelines) generally increased between the 2003–2004 and the 2008–2009 bathing seasons (Figure 40). In 2008–2009 54.6% of monitored freshwater beaches were suitable for swimming 'almost all the time', compared with 46.9% in 2007–2008.

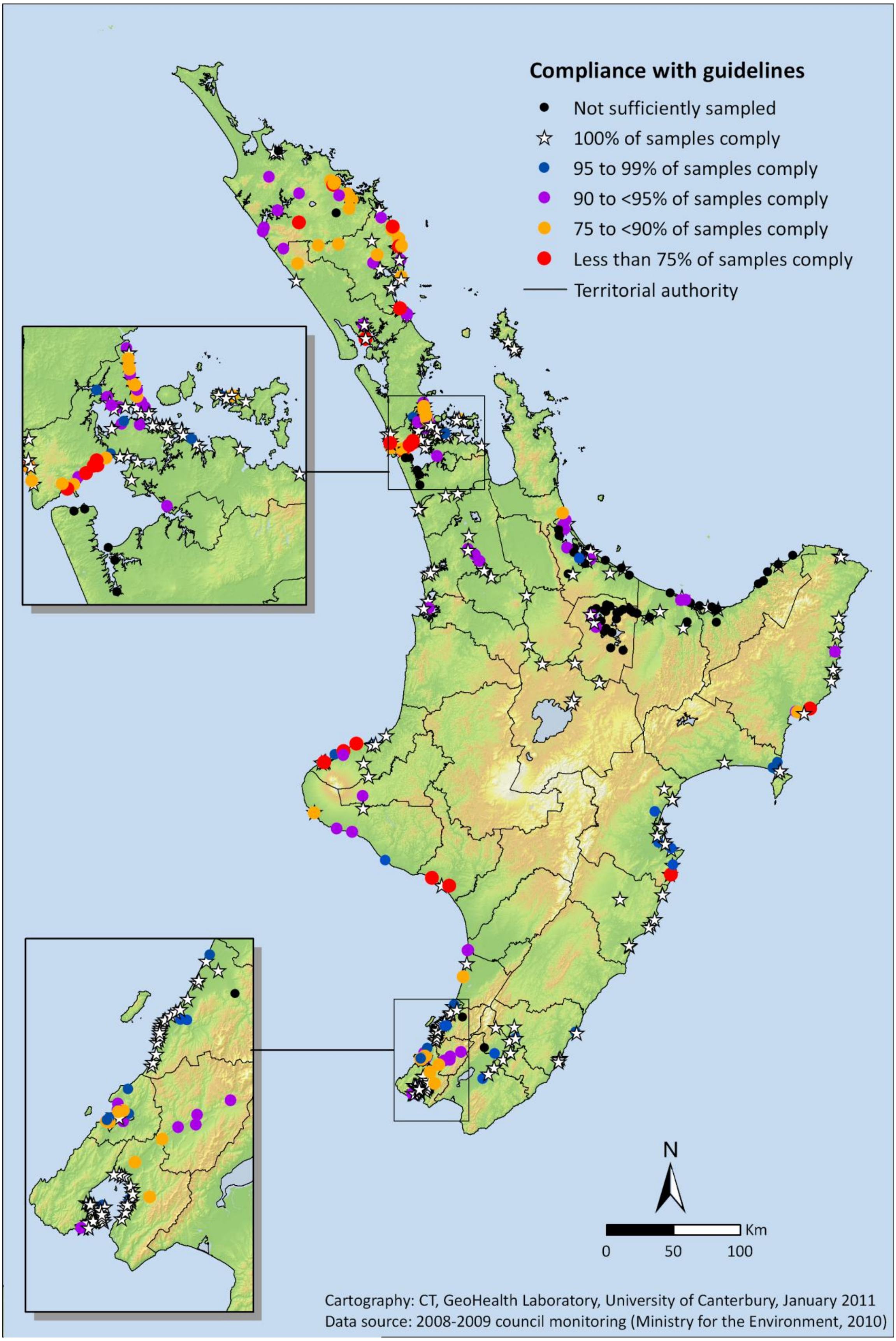
Figure 40: Proportion of freshwater beaches compliant with *E. coli* guidelines, 2003–2004 to 2008–2009



Source: Ministry for the Environment (2010d)

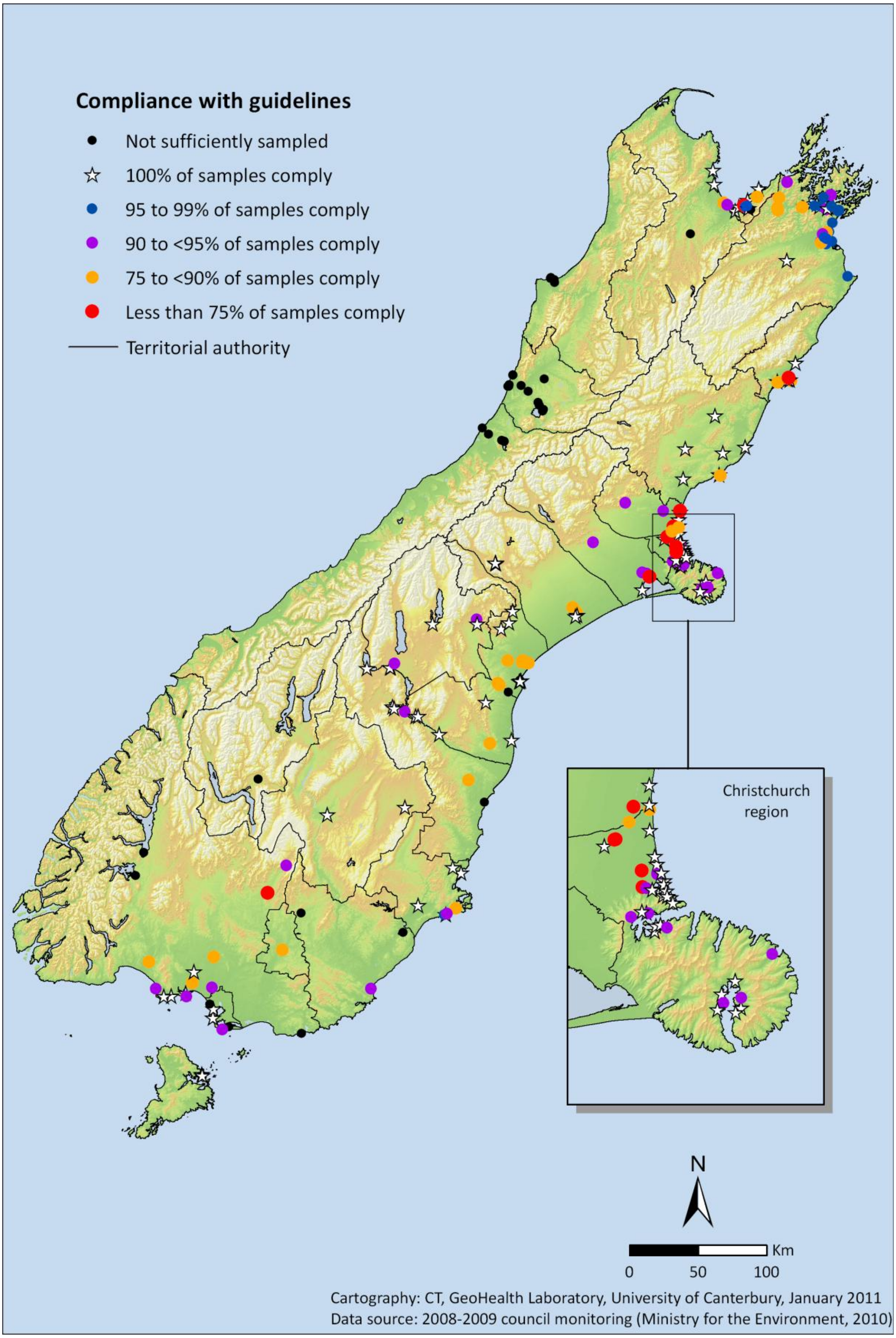
Figure 41 and
Figure 42 show monitored recreational marine and freshwater beaches in the North Island and South Island. The maps indicate the suitability of beaches for swimming in the 2008–2009 bathing season according to their exceedance rates for *Enterococci* (marine beaches) or *E. coli* (freshwater beaches), using the categories listed above. As noted previously, the proportion of freshwater beaches compliant with guidelines was lower than the proportion of complying marine beaches.

Figure 41: Exceedance rates from samples taken at monitored recreational beaches, North Island, 2008–2009



Source: Ministry for the Environment (2010d)

Figure 42: Exceedance rates from samples taken at monitored recreational beaches, South Island, 2008–2009



Source: Ministry for the Environment (2010d)

Exposure indicator: Estimated number of people with access to safe drinking water

Indicator	Population with access to safe drinking-water

Relevance of indicator

Access to safe drinking-water is a fundamental tenet of public health, vital for human health. However, access to safe drinking-water is not equal across New Zealand. The majority of the New Zealand population is supplied water by a reticulated supply (piped water distribution). About half of New Zealand's drinking-water is pumped from the ground, and the other half comes from surface sources (Pricewaterhouse Cooper 2004). Treatment plants can be used to remove actual or potential contaminants, such as bacteriological and protozoal contaminants, from the water.

Drinking-water supplies are not always safe, especially those that are untreated or insufficiently treated. These supplies often contain *E. coli*, an indicator bacterium that indicates the presence of faeces and hence an increased likelihood of water-borne pathogens. As a result, people can be exposed to contaminated drinking-water, which can lead to disease or death. Since 1996 the number of people in New Zealand on registered supplies that comply with the bacterial and protozoan requirements has steadily increased (Ministry of Health 2010).

This section estimates the number of people in New Zealand who have access to safe drinking-water. In particular, it examines the proportion of the New Zealand population serviced by registered reticulated drinking-water supplies known to comply with the Drinking-water Standards for New Zealand 2005 (Ministry of Health 2005), particularly with the *E. coli* and protozoal requirements.

Data source

The data on water quality were sourced from the 2008/09 Annual Review of Drinking-water Quality in New Zealand (Ministry of Health 2010). The report was prepared by ESR for the Ministry of Health and covered the 18-month period from January 2008 to June 2009.

The Annual Review contained results for the microbiological and chemical quality of drinking-water at supplies on the 2010 Register of Community Drinking-water Supplies in New Zealand. The drinking-water quality was assessed according to the standards in the Drinking-water Standards for New Zealand (for 2000, DWSNZ:2000 or 2005, DWSNZ:2005) (Ministry of Health 2005). Bacteriological compliance is best assessed at the distribution zone, while protozoan compliance is best assessed at the treatment plant. Data were supplied to ESR by public health units and/or DHBs. For the 2008/09 annual survey an alternative approach to counting the population in each distribution zone was used (Ministry of Health 2010), due to some previous issues with double-counting, but for the purposes of comparison, figures produced using the original method will be utilised in this report.

The Annual Review (Ministry of Health 2010) did not include water quality data for areas where:

- water suppliers could not be contacted or did not provide information
- supplies did not come from a registered supply.

Results

In 2008/09, an estimated 89% of the population received water from a registered reticulated drinking-water supply.

Bacteriologically compliant water from a registered supply served approximately 80% of the total New Zealand population in 2008/09, 3% less than in 2007/08 (Table 7). A further 9% of the population was served by a supply known not to comply (including not monitored). The remaining 11% of the population were not served by a registered reticulated supply (1% less than in 2007/08). According to the original method of estimating the distribution zone population, protozoal-compliant drinking-water served 76% of the New Zealand population in 2008/09 (Table 7) (Ministry of Health 2010).

Table 7: Percentage of the New Zealand population served by compliant drinking-water supplies, 2008/09

Population by access to drinking-water	Percentage of New Zealand population
Served by a registered reticulated drinking-water supply	89%
Not served by a registered reticulated drinking-water supply	11%
Bacteriological compliance	
Served by a registered reticulated drinking-water supply known to comply with *E. coli* requirements	80%
Served by a registered reticulated drinking-water supply known not to comply with *E. coli* requirements	9%
Protozoal compliance	
Served by a registered reticulated drinking-water supply known to comply with protozoal requirements	76% (63%)
Served by a registered reticulated drinking-water supply known not to comply with protozoal requirements	13% (26%)

Notes: *E. coli* and protozoal requirements are for the distribution zone, and are specified by the Drinking-water Standards for New Zealand 2005 (Ministry of Health 2005). Figures may not add to 100% due to rounding.

‘*While the distribution zone figures refer to the percentage of the total population of New Zealand, double-counting caused by many treatment plants supplying multiple zones, has meant that in the past the plant population percentages were estimates of the percentage of the population served by registered supplies. For the 2008/09 Annual Survey an alternative approach to population counting has been used because most of the population figures relate to treatment plants. Where a zone is supplied by more than one treatment plant, and the treatment plants are not equally compliant, the zone assumes the compliance status of the lowest-complying treatment plant*.’

Source: Ministry of Health (2010)

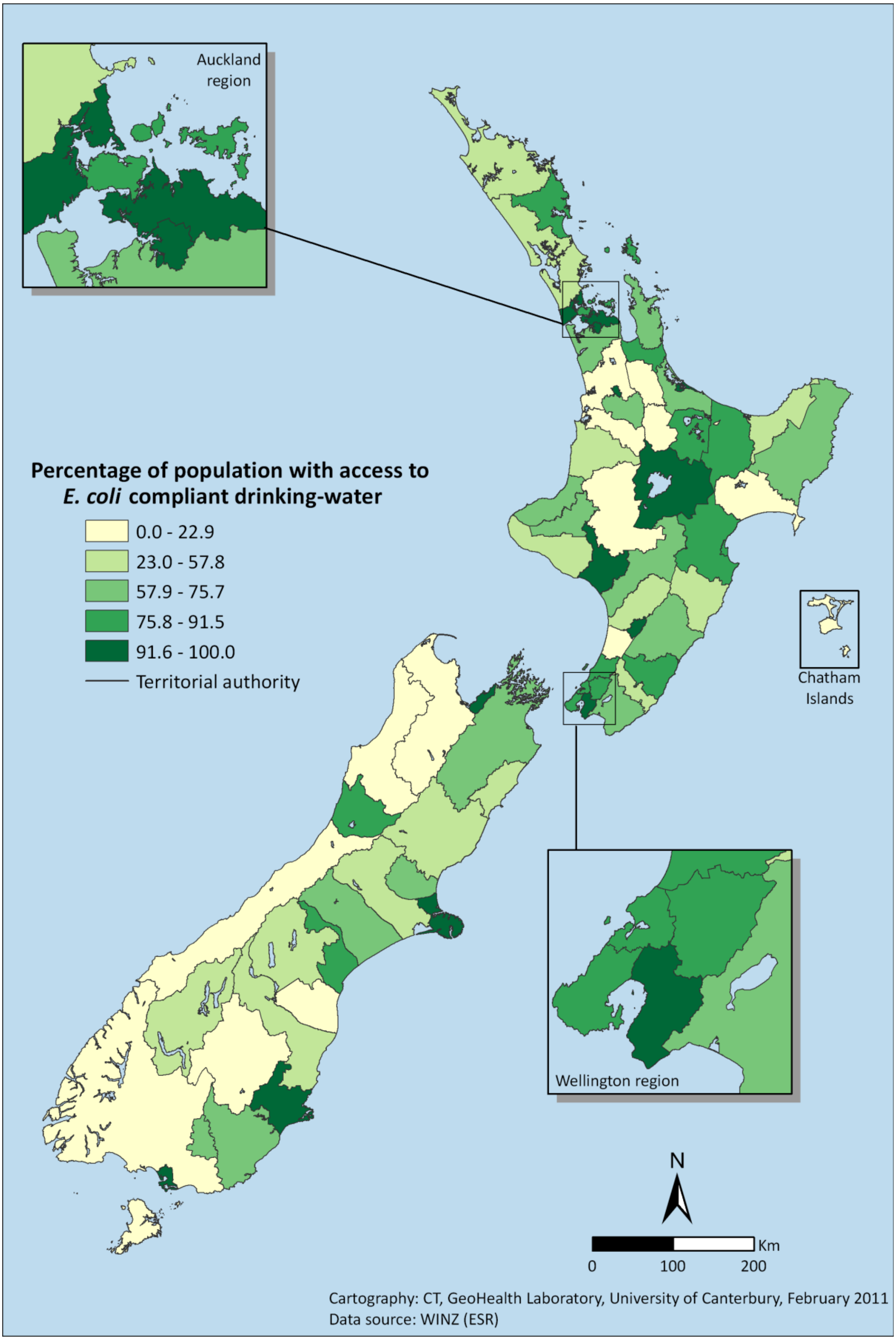
The compliance of drinking-water with bacteriological and protozoal requirements varied greatly by TA in 2008/09

Figure 43 shows that in some of the larger cities (eg, Christchurch City and Waitakere City) a high proportion of the population had access to bacteriologically safe drinking-water. By contrast, in some of the less densely populated territorial authorities, a low proportion of the population had access to bacteriologically safe drinking-water (eg, parts of the Waikato region). The main reason for non-compliance was inadequate monitoring rather than proven potential contamination of drinking-water. However, in many cases, unless drinking-water has been treated for *E. coli* the Ministry of Health recommends that drinking-water is assumed to be contaminated (Ministry of Health 2010).

For protozoal-compliant drinking-water, there was a relatively similar geographical pattern of access to safe drinking-water (Figure 44). In some TAs (ie, Waitakere City and Hamilton City), a high proportion of the population had access to protozoal-compliant drinking-water. However, for approximately 50% of the TAs, a low proportion of the population had access to protozoal-compliant drinking-water.

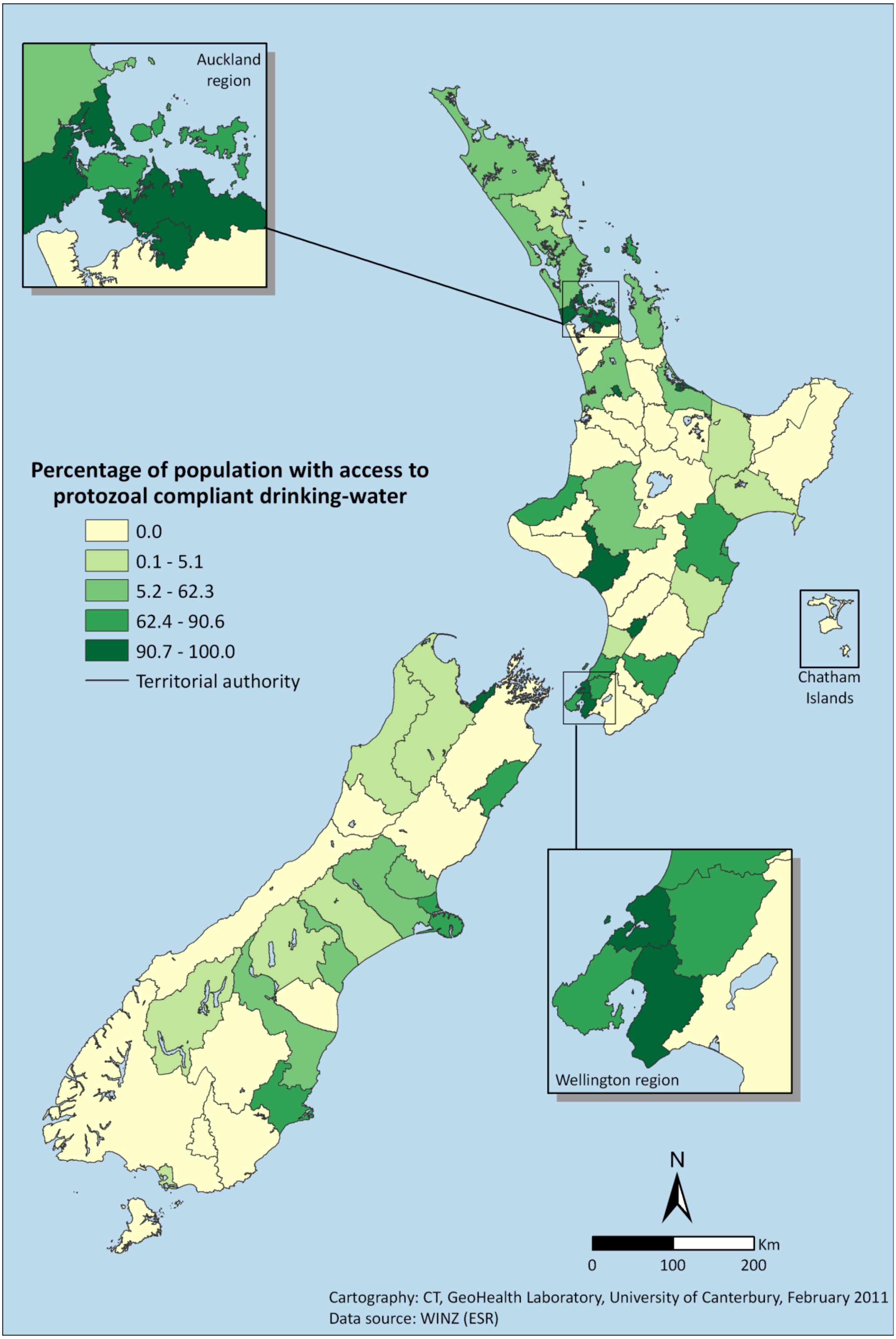
Generally, larger cities were more likely to comply with both bacterial and protozoan requirements than smaller cities and rural areas.

Figure 43: Percentage of population with access to bacteriologically compliant drinking-water, by TA, 2008/09



Source: Ministry of Health (2010)

Figure 44: Percentage of TA populations with access to protozoal-compliant drinking-water, 2008/09



Source: Ministry of Health (2010)

Effects indicator: Notifications of water-borne disease

Indicator Number of notifications of water-borne disease (campylobacteriosis, cryptosporidiosis, giardiasis)	

Relevance of indicator

Water-borne diseases are transmitted via water, either through drinking-water or through recreational use (ie, ingestion whilst swimming). This section focuses on levels of the following three notifiable gastrointestinal diseases which can be contracted through contaminated water:

- campylobacteriosis
- cryptosporidiosis
- giardiasis.

Campylobacteriosis is caused by the microorganism *Campylobacter* (most commonly the species *Campylobacter jejuni* and *C. coli*). When ingested by humans, the bacterium colonises the gut and damages the tissue in the intestine. The main transmission routes for *Campylobacter* are via food (particularly raw chicken), via water contaminated with excreta or via accidental ingestion of animal excreta. The incubation period for campylobacteriosis is one to ten days from the time of exposure. Symptoms include muscle pain, fever, diarrhoea, abdominal pain and nausea, and generally last one to seven days. Although anyone can become infected, younger children and young adults have higher rates or more severe disease. In a small number of cases, longer-lasting health effects include arthritis and Guillain-Barre syndrome, or even death (Heymann 2004).

Cryptosporidiosis is caused by the organism *Cryptosporidium parvum*, a protozoan parasite that also affects the intestines. The main transmission routes for *Cryptosporidium parvum* include contaminated water, person-to-person transmission, contact with animals, and ingestion of contaminated food (especially raw milk, and raw fruit and vegetables). The incubation period for cryptosporidiosis is three to eleven days after exposure, and symptoms include diarrhoea, vomiting and cramping, which generally last two to four days. The disease is usually self-limiting, but more severe effects can occur in immune-compromised individuals, which can lead to death in a small number of cases. Cryptosporidiosis can affect anyone, but young children and immune-compromised individuals are at increased risk.

Giardiasis is caused by the organism *Giardia intestinalis*, a protozoan parasite that causes gastrointestinal illness in humans. The main transmission routes for *Giardia intestinalis* are water that has been contaminated with faecal matter, food (particularly agricultural products) and person-to-person transmission. The incubation period for giardiasis is one to three weeks after exposure. The main symptoms are diarrhoea and cramps, which may last four to six weeks. Anyone can become infected; however, younger children are more susceptible, and the disease may be more severe among immune-compromised individuals. Giardiasis may cause lactose intolerance among some people and, for those who are immuno-compromised, it may cause death.

The three diseases are notifiable in New Zealand. All cases diagnosed by doctors and/or laboratories are required to be notified to the medical officer of health in the region, who notifies the case to the national data collection (EpiSurv) administered by ESR, or directly to EpiSurv for further investigation.

Notifiable diseases that have a possible contamination route through water but are not covered in this section are:

- salmonellosis
- typhoid/paratyphoid fever
- hepatitis A
- yersiniosis
- shigellosis
- gastroenteritis.

Data source

The data were sourced from the notifiable disease database, EpiSurv.

As part of the notification process of campylobacteriosis, cryptosporidiosis and giardiasis, information is collected on certain risk factors. For enteric disease, these risk factors include whether the individual had, during the incubation period:

- consumed untreated surface water, groundwater or rain water
- participated in water activities in a stream, river and/or beach
- recently travelled overseas.

Data collected on other risk factors but not included in this analysis include whether the individual had:

- consumed water other than regular supply
- consumed food from a food premises
- had contact with other symptomatic people
- had contact with children in nappies, with sewage or with other types of faecal matter or vomit
- had contact with farm animals
- had contact with sick animals
- a history of overseas travel that might account for this infection
- gone swimming in a public swimming pool, spa pool or other pool.

It should be noted that the risk factors are not confirmed as the cause of the disease; several risk factors may be recorded, and for a number of risk factors the majority of responses may be 'unknown'. For the analyses presented in this report, cases that had been overseas at some point during the incubation period were excluded from the analysis, as they were unlikely to have contracted the disease within New Zealand.

The analysis by TAs is based on the residential area of the case with no account taken if exposure occurred in another area. The average annual number of cases for 2007–2009 is the numerator, and 2008 population estimates is the denominator population. Crude rates have been used to represent the actual burden of disease.

A limitation of the analysis is that the data only includes reported cases of disease, but studies have shown that there is a notable rate of under-reporting (Ball 2006). Not all people who have an enteric disease will visit a medical practitioner, and not all cases will present a specimen for laboratory testing or will have their case notified.

Results

All disease cases

Approximately 122,900 cases of campylobacteriosis, cryptosporidiosis and giardiasis were notified in New Zealand from 2001 to 2009 (Table 8).

Campylobacteriosis accounted for the majority of these cases, and the age-standardised rates remained relatively constant from 2001 and 2007. Notifications of camphylobacteriosis in 2008 and 2009 were around 50% lower than in 2007.

Table 8: Notifications of campylobacteriosis, cryptosporidiosis and giardiasis, in New Zealand, 2001–2009, counts and age-standardised rate per 100,000

Year	Campylobacteriosis		Cryptosporidiosis		Giardiasis	
	Number	Age-standardised rate per 100,000 (95% confidence interval)	Number	Age-standardised rate per 100,000 (95% confidence interval)	Number	Age-standardised rate per 100,000 (95% confidence interval)
2001	9835	250.1 (245.2–255.1)	1174	33.6 (31.7–35.5)	1439	37.3 (35.4–39.3)
2002	12,113	307.8 (302.3–313.3)	916	26.0 (24.3–27.7)	1412	36.8 (34.9–38.7)
2003	14,452	363.1 (357.2–369.0)	799	23.0 (21.4–24.6)	1430	36.8 (34.9–38.7)
2004	11,853	295.4 (290.0–300.7)	569	16.6 (15.3–18.0)	1306	33.4 (31.6–35.3)
2005	13,676	337.8 (332.1–343.5)	851	24.4 (22.8–26.1)	1096	28.0 (26.4–29.7)
2006	15,638	388.2 (382.1–394.4)	697	20.0 (18.5–21.5)	1048	27.0 (25.4–28.7)
2007	12,099	297.6 (292.3–303.0)	868	25.2 (23.5–26.9)	1228	31.6 (29.9–33.4)
2008	6517	NA	764	NA	1660	NA
2009	7022	NA	814	NA	1640	NA

Source: EpiSurv (ESR)

Cases known to have untreated drinking-water as a risk factor

From 2001 to 2009 there were 9683 notifications (7.9% of all cases) of campylobacteriosis, cryptosporidiosis and giardiasis that recorded untreated drinking-water as a risk factor.

From 2001 to 2009 untreated drinking-water was a risk factor for 36.4% of cryptosporidiosis notifications (2712 of the 7452 notifications), 11.3% of giardiasis notifications (1382 of the 12,259 notifications) and 5.4% of campylobacteriosis notifications (5589 of the 103,205 notifications).

Table 9 shows an overall downward trend over time in both the number of disease notifications and the age-standardised notification rates per 100,000 of cases recording untreated drinking-water as a risk factor. This decrease may be due to less comprehensive information on risk factors being collected in later years than previously.

Table 9: Notifications of water-borne disease with untreated drinking-water as a risk factor, in New Zealand, 2001–2009, counts and age-standardised rate per 100,000

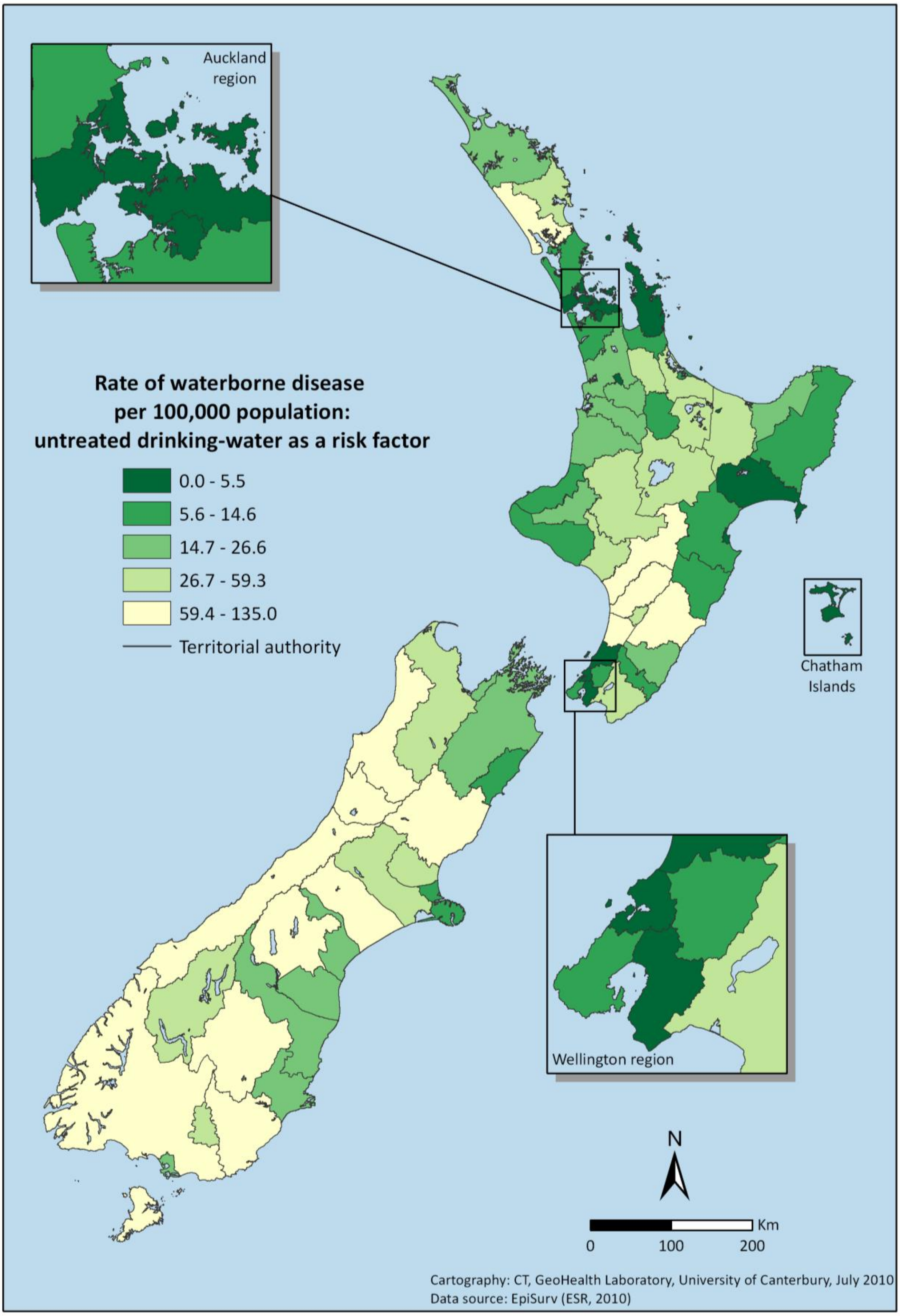
Year	Campylobacteriosis		Cryptosporidiosis		Giardiasis	
	Number	Age-standardised rate per 100,000 (95% confidence interval)	Number	Age-standardised rate per 100,000 (95% confidence interval)	Number	Age-standardised rate per 100,000 (95% confidence interval)
2001	884	23.4 (21.9–25.0)	280	8.1 (7.2–9.1)	202	5.3 (4.6–6.1)
2002	742	19.6 (18.2–21.1)	240	6.9 (6.1–7.9)	200	5.4 (4.7–6.2)
2003	768	19.7 (18.3–21.1)	185	5.3 (4.6–6.2)	160	4.1 (3.5–4.8)
2004	616	16.0 (14.7–17.3)	167	4.9 (4.1–5.6)	123	3.2 (2.7–3.8)
2005	609	15.9 (14.7–17.2)	169	4.9 (4.2–5.7)	133	3.5 (3.0–4.2)
2006	666	17.4 (16.1–18.8)	155	4.6 (3.9–5.3)	126	3.4 (2.8–4.0)
2007	509	13.0 (11.9–14.2)	157	4.7 (4.0–5.4)	129	3.3 (2.7–3.9)
2008	381	NA	180	NA	160	NA
2009	414	NA	106	NA	149	NA

Notes: Only those notifications that included 'drinking untreated water' as a risk factor were included in the analysis above. Untreated water was defined as untreated surface water, bore water or rain water during the incubation period. Cases exclude those cases who were overseas during the incubation period.

Source: EpiSurv (ESR)

The 2007–2009 notification rate of water-borne disease (campylobacteriosis, cryptosporidiosis and giardiasis) with a risk factor of drinking untreated water was highest in the South Island and in the central North Island (Figure 45).

Figure 45: Crude notification rate for cases of water-borne disease recording untreated drinking-water as a risk factor, by TA, rate per 100,000 people per year, 2007–2009



Source: EpiSurv (ESR)

Disease cases known to have contact with recreational water

The analysis examined cases where exposure to fresh and marine recreational water, including rivers, lakes and the ocean, during the incubation period was a risk factor. Exposure to a swimming pool or spa pool was not considered a risk factor and people who were overseas during the incubation period were excluded. It should be noted that contact with recreational water was not confirmed as the cause of disease.

The rate of notified water-borne diseases with recreational water as a risk factor was relatively low when compared with the overall rate of water-borne disease (Table 10). Approximately 3.9% of giardiasis cases from 2001 to 2009 were exposed to recreational water, compared with 3.8% of cryptosporidiosis cases and 1.5% of campylobacteriosis cases.

Over the period 2001–2009, there was an overall decline in the number and rate of disease notifications with recreational water as a risk factor. The decrease may be due to less comprehensive information on risk factors being collected than previously.

Table 10: Notifications of water-borne disease with recreational water as a risk factor, in New Zealand, 2001–2009, counts and age-standardised rate per 100,000

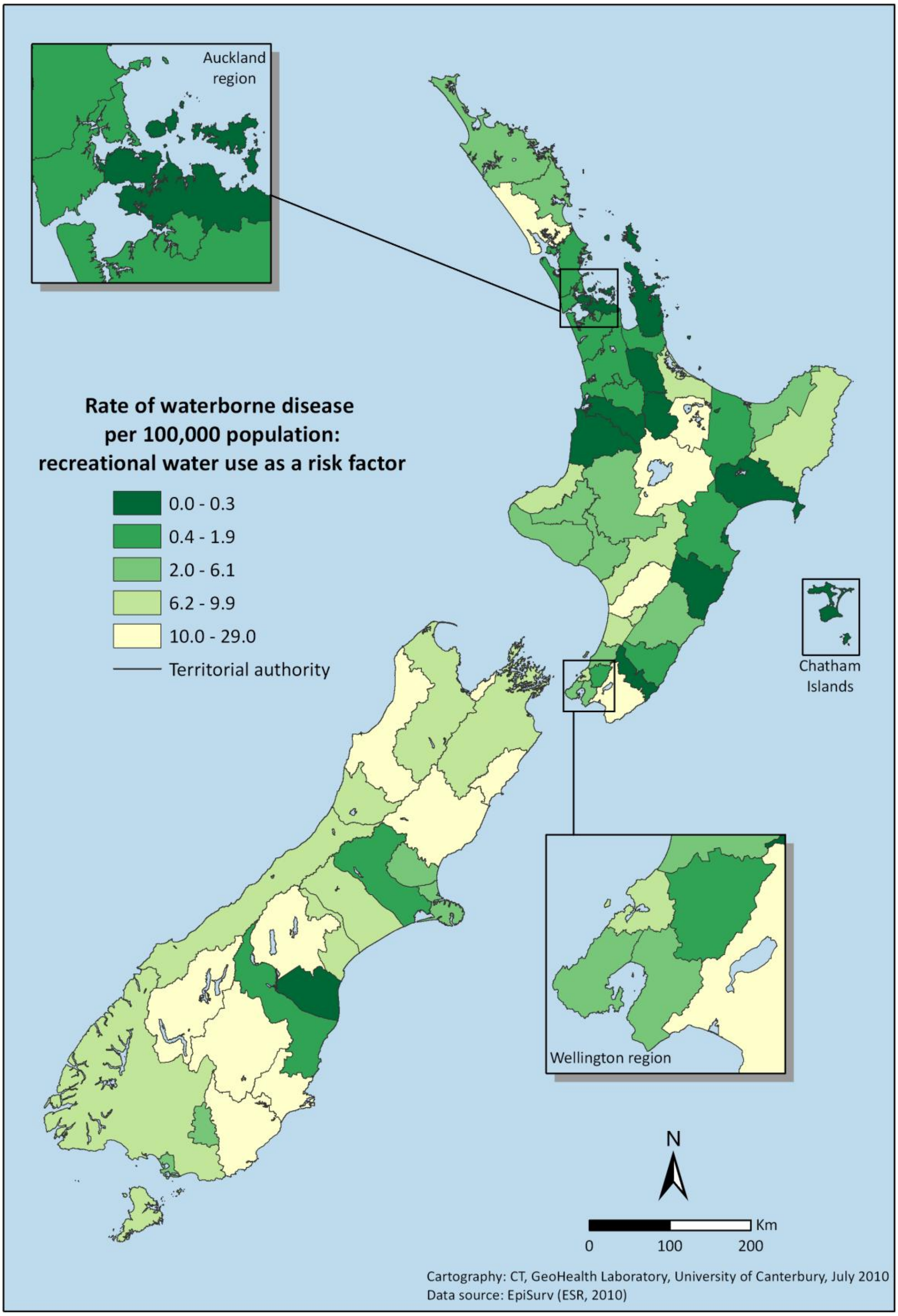
Year	Campylobacteriosis		Cryptosporidiosis		Giardiasis	
	Number	Age-standardised rate per 100,000 (95% confidence interval)	Number	Age-standardised rate per 100,000 (95% confidence interval)	Number	Age-standardised rate per 100,000 (95% confidence interval)
2001	259	7.1 (6.3–8.0)	70	2.0 (1.6–2.5)	83	2.2 (1.8–2.7)
2002	194	5.3 (4.6–6.1)	17	0.5 (0.3–0.8)	62	1.8 (1.4–2.3)
2003	280	7.5 (6.6–8.4)	53	1.5 (1.1–2.0)	67	1.8 (1.4–2.3)
2004	157	4.3 (3.6–5.0)	19	0.6 (0.3–0.9)	47	1.3 (0.9–1.7)
2005	203	5.5 (4.8–6.3)	38	1.1 (0.8–1.5)	49	1.3 (1.0–1.7)
2006	154	4.2 (3.6–4.9)	13	0.4 (0.2–0.7)	21	0.6 (0.4–0.9)
2007	125	3.4 (2.8–4.1)	32	0.9 (0.6–1.3)	58	1.6 (1.2–2.0)
2008	50	NA	22	NA	41	NA
2009	79	NA	21	NA	48	NA

Notes: Only those notifications that included 'recreational water' as a risk factor were included in this analysis. Exposures included swimming in streams, rivers and/or sea/beach, but not swimming in swimming pools or spas. Numbers and rates exclude those cases who were overseas during the incubation period.

Source: EpiSurv (ESR)

During 2007 and 2009, several TAs (eg, around north Canterbury and Otago) had comparatively high rates of notifications of water-borne disease (ie, campylobacteriosis, cryptosporidiosis and giardiasis) with a risk factor of recreational water. Caution should be exercised when interpreting these rates as some of the highest are based on very small numbers, for the most part fewer than five, therefore are likely to be unstable.

Figure 46: Water-borne disease (campylobacteriosis, cryptosporidiosis and giardiasis) with a risk factor of recreational water use by TA, crude rate per 100,000 people per year, 2007–2009



Source: EpiSurv (ESR)

Actions relating to water quality and health indicators

A number of actions have been taken to improve the quality of drinking-water and recreational water in New Zealand.

Resource Management Act 1991

The Resource Management Act 1991 is the main legislative tool for managing freshwater resources in New Zealand. Under this Act, regional councils and unitary authorities are responsible for coastal and freshwater management within their boundaries. Fulfilling this responsibility includes monitoring and reporting the water quality of recreational (coastal and freshwater) and drinking-water. Water quality is regularly monitored at 230 river and lake sites, 1100 groundwater sites and 380 coastal beaches (Ministry for the Environment 2007).

The Ministry for the Environment is developing a National Policy Statement for Freshwater Management under the Resource Management Act 1991, as a key way to deliver improved environmental outcomes for freshwater, and to recognise the management of freshwater as a matter of national significance (Ministry for the Environment 2008b). The proposed National Policy Statement states objectives and policies on the:

- quality of freshwater in New Zealand's rivers, lakes, wetlands and groundwater systems, including effects on the quality of freshwater arising from land-use intensification and land-use change
- demand for freshwater
- flows and levels of freshwater in rivers, lakes, wetlands and groundwater systems.

Drinking-water quality

There are several relevant drinking-water initiatives that aim to monitor and improve the quality of drinking-water in New Zealand. The National Environmental Standards for Sources of Human Drinking Water, which came into force in June 2008, are government-approved standards to reduce the risk of contamination in drinking-water under the Resource Management Act 1991. These standards require regional councils/unitary authorities to consider the effects of activities on drinking-water in their management of the natural and physical resources of their region.

Furthermore, the Drinking-water Standards for New Zealand 2005 (revised in 2008) (Ministry of Health 2008a) provide details on how to assess the quality and safety of drinking-water, as well as a check on the final water quality used by consumers. The Standards include water quality standards, levels for bacterial, protozoal, viral, cyanotoxin, chemical and radiological compliance, and compliance criteria for small water supplies and tankered drinking-water. The Drinking-water Standards for New Zealand 2005 replaced the 2000 Standards. The Standards have been in place in some form in New Zealand since 1984 and have been voluntary for networked drinking-water suppliers (usually local councils) to meet.

A key purpose of introducing such Standards has been to provide a 'yardstick' to help define what constitutes safe drinking-water. At present, there is no legislative requirement for any drinking-water supplies to comply with the Standards. However, in the future, the 2007 amendment to the Health Act 1956 (Part 2A), will require most networked drinking-water supplies to take 'all practicable steps' to meet the Standards.

Taking all practicable steps does not necessarily mean that the Standards must be met; the Health Act 1956 outlines a range of considerations for determining whether all practicable steps have been taken (Part 2A, section 69H). One of these considerations is 'affordability'. In practice a supplier will have taken all practicable steps if it has in place an approved Public Health Risk Management Plan[1] for the drinking-water supply, and implements provisions of the plan relating to the Standards (Part 2A, section 69V).

The date from which the 'all practicable steps' clause comes into effect varies by the size of the population that the water supply serves. When amendments to the Health Act 1956 first introduced the 'all practicable steps' clause, regulations determined that the clause would come into effect from 1 July 2009 on a progressive basis depending on water supply size. Following the change in Government in 2008, the regulations were changed to delay the clause coming into effect for new and large supplies until 1 July 2012 and to make it effective for all other networked water supplies on a progressive basis by 1 July 2016.

Recreational water quality

Current recreational water quality guidelines were set in 2003 by the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (Ministry for the Environment and Ministry of Health 2003). The aims of these guidelines are to minimise the public health risks from microbiological contamination in recreational waters, and to provide monitoring and reporting on the general health of freshwater and coastal beaches (Ministry for the Environment and Ministry of Health 2003). The existing guidelines replaced the Recreational Water Quality Guidelines from November 1999, which mainly concentrated on faecal bacteria, and instead employ a qualitative risk grading of the catchments supported by direct measurement of appropriate faecal indicators.

Several actions at all government levels have aimed to minimise the pressures on water quality, for example by minimising the discharge of pollutants into recreational water sources. Nationally, on 8 June 2009, the Government announced its new strategy New Start for Fresh Water. Its objectives are to:

- ensure water contributes to economic growth and environmental integrity
- provide stronger leadership and national direction
- fill science, technical, information and capability gaps
- develop management measures to set limits to manage quality and quantity issues, address the impacts of land-use intensification and improve the management of water demand.

Furthermore, the Dairying and Clean Streams Accord, signed in May 2003, aims to achieve clean, healthy water in dairying areas, by excluding stock from waterways and reducing discharges of dairy effluent (Ministry for the Environment 2007).

Local actions are generally consistent with a regional council's individual resource management plan and regional policy statement. Each council has strategies that are normally updated every 10 years. Furthermore, local strategies are typically in place where pressures on the environment are highest. For example, the Auckland region has elevated pressures from industry and

[1] This plan covers three main aspects of water supply: catchments and intake, treatment and storage, and distribution (ESR 2008).

accordingly has policies to mitigate discharges, such as the Industrial Pollution Prevention Programme and the Emergency Management Plan (Auckland Regional Council 2007). Other regions with agricultural-induced pressures have developed strategies to minimise stock effluent in recreational water, including Farm Dairy Effluent guidelines for farmers in Southland (May 2007), the Waterway Protection Programme in Otago (December 2003) and the Dairy Effluent Report in Canterbury (September 2006). In addition, each regional council operates a 24-hour Pollution Hotline, which allows the public to report water pollution to the council who can then investigate their claims.

Additionally, iwi and hapū across New Zealand have been proactive in engaging in a range of activities to protect, monitor and enhance water quality. Tāngata whenua take their role and responsibilities as kaitiaki seriously. The Ngāti Tūwharetoa Wai Ora programme monitors both the cultural and ecological health of waterways in its tribal rohe (district). The Rotorua Lakes Strategy Group is the overarching management group responsible for co-ordinating policy and actions to improve the recreational water quality of the Rotorua lakes. It is made up of representatives from Te Arawa Lakes Trust, Environment Bay of Plenty and Rotorua District Council. The group is now established in law as part of the Te Arawa Lakes Settlement, for co-ordinated management of the Rotorua lakes.

Discussion

Water quality is an important environmental health issue in New Zealand as clean water is essential to human health and wellbeing. The majority of the New Zealand population receives drinking-water from a reticulated supply, and has access to recreational beaches, both marine and freshwater. However, contaminated drinking and recreational water can negatively affect the health of the population and cause outbreaks of water-borne disease. For example, pathogens, in the first instance, can be expected to cause acute gastrointestinal illness. The symptoms and severity of gastrointestinal illness will vary depending on the specific conditions causing it. In general, the likelihood and severity of illness can be expected to vary depending upon the concentration of the pathogen or chemical in the drinking-water supply or recreational water.

Driving forces and pressures on water quality

Over the years, water quality is likely to have been affected by key driving forces and pressures such as increases in population size and urbanisation, as well as an increase in water-intensive forms of agriculture (such as dairy farming). These pressures have increased the overall demand for water, and additionally have increased the risk of contamination of water sources.

Drinking-water quality

In New Zealand, drinking-water supplies serving more than 500 people are required to be regularly monitored for *E. coli* and the effectiveness of protozoal treatment, according to the Drinking-water Standards for New Zealand 2005 (revised in 2008) (Ministry of Health 2008a). The Annual Review of Drinking-water Quality in New Zealand 2008/09 reported that a lower proportion of the population had access to *E. coli* and protozoan compliant drinking-water than in 2007/08, in addition to 1% fewer people being served by a registered drinking-water supply (Ministry of Health 2010).

Since 1996 there has been an overall increase in the number of people on registered drinking-water supplies, and in bacteriological and protozoal compliance (Ministry of Health 2010). In 2008/09, 80% of the population was supplied drinking-water that was compliant with *E. coli* thresholds, and 76% of the population was supplied with protozoal-compliant drinking-water.

These findings suggest that a sizeable proportion of the population still do not have access to safe drinking-water.

Recreational water quality

A number of marine beaches and freshwater beaches (such as lakes and rivers) are monitored for water quality during summer months, and are assessed according to the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas. Although there was an overall improvement in marine and freshwater recreational water quality between the 2003–2004 and the 2009–10 bathing seasons, there were annual fluctuations. In 2009–2010, approximately 23.0% of monitored marine beaches and 42.7% of monitored freshwater beaches were still not meeting the criteria for safe swimming 'almost all of the time'.

Health effects related to poor water quality

In terms of health effects, there has been a decrease over the past six years in the age-standardised rates of notifications of water-borne disease (campylobacteriosis, cryptosporidiosis and giardiasis) recording risk factors of drinking untreated water or exposure to recreational water. By contrast, the overall number of cases for these diseases (for all risk factors) has remained fairly consistent over this period.

One possible explanation for these decreasing rates of water-borne disease is that they have resulted from improved drinking and recreational water quality. Another possibility is that less comprehensive information on risk factors may be being collected than previously. It is also important to note that it is not possible to determine causal relationships from the data presented, and results are descriptive only.

Regional analyses

For drinking-water, there appears to be a regional relationship between compliance and notifications of water-borne diseases with a risk factor of drinking untreated water. For example, the South Island generally had lower compliance rates for bacteria and protozoa in drinking-water, and higher notification rates of water-borne disease with untreated drinking-water as a factor. By contrast, the North Island had higher compliance rates and lower disease rates. Furthermore, bacterial and protozoan compliance rates were generally highest in TAs with larger populations, such as Auckland City, Wellington City, Christchurch City and Dunedin City, which did not have high rates of potential water-borne disease with a risk factor of drinking untreated water. It appeared that rural communities were generally more likely to have lower compliance rates for bacteria and protozoa in drinking-water, and higher rates of potential water-borne disease.

For recreational water, there were possible regional correlations between the quality of recreational water, and cases of water-borne disease with a risk factor of coming into contact with recreational water. Some areas with beaches recording poor recreational water (such as Whangarei, Western Bay of Plenty, Canterbury and Otago) also had higher rates of water-borne disease with a risk factor of exposure to recreational water.

Summary

The monitoring of drinking and recreational water is important to ensure compliance with bacteriological and protozoan guidelines. It is evident that water quality is improving in New Zealand, for both drinking and recreational water. Reducing and eliminating pollution of water supplies should continue to improve water quality.

Chapter 7: Biosecurity

This section discusses biosecurity in the context of the environmental health issue of vector-borne disease. Vector-borne, zoonotic diseases (infectious diseases transmitted from animals to humans) involve four agents: the human host, the pathogen or agent, the vector and the (wildlife) reservoir (Ostfeld et al 2006). Key diseases spread by vectors (eg, mosquitoes) include malaria, dengue fever, West Nile virus and Ross River fever. Increasing movement of people and goods, as well as changes in the environment and habitats, means that it is important for countries such as New Zealand to monitor the risk and spread of vector-borne diseases, and to maintain vigilance in surveillance.

In New Zealand, biosecurity is the key method for eliminating the risk and spread of vector-borne disease. Biosecurity involves the protection of the economy, environment and health of the population from the introduction of foreign risky organisms, as well as the mitigation of the effects of organisms already present in the environment (MAF BNZ 2008a). From a human health perspective, early detection of biosecurity threats is a central part of the International Health Regulations 2005, which require countries to carry out surveillance in order to prevent the spread of public health emergencies (WHO 2008).

The importance of biosecurity is becoming increasingly recognised as the interconnection between the environment and human health becomes better understood (McMichael 2005). Risky organisms entering the country can pose serious threats to the environment and to ecosystems, which are the networks of interactions between organisms, vital for providing life support systems and as a buffer to human health and wellbeing (Parkes and Weinstein 2004). Disruptions can affect the entire ecosystem, including its long-term resilience and stability.

Biosecurity also has an impact on commerce, industry, research and environmental sustainability. In New Zealand, biosecurity efforts are led by the Ministry of Agriculture and Forestry's Biosecurity New Zealand (MAF BNZ), as well as a number of other key agencies and groups (Table 11). The broad ecosystems approach to biosecurity is reflected in the key values of MAF BNZ which include economic, environmental, health and social/cultural values (including values of Māori) of New Zealand that are threatened by risky organisms (MAF BNZ 2008d). MAF BNZ considers the impact of the risky organism or the proposed response options on the following: the sustainable economic growth and prosperity for New Zealanders; healthy New Zealanders and a vibrant rural community; and maintained and enhanced economic, social and cultural benefits for New Zealanders from the natural environment (MAF BNZ 2008d).

In New Zealand, driving forces such as the growing number of migrants and tourists, as well as the number of vessels and products entering New Zealand each year, continue to place pressure on biosecurity efforts, by increasing the risk of a border incursion of pests or infectious agents (MAF BNZ 2008a). Environmental factors such as climate change can also put pressure on biosecurity efforts, for example by increasing the availability of suitable habitats for disease vectors such as mosquitoes within New Zealand (Woodward et al 2001).

Biosecurity surveillance and intervention in New Zealand occur at three stages, namely pre-border, border and post-border. Each stage progressively reduces the risk of a biosecurity breach (Figure 47) (MAF BNZ 2008a).

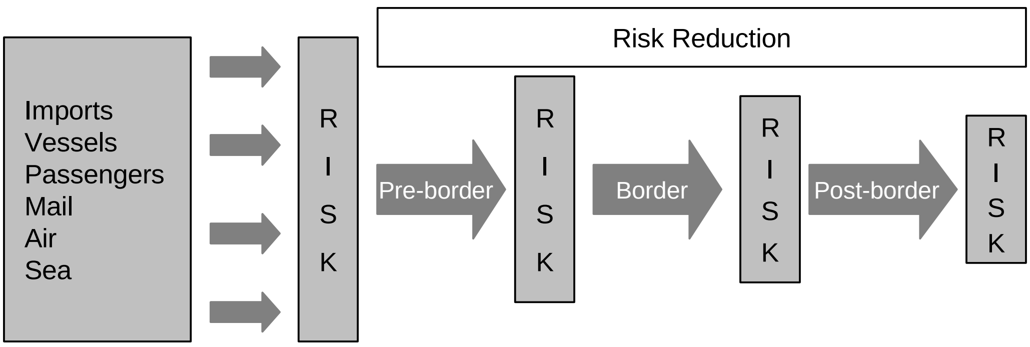
Through the deployment of appropriate surveillance and intervention systems, the residual risk at each stage reduces, although it does not disappear completely. While biosecurity can come at a substantial cost, surveillance and control efforts are considered far more cost-effective than not addressing the problem and allowing it to escalate, an approach with costly negative economic and/or health impacts (MAF BNZ 2008a).

The risk of vector-borne disease is very small in New Zealand. However, it is still important to monitor because of a number of separate but inter-related factors that, when combined, increase the risk of vector-borne disease in New Zealand. These factors include: increasing movement of people and goods worldwide; climate change (creating more suitable habitats for vectors in New Zealand); and the close proximity of, and close relations with, a number of countries in the Western Pacific and South East Asia, where vector-borne diseases are endemic.

Table 11: Key agencies and groups involved in biosecurity efforts in New Zealand

- Ministry of Agriculture and Forestry, Biosecurity New Zealand
- Ministry of Health
- Ministry of Fisheries
- Ministry for the Environment
- Department of Conservation
- Ministry of Tourism
- Ministry of Economic Development
- Ministry of Foreign Affairs and Trade
- Environmental Risk Management Authority
- New Zealand Customs
- New Zealand Food Safety Authority
- National Institute of Water and Atmospheric Research
- National Centre for Biosecurity and Infectious Disease
- Other Crown Research Institutes
- Local government
- Public health units
- Industry partners, including importers and exporters, and the agriculture, forestry, viticulture, horticulture, marine, transport and tourism sectors
- Non-governmental organisations, including voluntary and advocacy groups

Figure 47: Biosecurity risk continuum (potential for disease and disease-causing organisms to enter New Zealand)



Source: Adapted from MAF BNZ (2008a, p 11)

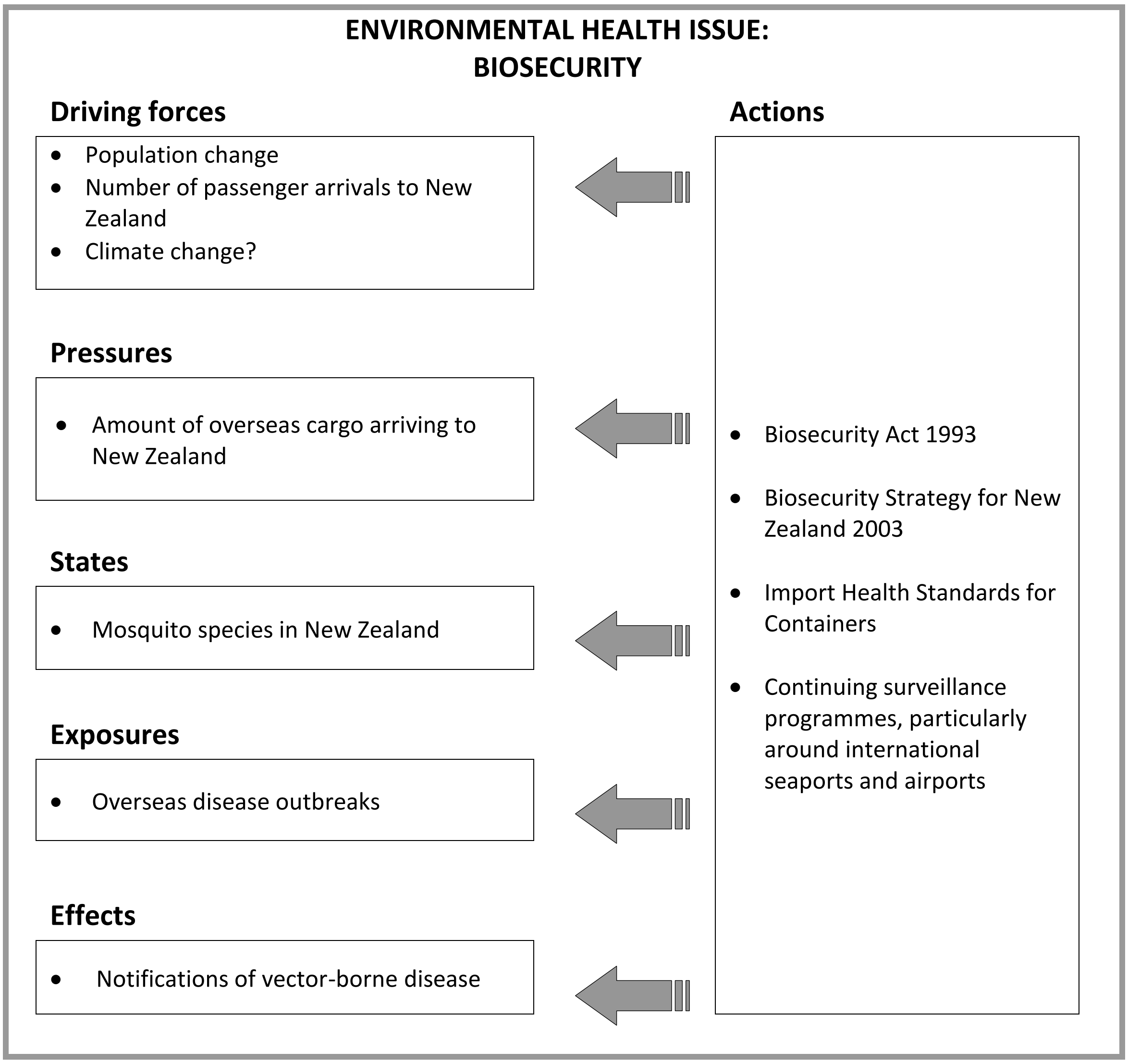
Overview of indicators

The key indicators for biosecurity included in the report are:

- state: distribution of potential disease-vector species in New Zealand
- exposure: overseas outbreaks of notifiable diseases
- effects: vector-borne disease notifications.

Figure 48 shows the indicators in the DPSEEA framework, and illustrates the driving force and pressure indicators related to biosecurity.

Figure 48: The DPSEEA framework for biosecurity environmental health indicators



State indicator: Distribution of potential disease-vector species in New Zealand

Indicator	Distribution and status of potential disease-vector species in New Zealand

Relevance of indicator

New Zealand's unique flora and fauna are facing increasing threats. Driving forces and pressures such as increased trade and tourism continue to increase the potential risk of border incursions of exotic species and organisms (MAF BNZ 2008c). These potential invasive species and organisms pose an ongoing biosecurity risk as they increase the potential for the introduced organisms and pathogens to become established.

Almost all vector-borne diseases in New Zealand result from overseas travel, although the potential for exposure to a disease vector from within New Zealand is increasing. Arboviruses (ie, viruses carried by insects) represent a potential risk, as some of the known or related vector species have been confirmed in New Zealand. For example, the Southern Saltmarsh mosquito, which was found in a number of locations around the country and successfully eradicated, is a known vector for Ross River fever.

Disease vectors tend to exist within certain ecological environments (Plant and Watson 2008). Environmental change associated with climate change (a rise in mean temperature and rainfall) in combination with increasing human encroachment into vector habitats can increase exposure to disease (Weinstein et al 1997). It is therefore important to monitor the distribution of known or potential disease-vectors.

Data source

Data are sourced from the MAF BNZ and the New Zealand BioSecure Entomology Laboratory, a laboratory service contracted by central government and run by Southern Monitoring Services Limited.

Results

Native mosquito species

The 12 native mosquito species, found throughout New Zealand (Weinstein et al 1997; Cane 2008), generally carry no risk as vectors for human disease. Two mosquitoes (*Culiseta tonnoiri* and *Culex pervigilans)* are capable vectors of the Whataroa virus, which is found in the wild bird population of Westland (Weinstein et al 1997; Cane 2008). This disease is not known to be zoonotic, and there are no confirmed records of human infection (Weinstein et al 1997; Derraik and Maguire 2005). Of greater risk to human health are species intercepted through biosecurity surveillance.

Introduced species

Table 12 presents the four non-native mosquito species that are potential arbovirus vectors in New Zealand. The first three were likely to have been introduced through shipping, while the Southern Saltmarsh mosquito was possibly introduced through either shipping or aircraft (S Gilbert, Ministry of Health, personal communication, November 2008).

Table 12: Introduced mosquitoes in New Zealand

Species	Date first found in New Zealand	Human diseases that the species is a potential vector for	Distribution in New Zealand
Culex (Culex) quinquefasciatus	1830s*	Periodic Filariasis, West Nile fever, and possibly Murray Valley encephalitis and Ross River fever	North Island, northern parts of South Island
Aedes (Finlaya) notoscriptus	1916**	Ross River fever, Barmah Forest, Dengue fever and possibly Murray Valley encephalitis	North Island, South Island to Lyttelton
Aedes (Halaedes) australis	1961*	A vector of the Ross River virus (in Tasmania and laboratory conditions) - not considered a major public health risk	Southern half of South Island
Aedes (Ochlerotatus) camptorhyncus Southern Saltmarsh Mosquito	1998*	Ross River fever and possibly Murray Valley encephalitis	Port areas, mainly North Island, but also the Marlborough region of the South Island (eradicated as of 2010)

Source: * Southern Monitoring Services Ltd (2010; Cane (2008)
** Weinstein et al (1997)

The Southern Saltmarsh mosquito (*Aedes camptorhyncus*) is a pest species in both Australia and New Zealand (New Zealand BioSecure Entomology Laboratory 2007; MAF BNZ 2010a and 2010b). The mosquito was found in 12 sites overall from 1998 to 2009, through routine surveillance (Table 13). An eradication programme is on track to eliminate the mosquito from all known sites by 2010 (MAF BNZ 2010a).

Table 13: Sites of Southern Saltmarsh mosquitoes found in New Zealand

Site	Region	Year first found	Date of eradication
Napier	Hawke's Bay region	1998	2003
Mahia	Hawke's Bay region	2001	2003
Tairawhiti	Gisborne region	2001	2004
Porangahau	Hawke's Bay region	2001	2004
Whitford	Auckland region	2002	2004
Mangawhai	Northland region	2002	2004
Coromandel	Thames–Coromandel region	2006	2009
Northern Kaipara	Northland region	2002	2007
Wairau	Marlborough region	2004	Expected 2010
Grassmere	Marlborough region	2004	2008
Whangaparaoa	Auckland region	2004	2007
Southern Kaipara	Auckland region	2002	2008

Source: MAF BNZ (2010a)

Intercepted species known to be disease vectors

Table 14 lists the mosquito species that have been intercepted at the New Zealand border from July 2001 to July 2009. Interceptions are defined as the detection of an exotic organism at the border before it enters the country. Of the 22 listed mosquito species, six (*Aedes aegypti, Culex sitiens, Aedes vigilax, Aedes polynesiensis, Aedes camptorhynchus* and *Aedes annulirostris*) were found in 2009. These six species are known to be human disease vectors.

Table 14: Exotic mosquitoes intercepted at the New Zealand border, 2001–2009

Species	2002	2003	2004	2005	2006	2007	2008	2009	Total 2001–2009
Aedes albopictus		1	2	2	1	3	2		11
Aedes japonicus	2	1		1					4
Aedes aegypti			1	3		1	1	2	8
Culex sitiens		1				2		2	5
Culex australicus				1	1				2
Aedes vigilax	1					1		1	3
Aedes polynesiensis			2					1	3
Aedes camptorhynchus			1					2	3
Aedes vexans									
Aedes alternans		1				1			2
Uranotaenia novobscura				1					1
Culex quinquefasciatus									
Tripteroides bambusa				1					1
Culex pipiens pallens									
Culex gelidus		1							1
Culex fusocephala									
Aedes sierriensis	1								1
Toxorhynchites speciosus.									
Aedes togoi							1		1
Aedes vittiger									
Aedes cooki									
Aedes annulirostris								1	1
Total	4	5	6	9	2	8	4	9	47

Source: Southern Monitoring Services Ltd; M Disbury, New Zealand BioSecure Entomology Laboratory, personal communication, 13 October 2008 and 12 February 2009

Aedes albopictus (the Asian Tiger mosquito) is of particular concern, and is considered a 'severe pest species' (New Zealand BioSecure Entomology Laboratory 2007). The mosquito is a vector of many arbovirus diseases, including dengue fever, Japanese encephalitis, Ross River fever, Chikungunya fever, Cache Valley virus disease and West Nile virus (New Zealand BioSecure Entomology Laboratory 2007). It has been intercepted at the New Zealand border more times (11) than any other exotic mosquito, and since 2003 has been intercepted at the New Zealand border in every year except 2009.

Exposure indicator: Overseas outbreaks of notifiable diseases

Indicator	Outbreaks overseas of notifiable diseases

Relevance of indicator

Biosecurity disease threats can enter New Zealand in a number of ways: from returning residents who were exposed and developed a disease while overseas; from people carrying disease who visit or migrate to New Zealand; and from organisms that enter via host/vector species or as result of trade imports (on or in goods coming into New Zealand) (Eberhart-Phillips 1999).

A number of emerging and resurgent zoonotic diseases are currently causing international concern. These include Lyme disease, Ebola and Marburg haemorrhagic fevers, Nipah virus/Hendra disease, West Nile fever, dengue fever, malaria, Chikungunya fever and avian influenza (A/H5N1) (McMichael 2005; Moore 2007).

Data source

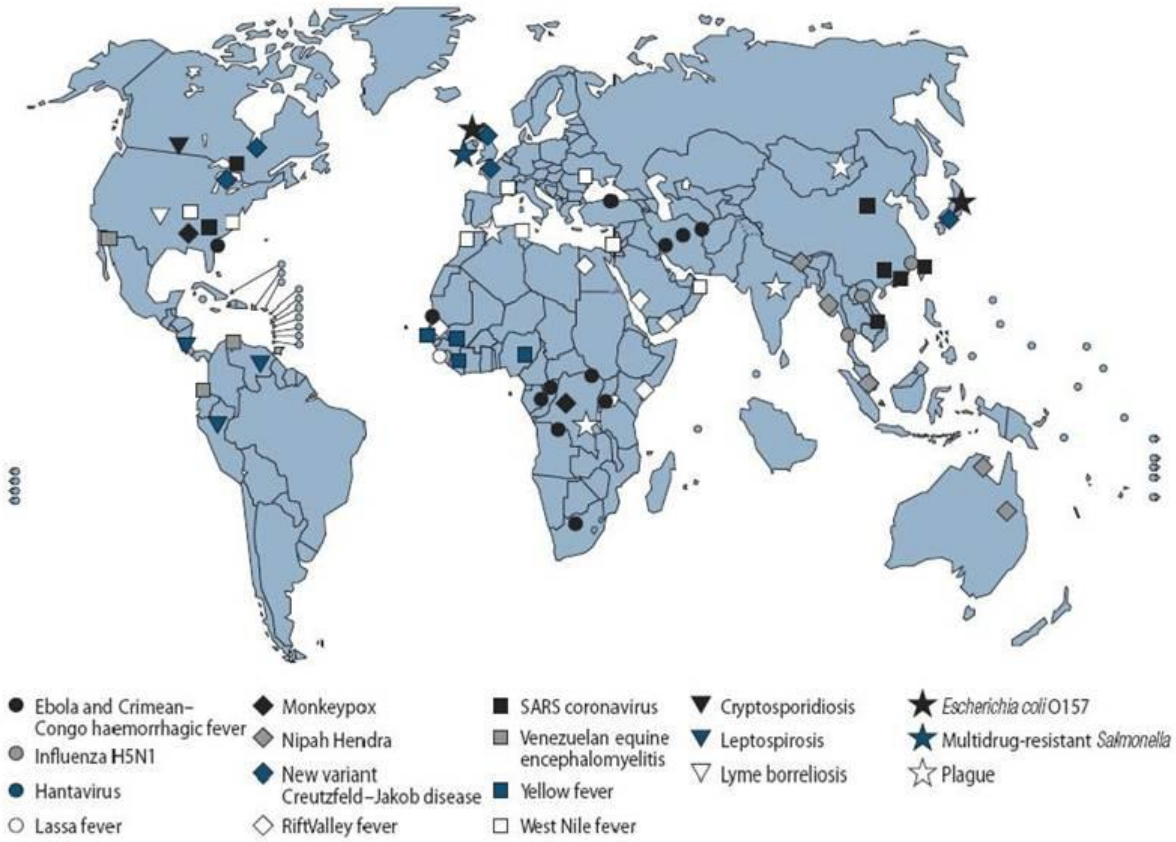
The data are from the WHO, principally the World Health Report and the Epidemic and Pandemic Alert and Response (EPR) programme (WHO 2009). All notifiable outbreaks reported on the WHO website are shown. To show the possible threats from a wide variety of diseases, the outbreaks include vector-borne disease as well as other infectious diseases.

Results

Many countries with key emerging and re-emerging infectious and notifiable diseases are found near New Zealand, and are also our key trading partners (eg, Australia, China and Singapore) (Figure 49).

In general, a larger number of countries in 2008 and 2009 experienced avian influenza outbreaks than other outbreaks. The exceptions were meningococcal disease, which was found across 13 countries in central Africa in 2008 (with three countries reporting above the epidemic threshold), and yellow fever, which was found in six countries in 2009.

Figure 49: Selected emerging and re-emerging infectious diseases in the world, 1996–2004



Source: WHO (2007)

Table 15: International notifiable disease outbreaks by country, 2008–2009

Disease	2008	2009
Avian Influenza (A/H5N1)	Bangladesh, China, Egypt, Indonesia, Pakistan, Vietnam, Cambodia,	Cambodia, Vietnam, Egypt, China, Indonesia
Cholera	Guinea Bissau, Iraq, Vietnam, Zimbabwe	Zimbabwe
Dengue haemorrhagic fever	Brazil	
Ebola haemorrhagic fever	Democratic Republic of Congo, Uganda	Democratic Republic of Congo, Phillippines
Enterovirus	China	–
Extensively Drug-Resistant Tuberculosis	–	–
Malaria	–	–
Marburg Haemorrhagic Fever	Netherlands, Uganda	–
Meningococcal disease	13 countries of the African meningitis belt	Chad, countries of the African Meningitis Belt
Poliomyelitis	Nigeria	Nigeria, West Africa, Sudan
Rift Valley Fever	Madagascar, Sudan	
Yellow Fever	Brazil, Central African Republic, Côte d'Ivoire, Guinea, Liberia, Paraguay, Burkina Faso	Cameroon, Guinea, Republic of Congo, Liberia, Central Africa Republic, Sierra Leone

Source: WHO (2010)

Many of the countries with bird and/or human cases of avian influenza (A/H5N1) are geographically close to and important economic partners for New Zealand (Table 16). A number of countries are also the places of residence for relatively large numbers of overseas passengers arriving to New Zealand (eg, from China, Indonesia and Thailand), as shown in Figure 8: (Chapter 3).

Table 16: Number of confirmed human cases and deaths of avian influenza (A/H5N1) reported to the World Health Organization, by country and year, 2003–2009

Country	2003	2004	2005	2006	2007	2008	2009	Total 2003–2009
Azerbaijan				8 (5)				8 (5)
Bangladesh						1 (0)		1 (0)
Cambodia			4 (4)	2 (2)	1 (1)	1 (0)	1	9 (7)
China	1 (1)		8 (5)	13 (8)	5 (3)	4 (4)	7(4)	37 (24)
Djibouti				1 (0)				1 (0)
Egypt				18 (10)	25 (9)	8 (4)	39 (4)	90 (27)
Indonesia			20 (13)	55 (45)	42 (37)	24 (20)	21 (19)	162 (134)
Iraq				3 (2)				3 (2)
Laos					2 (2)			2 (2)
Myanmar					1 (0)			1 (0)
Nigeria					1 (1)			1 (1)
Pakistan					3 (1)			3 (1)
Thailand		17 (12)	5 (2)	3 (3)				25 (17)
Turkey				12 (4)				12 (4)
VietNam	3 (3)	29 (20)	61 (19)		8 (5)	6 (5)	5 (5)	112 (57)
Total	4 (4)	46 (32)	98 (43)	115 (79)	88 (59)	44 (33)	73 (32)	468 (282)

Notes: Only includes laboratory-confirmed cases. All dates refer to the date of onset of the illness.
Source: WHO (2010)

Effects indicator: Vector-borne disease notifications

Indicator	Vector-borne disease notifications in New Zealand 1997–2009

Relevance of indicator

Vector-borne disease is an important environmental health issue, and is inherently linked to the environment. Vector-borne zoonotic diseases, which can pass from animals to humans, involve four agents: the human victim, the pathogen, the vector and the (wildlife) reservoir (Ostfeld et al 2006). For example, West Nile fever is caused by the West Nile virus pathogen, transmitted by mosquito vector from a reservoir of wild birds (Heymann 2004; Stürchler 2006). Pathogens causing particular diseases can be carried by different vector species and be hosted by different wildlife reservoirs.

Pathogens coexist parasitically with wildlife reservoirs, and vectors act as obliging modes of transport helping pathogen dispersal (Holt and Dobson 2006). The opportunity for human–wildlife interaction continues to increase, as human environmental activity expands and encroaches into native forest and previously undeveloped land. Increased human exposure to wildlife results in the opportunistic emergence of new human diseases and a greater likelihood of transmission of known disease pathogens (Moore 2007; Goldberg et al 2008). As a result, newly emerging and pre-existing vector-borne diseases will continue to be an important environmental health issue.

Data source

Data for the notifications of the main vector-borne diseases for 1997–2009 were sourced from EpiSurv (ESR).

Data have also been presented for two travel-related exposure risk factors for these diseases. The first is having been overseas during the incubation period of the disease. The second is having undertaken previous overseas travel that may have been related to the disease. For some notifications, one or both of these risk factors were recorded as 'unknown'.

The quality of these data cannot be independently verified. Given the legal status of notifiable disease data, it is expected that the number of notified cases will be an accurate reflection of laboratory-confirmed and EpiSurv-recorded data. However, there may be a greater degree of variability in the completeness and accuracy of the associated data on risk factors. This variability can in part be the result of the individual (the case) failing to provide full or accurate information.

Results

Between 1997 and 2009 the most commonly notified vector-borne diseases in New Zealand were malaria and dengue fever (Table 17). There were also several more rare diseases that had on average a few notifications each year, such as Rickettsial disease and Ross River virus.

Table 17: Number of notifications of vector-borne diseases in New Zealand, 1997–2009

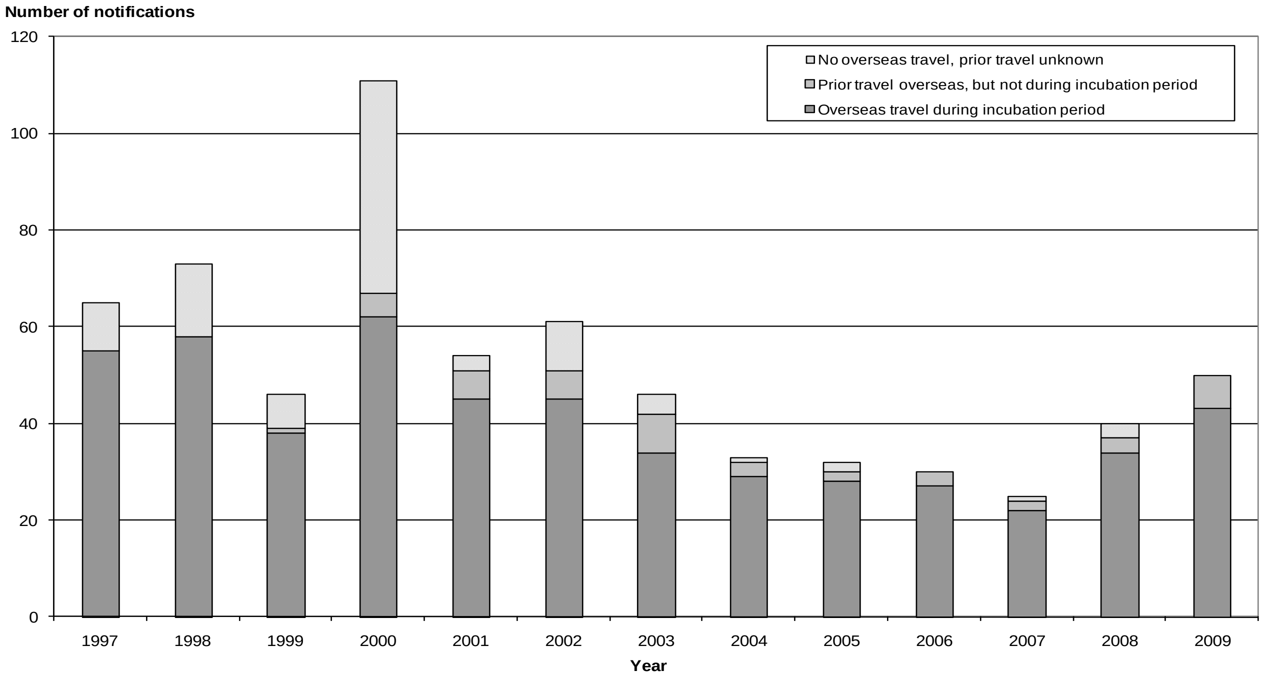
Disease	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total
Malaria	65	73	46	111	54	61	46	33	32	30	25	40	50	666
Dengue fever	14	26	9	7	93	70	55	8	11	19	114	113	140	679
Rickettsial disease	1			10	5	6	1	2	1			10	6	42
Ross River virus	1	1	1	2	3	1	1	5	1	2		1	3	22
Cysticercosis									3		2			5
Barmah Forest virus infection			1					1	2			0	2	6
Chikungunya fever											1	1	1	3
Japanese encephalitis								1						1
Lyme disease										1				1
Total	81	100	57	130	155	138	103	50	50	52	142	165	202	1425

Source: EpiSurv (ESR)

The number of cases with individual vector-borne diseases has continued to increase since 2007, and in 2009 the highest number of cases (202) since 1997 was notified. Figure 50 shows the number of malaria notifications fell continuously from a peak of 111 cases in 2000, to 25 cases in 2007. In contrast, the number of malaria notifications increased during 2008 (40 cases) and 2009 (50 cases).

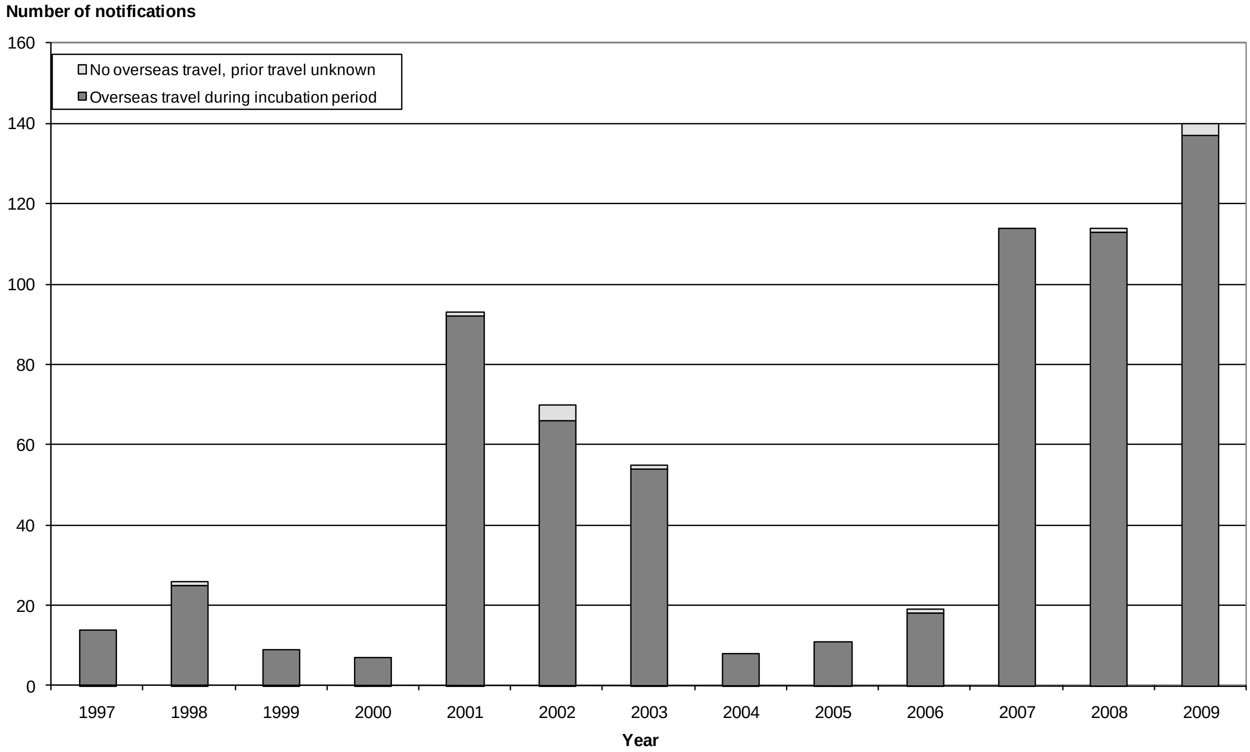
There was a marked increase in dengue fever notifications from 2006 (19 cases) to 2009 (140 cases) (Figure 51). In addition, three cases of dengue fever had no prior overseas travel, or it was not known whether there was prior travel. There have been outbreaks of dengue fever in a number of Pacific Islands and in Queensland, Australia during this period.

Figure 50: Number of notifications of malaria in New Zealand, by exposure risk factor and year, 1997–2009



Source: EpiSurv (ESR)

Figure 51: Number of notifications of dengue fever cases in New Zealand, by exposure, risk factor and year, 1997–2009



Source: EpiSurv (ESR)

There were 22 notifications of Ross River fever in 1997–2009. However, studies have suggested that 25–95% of infections of Ross River fever are unapparent (Stürchler 2006), particularly in children (Heymann 2004).

It is important to monitor the travel-related risk factors for these diseases to determine whether cases are contracting the disease outside of or within New Zealand. Furthermore, it is important to take into account the characteristics of each disease during monitoring, as diseases such as malaria can keep recurring a long time after first exposure.

The majority of cases of vector-borne disease were overseas during the incubation period, while others had previous overseas travel as a possible risk factor for disease (Table 18). Overall, 83% of malaria cases and 98% of dengue fever cases reported overseas travel at some point, while for the remaining cases it was not known whether there had been prior travel. Additionally, there were four diseases where all notified cases from 1997 to 2009 had reported being overseas during the incubation period. These diseases were Barmah Forest virus disease, Chikungunya fever, Japanese encephalitis and Lyme disease – all of which are rare in New Zealand. The results suggest that exposure almost certainly occurred overseas.

Table 18: Number of notifications of vector-borne diseases in New Zealand, by exposure risk factors, 1997–2009

Disease	Number of notifications					Proportion travelled overseas, either during incubation or prior to illness (%)
	Overseas travel during incubation period	Prior travel overseas, but not during incubation period	No overseas travel, no prior travel	No overseas travel, prior travel unknown	All notifications 1997–2009	
Malaria	520	46		100	666	85
Dengue fever	667			12	679	98
Rickettsial disease	7		20	12	39	18
Ross River fever	19			3	22	86
Cysticercosis	4			1	5	80
Barmah Forest virus infection	6			0	6	100
Chikungunya fever	3				3	100
Japanese encephalitis	1				1	100
Lyme disease	1				1	100

Source: EpiSurv (ESR)

Actions relating to biosecurity and health indicators

Recently, biosecurity actions have become more focused on protecting human health and indigenous environments. To continue managing biosecurity risks, it will be of increasing importance to maintain biosecurity surveillance and protection.

Biosecurity Act 1993

Inaugural biosecurity legislation was introduced in New Zealand with the Biosecurity Act 1993. This legislation mainly established Pest Management Strategies for each of the important pests in New Zealand (MAF 1997). The Act specifies that strategies are to be developed at both the national and regional levels, and it defines the role and responsibilities of pest management agencies in the control of pests. In addition, section 22 of the Biosecurity Act 1993 outlines a Risk Analysis that should be implemented. It identifies all the appropriate measures for effectively managing the risks posed by unwanted and threatening organisms.

As a result, each regional council in New Zealand has an updated Regional Pest Management Strategy. Furthermore, the Biosecurity Act 1993 has established co-operation among agencies at all levels.

Biosecurity Strategy for New Zealand 2003

In 2003 the Biosecurity Strategy for New Zealand became effective, covering slightly different aspects from the Biosecurity Act 1993. The Strategy sets an overall direction for biosecurity, and identifies areas of priority for biosecurity programmes. It applies to primary production, public health, and indigenous terrestrial, marine and freshwater environments. In addition, it provides guidance to all agencies involved in biosecurity, and raises public awareness and understanding of biosecurity. In 2007 the Biosecurity Science, Research and Technology Strategy for New Zealand was implemented to address the scientific implications of the original Biosecurity Strategy.

Biosecurity New Zealand and the Biosecurity Surveillance Strategy 2020

One of the key outcomes of the Biosecurity Strategy was the creation of Biosecurity New Zealand, a division of MAF (Biosecurity Council 2003). Biosecurity New Zealand was formed on 1 July 2007, from the integration of MAF Biosecurity and MAF Quarantine Services, as a single agency to be accountable for the full range of biosecurity activities.

MAF BNZ is charged with the leadership of the New Zealand biosecurity system. It has developed the Biosecurity Surveillance Strategy 2020 (MAF BNZ 2008a), which defines the desired future state of biosecurity surveillance within New Zealand.

Import standards

More specific legislation has evolved since the introduction of the Biosecurity Act 1993, mainly around import standards and health risks from pests, which are some of the key driving forces and pressures for biosecurity and health in New Zealand. For instance, the Import Health Standard for Containers (implemented in September 2003) specifies the requirements to be met for reducing biosecurity risks associated with importing sea containers and associated packaging of containerised cargo into New Zealand (MAF 2003). The Import Health Standard for Equipment (October 2007) mitigates the possible adverse effects of bringing wet sporting equipment into New Zealand (MAF BNZ 2008b).

Health-related actions for biosecurity attempt to minimise adverse health caused by people and alien species entering New Zealand. For example, the Maritime Declaration of Health (2005), in co-ordination with the International Health Regulations 2005, requires all vessels arriving in New Zealand to report to health authorities on the health conditions on board during the voyage and the health status of passengers and crew (Ministry of Health 2007). The National Centre for Disease Investigation, the Exotic Disease Response Standard and the Exotic Disease system incorporate field investigations, diagnosis, management and control of exotic diseases with the exotic disease surveillance and laboratory diagnosis functions (MAF BNZ 2008c).

Biosecurity in practice

There are three levels of biosecurity in New Zealand (Biosecurity Council 2003). Biosecurity starts at the international level, with the gathering and exchange of information and intelligence on emerging risks. This level is implemented through international agreements and standards.

At the second level, border activities provide security at the point at which people and goods enter into (and exit from) New Zealand by air and sea craft. This level is implemented at the border by detection, inspection and quarantine activities.

Finally, risk management activities are carried out post-border to mitigate the impacts of pests and diseases that have crossed the border into New Zealand. This level is implemented post-border through surveillance strategies and incursion response programmes.

Discussion

Risk organisms entering the country can pose serious threats to the environment and to ecosystems. Biosecurity efforts are crucial for minimising the impact of risk organisms on our economic, environmental, health and social/cultural values in New Zealand. This chapter has focused on the specific environmental health issue of vector-borne disease, which is one of the negative impacts of a potential biosecurity breach.

Current low level of risk

The risk of an outbreak of vector-borne disease within New Zealand is currently relatively low. There is a low risk of an arbovirus becoming established in New Zealand through an introduced vector, because potential host species in New Zealand are low in number and limited in their geographic spread. Biosecurity surveillance and eradication programmes are well established within New Zealand, reducing the risk of an incursion. However, one example of a potential risk was the Southern Saltmarsh mosquito, a host for Ross River virus. There have been 22 cases of Ross River fever notified in New Zealand over the past 13 years.

Driving forces and pressures on biosecurity and health

The pressures on biosecurity emphasise the importance of continuing to conduct monitoring and surveillance of biosecurity threats. The overall driver of the biosecurity risk to New Zealand is globalisation, which is increasing the flows of people, goods and vectors across borders. Pressures such as these continue to impact on biosecurity in New Zealand. For example, there has been a large increase in the number of people entering New Zealand, increasing the risk of an incursion. This growth in arrivals has been driven by tourism and by increased numbers of New Zealanders travelling overseas and then returning. Economic growth has also been driving these trends as well as increasing the volume of imports of goods into New Zealand.

Risk of a vector species entering New Zealand

New Zealand has close ties with many countries where vector species are endemic. There are a number of arboviruses (arthropod-borne diseases) that are common in New Zealand's close neighbours, including Australia and the Pacific Islands. These include diseases in the biological groupings of alphaviruses (such as Barmah Forest virus, Chikungunya fever and Ross River virus) and flaviviruses (particularly dengue fever and, to a lesser extent, Japanese encephalitis) (Bailey et al 2004; Heymann 2004; Stürchler 2006). These close connections with nearby countries that contain vector species increase the risk of one of these vector species entering New Zealand.

Risk of a vector species becoming established in New Zealand

There is also an increased risk of a vector species becoming established in New Zealand, with a potential change of habitat as a result of climate change and changes in land use. Warmer temperatures as a result of climate change could make the New Zealand environment more habitable for many vector species, and changing land use and increasing human encroachment from land-use development increase the likelihood of exposure to vectors and vector-borne diseases. Overall, these combined pressures on the New Zealand environment mean that it is important to continue biosecurity monitoring, surveillance and eradication measures.

Other health effects related to eradication of exotic species

It is important to note that eradication measures for exotic species also have potential environmental health relevance, even where the organism is not considered to pose a direct human health risk. Some pests (eg, agricultural pests) could have a large negative impact on the country's economy if they became established in New Zealand, and for this reason, some pest incursions require robust eradication programmes.

When considering options on how best to control a pest incursion, MAF BNZ is required to ensure that decision-making takes into account a range of risk factors that might affect human health and lifestyle (Ministry of Health 2006a). Aside from the toxicity of the chemical or biological agent, which is assessed and controlled by the approval issued for its use under the Hazardous Substances and New Organisms Act 1996 (Barratt et al 2000), the potential for adverse health can relate to the mode of deployment of the eradication agent.

An example of giving consideration to the mode of deployment comes from the aerial spraying of Foray 48B in the painted apple moth (PAM) eradication programme. Experience from the PAM programme indicated the possibility of some health effects 'categorised as minor irritations or allergic reactions involving the upper respiratory system, skin and/or eyes, and feelings of anxiety and/or frustration about being exposed to the spray' (Ministry of Health 2006a). Two recent literature reviews (Ministry of Health 2004, 2006a) and a birth defects study (Ministry of Health 2006b) concluded there was little or no discernible epidemiological evidence of any ill-health effect on the public from exposure to the aerial spraying of Foray 48B.

Summary

As trade and international travel increase, New Zealand will continue to face potential biosecurity incursions that threaten our environment, economy, society, and human health and wellbeing. This ongoing potential highlights the importance of continuing to conduct biosecurity surveillance. In relation to vector-borne disease, it will be important to monitor overseas outbreaks of vector-borne disease and the spread of vector species within New Zealand, and to continue to minimise the risk of a vector entering the country through constant vigilance and surveillance.

Chapter 8: Summary of key findings

The environment plays an important role in the health and wellbeing of a population. It provides our basic needs for leading healthy lives, including clean air and fresh water. Monitoring of environmental health is important, as robust and reliable scientific information provides key information for decision-makers, environmental health practitioners and the community.

Air quality and health

Air quality is a critical aspect of environmental health in New Zealand, and is paramount for health and wellbeing. Air pollutants include particulate matter and toxic gases such as nitrogen dioxide. Pressures on ambient air quality include home heating, vehicle emissions, industrial processes and power stations, as well as natural sources. Indoor air quality can be affected by tobacco smoke and by fuels used for cooking and heating. Human health effects from poor air quality (indoor and outdoor/ambient air) include respiratory problems, particularly in the young and old, and in people with pre-existing medical problems.

Trends in New Zealand suggest there will be increasing pressures on air quality in the future, coming from population growth and urbanisation (with high population density in the cities), increasing energy consumption and increasing numbers of cars. These pressures may be offset by improved technology to reduce emissions, for example by using clean heating and more efficient vehicles. There have been improvements in some of the key pressures on air quality, for example a decline in the use of wood and coal burners for home heating.

However, in 2008 over half of all monitored airsheds did not meet the National Environmental Standards for Air Quality for particulate matter (PM_{10}). Of particular note were the 17 South Island airsheds, none of which met the national standards. The exceedance days they recorded are thought to be the result of a higher use of wood and coal burners, as well as colder temperatures and weather conditions.

Currently, the National Environmental Standards for Air Quality have severe penalties for industry in airsheds that do not meet the ambient standard for PM_{10} by 2013. In 2009 over half of the monitored airsheds did not meet the PM_{10} standard. The standards are currently under review and it is proposed that the severe penalties for industry be either removed or modified. The target compliance date of 2013 is similarly under review. Irrespective of the proposed changes, there will need to be further reductions in emissions of PM_{10} in order to meet the ambient standard.

Summary of key findings for air quality and health

Driving forces and pressures

- The New Zealand population has more than doubled over the past 50 years, to over 4 million people in 2006. In some territorial authorities the population increase has been greater than 20% over the past 10 years. In the Queenstown-Lakes District the increase has been 60.7%.
- The amount of energy consumed continues to increase. In 2008 about a third of all energy consumed was by the 'unallocated' sector, mainly private transport, and a further 10% by the transport industry.
- The number of vehicles continues to increase. Compared with similar countries, in New Zealand the number of cars per population is very high (694 cars per 1000 people), and vehicles are relatively old (with an average age for light vehicles of 11 years).
- In 2006 a large proportion of dwellings used wood fires (39.0%) or coal fires (6.7%) to heat their houses, a marked decrease since 1996.

State

- In 2009, 27 of the 40 monitored airsheds in New Zealand breached the national standard for particulate matter. The airsheds with the highest concentrations of PM_{10} in 2009 were in Rotorua, Otago 1, Mosgiel, Invercargill, Timaru and Hastings.
- In 2007 and 2008 – for the first time since 2004, when the standards were introduced – the national environmental standards for CO, NO_2 and SO_2 were not breached at any monitoring sites. Overall, 13 of the 20 DHBs had at least one airshed exceeding the PM_{10} National Environmental Standards for Air Quality in 2009.

Exposure

- Almost one in 10 children (9.6%) was exposed to second-hand tobacco smoke in the home in 2006/07, and one in 15 non-smoking adults (7.5%) aged 15 years and over. Māori and people living in more socioeconomically deprived areas were more likely to be exposed to second-hand tobacco smoke in their home, compared with other people.
- There were high rates of exposure to second-hand smoke in the home for children living in the Waikato DHB and in the combined area of Northland, Tairawhiti, Hawke's Bay, Lakes and Whanganui DHBs.

Effects

- In 2007 there were high hospitalisation rates for respiratory disease (5120 per 100,000) among children aged 0–4 years.
- There were high hospitalisation rates for respiratory disease for children aged 0–4 years in the Northland, Counties Manukau, Lakes, Bay of Plenty, Tairawhiti, Hawke's Bay, Whanganui, Hutt, Wairarapa and Canterbury DHBs.

Actions

- The National Environmental Standards for Air Quality implemented national standards for five air pollutants (PM_{10}, NO_2, SO_2, CO and O_3), banned certain toxins from being discharged into the air, and introduced a design standard for new wood burners.
- There has been a variety of initiatives to improve air quality, including transport initiatives at the national level (eg, as of January 2008 all imported vehicles must meet recent emission standards (Ministry for the Environment 2010b)) and the local level (eg, giving free exhaust emission checks).

Water quality and health

Water quality is another important environmental health issue in New Zealand. Clean and safe drinking-water is essential for human health and wellbeing. Water (including drinking-water and recreational water) can become contaminated with toxins, excessive nutrients and human and animal wastes. Contamination of drinking-water and recreational water can lead to health problems, including gastrointestinal (enteric) diseases.

Overall, New Zealand enjoys relatively clean and plentiful freshwater and healthy offshore marine environments by international standards. However, driving forces such as population growth have increased pressures on the quality of freshwater and coastal marine water in New Zealand, by encouraging agricultural and urban development. The dramatic increase in the number of dairy cattle in the South Island over the past 15 years may, in some cases, place pressures on water allocation and quality.

Not everyone in the population has access to safe drinking-water and safe recreational water. The proportion of the population with access to safe drinking-water has increased over the past 10 years, but 20% of the population do not have access drinking-water that is bacteriologically safe, and 24% do not have access to protozoally safe drinking-water. In addition, 71.2% of all monitored marine beaches and 46.9% of all monitored freshwater beaches were suitable for swimming 'almost all of the time'.

There has been a recent decrease in the rate of water-borne disease (campylobacteriosis, giardiasis and cryptosporidiosis) with risk factors of untreated drinking-water or use of recreational water, although the reason for these decreases is unknown.

In future, the aim will be to continually increase the proportion of the population with safe recreational water and safe drinking-water, and to encourage local authorities and drinking-water suppliers to comply with the drinking-water standards, in order to maintain and improve the health and wellbeing of the New Zealand population.

Summary of key findings for water quality and health

Pressures

- The number of dairy cows in the South Island has increased markedly over the past 15 years, which may have had implications for water quality (due to run-off of fertilisers and effluent) and water allocation (due to irrigation).

State

- In the 2008–2009 bathing season, 71.2% of all monitored recreational marine beaches were suitable for swimming 'almost all of the time'.
- In 2008–2009, 54.6% of all monitored freshwater beaches were suitable for swimming 'almost all the time'. A number of territorial authorities had beaches that were 'often unsuitable for swimming'.

Exposure

- In 2008/09, 80% of the population had access to drinking-water that was bacteriologically (*E. coli*) compliant, but one in five people (20%) did not.
- In 2008/09, 76% of the population had access to drinking-water that was protozoally (*Cryptosporidium*) compliant, but one in four people (24%) did not.
- In 2008/09, 11% of the population was not served by a registered reticulated drinking-water supply.

Effects

- From 2001 to 2009 there were decreases in the rates of campylobacteriosis, cryptosporidiosis and giardiasis with a risk factor of either drinking untreated water, or having contact with recreational water at a marine or freshwater beach.

Actions

- The Drinking-water Standards for New Zealand 2005 (revised in 2008) include water quality standards and compliance levels (eg, for bacteriological and protozoal levels).
- The Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (2003) set guidelines for the allowable microbiological concentration in water.
- Additional actions are being implemented to improve water quality. For example, the Dairying and Clean Streams Accord has targets for excluding stock from waterways and dairy effluent discharge compliance.

Biosecurity and health

Biosecurity involves protecting the economy, environment and health of the population from the introduction of foreign risk organisms, as well as mitigating the effects of organisms already present in the environment. One type of biosecurity risk is vector-borne diseases (infectious diseases passing from animals to humans via a vector such as a type of insect), which are an important global environmental health issue. Increasing globalisation, as well as changes in the environment and habitats, means that it is important for countries such as New Zealand to monitor the risk and spread of vector-borne diseases, and to maintain vigilance in surveillance.

Results suggest that there is a low risk of an arbovirus becoming established in New Zealand through an introduced vector, because potential host species are low in number and limited in their geographic spread.

There are a number of pressures on biosecurity in New Zealand. These include the arrival of over 4.4 million visitors, over 17 million tonnes of cargo and over 550,000 sea containers to New Zealand each year. Many of these people and much of the cargo come from nearby countries (such as the Asian region) where vector species are endemic. These pressures emphasise the importance of continuing to conduct monitoring and surveillance of biosecurity risks, as trade and international travel continue to increase.

Summary of key findings for biosecurity and health

Driving forces and pressures

- There were over 4.4 million passenger arrivals to New Zealand in 2009, including approximately 2.5 million short-term overseas visitors.
- In 2009 about 17.4 million tonnes of cargo and over 550,000 sea containers were imported into New Zealand.

State

- In New Zealand, there are only a few species of exotic mosquitoes known to be vectors for a notifiable infectious disease.
- From 2002 to 2009 there have been a total of 47 interceptions of mosquitoes at the New Zealand border.
- The Southern Saltmarsh mosquito, a disease vector for Ross River fever and a pest species in New Zealand, is on track to be eliminated through eradication programmes from all 12 sites in New Zealand by 2010.

Effects

- There were 1425 notifications of vector-borne disease in New Zealand between 1997 and 2009, 367 of which occurred between 2008 and 2009 alone.
- Between 2000 and 2007 the annual reported number of malaria cases decreased from 111 to 25. There were 40 cases in 2008 and 50 cases in 2009.
- In 2009 there were 140 cases of dengue reported, compared with 114 in 2007 and 19 in 2006.

Actions

- The Biosecurity Act 1993 established Pest Management Strategies for each of the important pests in New Zealand, while the Biosecurity Strategy for New Zealand 2003 identifies areas of priority for biosecurity programmes, also covering public health.
- The Import Health Standard for Containers specifies requirements to be met for reducing biosecurity risks associated with importing sea containers and cargo into New Zealand.
- In practice, there are three levels of biosecurity in New Zealand: (a) globally, through international agreements and standards; (b) at the border, through detection, inspection and quarantine activities; and (c) post-border, through surveillance strategies and incursion response programmes.

Conclusion

The report draws attention to some of the key issues in environmental health in New Zealand, with a particular focus on air quality, water quality and biosecurity. There are a number of pressures on the environment, including from the effects of population growth, increasing energy consumption and increasing numbers of vehicles on the road.

The majority of drinking-water is safe to drink, although there is room for improvement, as a proportion of drinking-water supplies is not meeting the drinking-water standards. There were similar findings regarding air quality, with a large number of airsheds exceeding air pollution guidelines at least once during the year. The biosecurity chapter showed that the importance of maintaining biosecurity efforts, as a means of keeping pests and diseases out of New Zealand, may be growing.

This report has not covered the full range of environmental health issues facing New Zealanders today. Other issues that it has not addressed include:

- Māori and environmental health
- land-use practices
- intensification of agriculture
- lack of heating
- obesogenic environments
- traffic injury and mortality
- food safety
- occupational health risks
- housing
- waste and sanitation
- climate change
- the built environment.

It is critical to continue monitoring and addressing environmental health issues such as water quality, air quality and biosecurity, as well as other important environmental health issues, to ensure that future generations of New Zealanders can enjoy the natural resources of this country without exposure to environmental hazards and subsequent poor health.

Appendix A: Reference Maps

Figure A.1: Map of District Health Boards in New Zealand

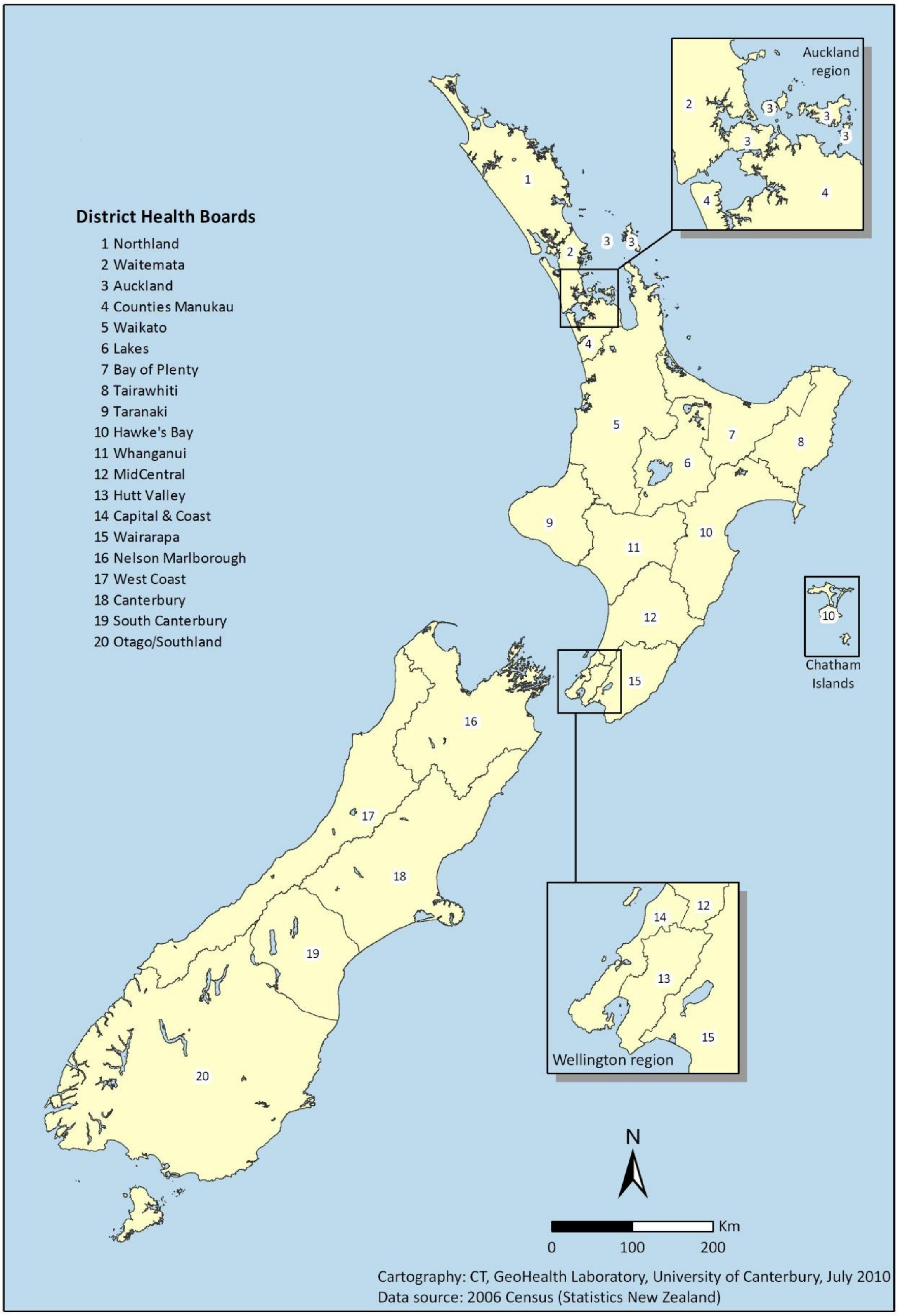
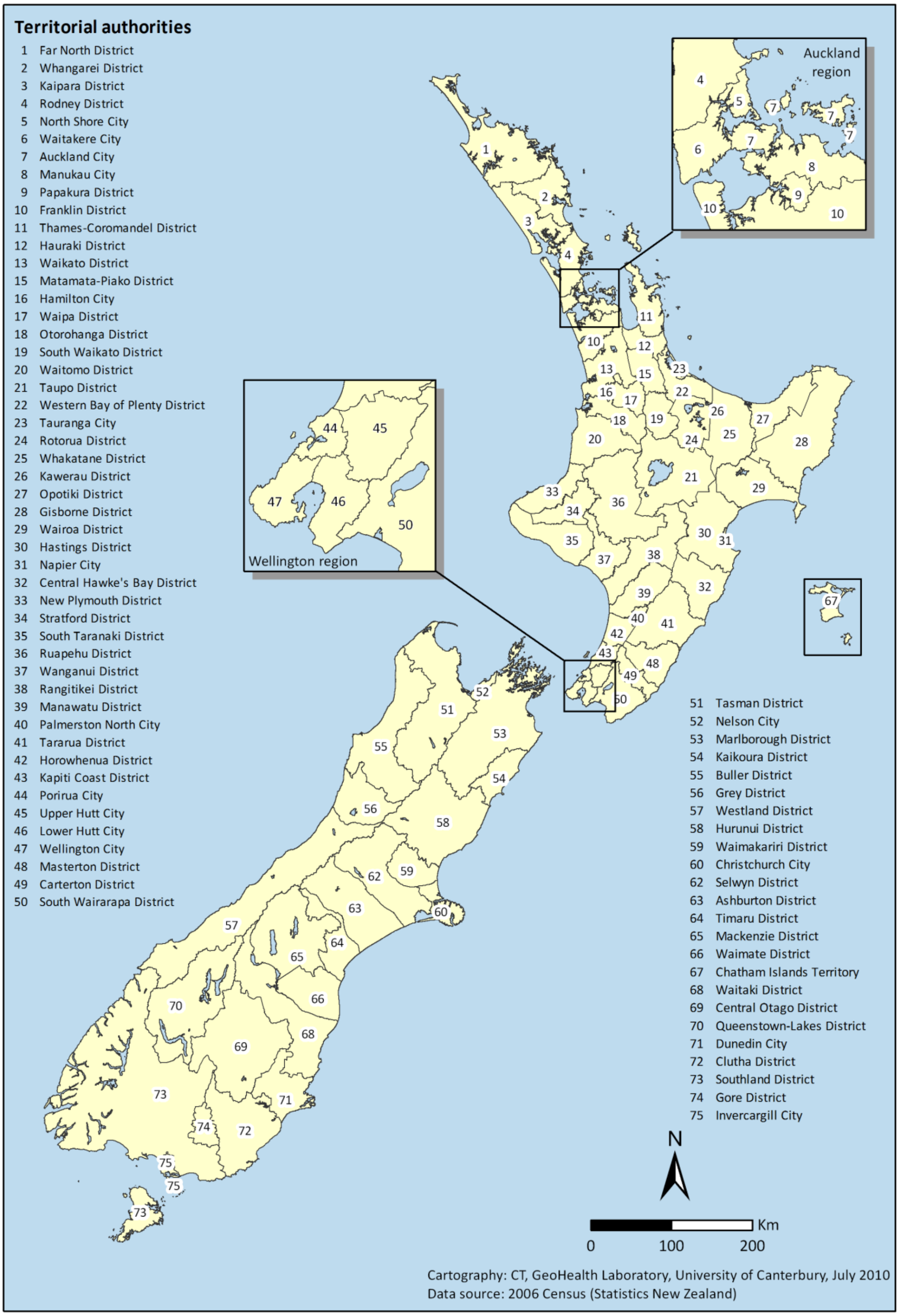


Figure A.2: Map of territorial authorities in New Zealand



Appendix B: Summary of Population Characteristics

Table B.1: Estimated 2006 Census population characteristics by DHB

Source: Statistics New Zealand (2010c)

District Health Board	2006 Census usually resident population	Population aged 0–4 years (%)	Population aged 65+ years (%)	Māori (total response) (%)	Pacific (total response) (%)	Population living in NZDep2006 deciles 7–10 (%)
Northland	148,440	6.9	14.5	29.3	2.5	57.1
Waitemata	481,611	6.8	11.0	8.9	7.3	26.3
Auckland	404,619	6.4	9.6	7.4	12.4	40.1
Counties Manukau	433,086	8.4	8.8	15.5	21.5	51.1
Waikato	339,192	7.2	12.6	19.9	3.1	45.7
Lakes	98,319	7.7	11.9	31.9	3.7	51.5
Bay of Plenty	194,931	6.8	15.9	23.4	1.9	45.4
Tairawhiti	44,463	8.2	12.0	44.4	2.9	65.5
Taranaki	104,277	6.6	14.8	15.2	1.3	41.1
Hawke's Bay	148,248	7.1	13.9	22.9	3.6	47.3
Whanganui	62,211	6.5	15.7	23.2	2.2	54.4
MidCentral	158,841	6.6	14.1	16.8	2.9	45.2
Hutt	136,101	7.3	11.3	15.8	8.6	41.3
Capital and Coast	266,658	6.6	10.5	9.9	8.2	28.2
Wairarapa	38,613	6.3	16.4	14.2	2.2	44.5
Nelson Marlborough	130,062	6.0	14.7	8.4	1.3	32.1
West Coast	31,326	6.1	13.8	9.3	0.9	51.2
Canterbury	466,407	6.3	13.4	7.2	2.2	29.6
South Canterbury	53,877	5.5	18.0	5.9	0.8	30.4
Otago	179,397	5.5	14.4	6.4	1.7	32.6
Southland	106,827	6.5	12.9	10.6	1.5	31.2
Total	**4,027,947**	**6.8**	**12.3**	**14.0**	**6.6**	**39.5**

Table B.2: 2006 Census population characteristics by territorial authority

Territorial authority	2006 Census usually resident population	Population growth 1996–2006 (%)	Population aged 0–4 years (%)	Population aged 65+ years (%)	Māori (total response) (%)	Pacific (total response) (%)	Population living in NZDep2006 deciles 7–10 (%)	Population living in urban areas (%)
Far North District	55,845	5.5	7.0	13.8	39.6	2.8	71.1	39.8
Whangarei District	74,463	11.6	6.8	14.9	23.6	2.3	47.5	65.9
Kaipara District	18,135	4.4	7.2	15.0	21.0	2.5	53.4	24.5
Rodney District	89,559	34.7	6.3	14.9	8.3	2.0	16.5	68.7
North Shore City	205,605	19.4	6.1	10.8	6.1	3.2	11.0	100.0
Waitakere City	186,444	19.8	7.9	9.3	12.3	14.4	47.9	98.7
Auckland City	404,658	17.0	6.4	9.6	7.4	12.4	40.1	99.8
Manukau City	328,968	29.4	8.5	8.3	14.4	26.3	55.2	98.9
Papakura District	45,183	13.8	8.2	10.1	25.2	9.7	55.2	100.0
Franklin District	58,932	23.2	7.7	10.5	14.5	3.4	25.0	53.1
Thames-Coromandel District	25,938	4.5	5.3	21.2	15.5	1.2	47.1	64.9
Hauraki District	17,193	-0.7	6.3	17.0	18.5	2.1	59.8	49.2
Waikato District	43,959	12.3	8.0	10.0	24.3	2.2	38.9	70.8
Matamata-Piako District	30,483	2.8	7.0	15.6	12.7	1.0	36.2	54.7
Hamilton City	129,249	17.7	7.4	10.1	19.0	4.0	49.0	100.0
Waipa District	42,501	13.3	6.8	14.2	12.7	1.1	24.8	80.0
Otorohanga District	9,075	-6.1	7.6	10.3	26.0	1.6	43.5	28.5
South Waikato District	22,641	-9.5	7.8	12.6	29.6	11.3	65.8	76.4
Waitomo District	9,438	-3.0	8.1	11.4	38.6	2.3	58.3	46.8
Taupo District	32,418	5.6	7.0	13.6	26.7	2.6	41.6	78.9
Western Bay of Plenty District	42,075	20.3	6.0	15.5	16.5	1.7	29.8	42.2
Tauranga City	103,632	33.2	6.7	17.4	16.0	1.8	40.8	99.9
Rotorua District	65,901	2.2	8.0	11.1	34.5	4.3	56.4	81.5
Whakatane District	33,300	0.4	7.7	12.6	39.6	2.1	59.6	65.0
Kawerau District	6,924	-11.6	8.8	12.4	58.5	3.6	90.3	100.0
Opotiki District	8,976	-3.7	8.0	13.9	54.4	2.3	84.6	46.5
Gisborne District	44,463	-2.9	8.2	12.0	44.4	2.9	65.5	73.2
Wairoa District	8,481	-14.3	8.1	12.1	56.6	1.9	85.3	50.4
Hastings District	70,842	6.9	7.4	12.8	22.9	4.9	47.3	89.0
Napier City	55,359	3.5	6.6	15.6	17.7	2.5	43.5	100.0
Central Hawke's Bay District	12,957	-0.6	6.7	13.3	20.8	2.0	41.0	45.8
New Plymouth District	68,901	1.2	6.1	15.4	13.6	1.4	37.4	85.1
Stratford District	8,892	-6.8	7.2	15.1	10.9	0.4	45.5	60.0
South Taranaki District	26,487	-9.1	7.6	13.2	20.7	1.3	49.2	61.0
Ruapehu District	13,569	-19.0	7.6	10.6	36.5	2.1	65.1	63.2
Whanganui District	42,636	-5.3	6.3	17.3	21.3	2.3	57.5	91.4

Table B.2 continued: 2006 Census population characteristics by territorial authority

Territorial authority	2006 Census usually resident population	Population growth 1996–2006 (%)	Population aged 0–4 years (%)	Population aged 65+ years (%)	Māori (total response) (%)	Pacific (total response) (%)	Population living in NZDep2006 deciles 7–10 (%)	Population living in urban areas (%)
Rangitikei District	14,712	-10.1	6.6	14.4	23.5	1.5	45.9	55.2
Manawatu District	28,254	0.6	6.4	12.9	13.7	1.4	32.6	56.7
Palmerston North City	75,543	3.3	6.7	11.6	15.0	3.6	40.3	97.9
Tararua District	17,634	-7.5	7.3	14.0	19.8	1.3	45.8	53.7
Horowhenua District	29,865	-0.9	6.3	20.0	20.4	3.4	65.2	83.4
Kapiti Coast District	46,200	19.7	5.7	23.3	11.9	2.1	31.5	92.7
Porirua City	48,546	4.1	8.7	7.9	19.9	25.3	52.4	99.7
Upper Hutt City	38,415	4.6	6.7	12.5	13.5	4.3	34.5	94.7
Lower Hutt City	97,701	1.9	7.6	10.9	16.7	10.3	44.0	99.4
Wellington City	179,466	13.8	6.2	8.4	7.4	5.0	22.1	99.6
Masterton District	22,626	-0.6	6.2	16.8	16.5	2.7	51.1	86.2
Carterton District	7,098	4.2	6.6	15.0	9.6	1.5	39.9	58.2
South Wairarapa District	8,889	-0.5	6.4	16.3	12.3	1.6	31.5	63.7
Tasman District	44,625	17.5	6.5	13.6	6.9	0.8	26.8	59.0
Nelson City	42,891	6.6	5.9	14.5	8.4	1.7	40.6	98.0
Marlborough District	42,549	10.8	5.6	16.2	10.0	1.5	29.0	76.6
Kaikoura District	3,621	3.0	5.3	14.9	16.3	0.9	29.8	59.9
Buller District	9,702	-7.7	5.7	15.6	8.3	0.6	66.5	50.0
Grey District	13,221	-3.5	6.4	13.5	8.3	1.1	50.0	73.1
Westland District	8,403	1.5	6.0	12.3	12.1	0.8	35.2	42.2
Hurunui District	10,476	11.4	6.7	14.3	5.6	0.4	27.1	7.0
Waimakariri District	42,834	32.4	6.7	13.9	6.7	0.6	16.9	66.2
Christchurch City	348,435	10.1	6.2	13.5	7.4	2.7	34.8	99.2
Selwyn District	33,666	35.8	7.1	9.0	6.0	0.9	1.1	36.6
Ashburton District	27,372	8.7	6.4	16.3	6.0	1.4	19.9	61.5
Timaru District	42,867	0.6	5.4	18.3	6.1	0.9	32.4	80.1
Mackenzie District	3,801	-6.8	6.3	12.9	4.3	0.6	6.7	26.8
Waimate District	7,206	-5.4	5.6	19.2	5.2	0.6	31.1	39.2
Chatham Islands Territory	609	-16.5	8.9	8.9	60.6	1.5	0.0	0.0
Waitaki District	20,223	-6.3	5.5	20.0	5.4	1.1	31.6	62.7
Central Otago District	16,647	11.3	5.7	17.4	7.0	0.6	12.4	50.4
Queenstown-Lakes District	22,956	60.7	5.7	8.5	5.5	0.7	6.5	76.8
Dunedin City	118,683	0.5	5.2	13.4	6.2	2.1	38.3	93.5
Clutha District	16,839	-6.5	7.0	13.4	8.8	0.8	27.0	35.3
Southland District	28,440	-6.9	7.2	11.6	9.2	0.6	13.1	19.3
Gore District	12,108	-8.8	6.3	16.8	9.2	0.6	36.5	79.8
Invercargill City	50,328	-5.4	6.4	14.5	13.3	2.4	47.2	96.5
New Zealand Total	**4,027,947**	**11.3**	**6.8**	**12.3**	**14.0**	**6.6**	**39.5**	**86.0**

Source: Statistics New Zealand (2010c)

Table B.3: 2006 Census population characteristics by airshed

North Island airshed	Highest 24-hour PM_{10} average 2009	Number of PM_{10} exceedances 2009	2006 Census usually resident population	Māori (total response), 2006 (%)	NZDep2006 deciles 7–10 (%)	Territorial authority	Regional council/unitary authority	District Health Board
Kaitaia	NA	NA	5,520	50.7	96.1	Far North District	Northland Region	Northland
Whangarei	94*	0	43,470	28.3	63.9	Whangarei District	Northland Region	Northland
Warkworth	NA	NA	3,090	10.0	48.5	Rodney District	Auckland Region	Waitemata
Kumeu	119*	1	1,580	9.3	0.0	Rodney District	Auckland Region	Waitemata
Auckland	134	4	1,159,860	10.5	41.4	North Shore City, Waitakere City, Auckland City, Manukau City, Papakura District, Rodney District	Auckland Region	Waitemata, Auckland, Counties Manukau
Pukekohe	NA	NA	14,860	18.7	47.0	Franklin District	Auckland Region	Counties Manukau
Hamilton City	101	2	129,260	18.9	49.0	Hamilton City	Waikato Region	Waikato
Matamata	45	0	6,380	11.2	56.1	Matamata-Piako District	Waikato Region	Waikato
Putaruru	55	3	3,760	32.1	88.3	South Waikato District	Waikato Region	Waikato
Rotorua	126	27	45,600	35.5	62.1	Rotorua District	Bay of Plenty Region	Lakes
Tokoroa	80	17	13,020	35.3	82.2	South Waikato District	Waikato Region	Waikato
Te Kuiti	53	4	4,420	45.9	86.5	Waitomo District	Waikato Region	Waikato
Taupo	66	7	18,800	22.5	37.6	Taupo District	Waikato Region	Lakes
Napier	68	3	33,140	22.9	58.8	Napier City	Hawke's Bay Region	Hawke's Bay
Hastings	80	12	26,350	22.6	65.8	Hastings District	Hawke's Bay Region	Hawke's Bay
Taihape	46	0	1,920	34.7	59.7	Rangitikei District	Manawatu-Whanganui Region	Whanganui
Wairarapa	55	1	35,420	14.3	48.5	Masterton District, Carterton District, South Wairarapa District	Wellington Region	Wairarapa
Upper Hutt	25	0	35,630	13.8	37.3	Upper Hutt City	Wellington Region	Hutt Valley
Lower Hutt	31	0	73,640	15.3	43.6	Lower Hutt City	Wellington Region	Hutt Valley
Wainuiomata	41	0	16,590	27.2	64.9	Lower Hutt City	Wellington Region	Hutt Valley
Porirua	30	1	59,960	17.6	46.4	Porirua City, Wellington City	Wellington Region	Capital and Coast
Wellington	31	0	93,560	7.7	35.8	Wellington City	Wellington Region	Capital and Coast
Karori	30	0	11,130	5.4	6.4	Wellington City	Wellington Region	Capital and Coast

South Island airshed	Highest 24-hour PM_{10} average 2009	Number of PM_{10} exceedances 2009	2006 Census usually resident population	Māori (total response), 2006 (%)	NZDep2006 deciles 7–10 (%)	Territorial authority	Regional council/unitary authority	District Health Board
Nelson A	89	34	9,030	12.9	75.9	Nelson City	Nelson Region	Nelson–Marlborough
Nelson B	65	8	20,160	7.7	34.6	Nelson City	Nelson Region	Nelson–Marlborough
Richmond	79	21	12,410	5.6	22.5	Tasman District	Tasman Region	Nelson–Marlborough
Blenheim	51	1	22,570	10.2	40.5	Marlborough District	Marlborough Region	Nelson–Marlborough
Reefton	91	16	1,020	11.2	100.0	Buller District	West Coast Region	West Coast
Rangiora	88*	2	11,500	6.2	25.5	Waimakariri District	Canterbury Region	Canterbury
Kaiapoi	86	23	8,360	9.2	25.4	Waimakariri District	Canterbury Region	Canterbury
Christchurch	85	13	334,170	7.4	35.7	Christchurch City	Canterbury Region	Canterbury
Ashburton	128*	8	13,780	7.3	32.6	Ashburton District	Canterbury Region	Canterbury
Geraldine	94*	7	2,380	5.5	17.0	Timaru District	Canterbury Region	South Canterbury
Timaru	134	38	25,420	6.2	42.7	Timaru District	Canterbury Region	South Canterbury
Waimate	112*	9	3,070	4.5	66.2	Waimate District	Canterbury Region	South Canterbury
Otago 1	137	60	14.220	7.3	13.6	Central Otago District, Queenstown-Lakes District	Otago Region	Otago, Southland
Mosgiel (Otago 2)	145	35	50,430	6.3	35.0	Dunedin City, Clutha District, Waitaki District	Otago Region	Otago
Dunedin (Otago 3)	77*	8	75,420	6.1	46.4	Dunedin City, Clutha District, Waitaki District	Otago Region	Otago
Gore	59	2	7,640	7.4	40.3	Gore District	Southland Region	Southland
Invercargill	78	5	41,810	13.0	52.5	Invercargill City	Southland Region	Southland

Notes: Airsheds that exceeded the national standards are highlighted in grey. This table provides the estimated usually resident population from 2006 for each airshed, and the estimated proportion of the population identifying as Māori, and living in areas of higher relative socioeconomic deprivation. The population estimates were calculated using 2006 Census data, including in each airshed the meshblocks that had their population-weighted centroid within the airshed boundary. Socioeconomic deprivation was defined as being in deciles 7–10 on the New Zealand Index of Socioeconomic Deprivation 2006 (Salmond et al 2007). These population data are provided for context, and cannot necessarily be interpreted as number of people exposed to elevated PM_{10} concentrations, as actual individual exposure levels depend on a number of factors, including the time of day, atmospheric conditions, and duration spent in the area. The Auckland airshed includes Auckland urban, North Shore and Whangaparaoa airsheds. The Otago 1 airshed includes Alexandra, Arrowtown, Clyde, Cromwell, Naseby, Ranfurly and Roxburgh airsheds. The Otago 2 airshed includes South Dunedin, Green Island, Mosgiel, Milton and Palmerston airsheds. The Otago 3 airshed includes North Dunedin, Central Dunedin, Port Chalmers, Balclutha, Waikouaiti and Oamaru airsheds.

* The highest 24-hour average value for this airshed was due to transboundary pollution from Australian dist storms. The exceedance due to this event has not been included in this table.

Source: Statistics New Zealand (2010c)

Appendix C: Summary of Data Sources

The following section briefly describes the government and non-government agencies from which data were sourced for this report.

Ministry of Health

The Ministry of Health is responsible for ensuring that the health and disability system works for all New Zealanders. It collects administrative health data, including hospitalisation data and mortality data, and is responsible for carrying out population surveys, to monitor the health of New Zealanders.

Indicators in this report presenting data sourced from the Ministry of Health are:

- respiratory disease hospitalisations and mortality
- exposure to second-hand smoke at home.

Institute of Environmental Science and Research

The Institute of Environmental Science and Research (ESR) is a Crown Research Institute that provides a range of scientific services for public health, environmental health and forensic science. ESR is responsible for the collection and dissemination of data on notifiable diseases and also manages a drinking-water database (Water Information New Zealand) that collects information about grading and compliance of drinking-water sources in New Zealand.

Indicators in this report that use data sourced from ESR are:

- notifications for vector-borne and water-borne diseases
- drinking-water quality.

Ministry for the Environment

The Ministry for the Environment provides leadership on environmental sustainability and improving the New Zealand environment, and is responsible for monitoring and reporting on the health of the environment. As part of this role, it released the report Environment New Zealand 2007 (Ministry for the Environment 2007), and is currently developing environmental indicators for New Zealand. The Ministry for the Environment collates regional data on ambient air and water quality (including both freshwater and marine).

Indicators in this report that use data sourced from the Ministry for the Environment are:

- some air quality pollutants
- quality of recreational water (both freshwater and marine).

Statistics New Zealand

Statistics New Zealand is New Zealand's national statistical office, and is the main source of official statistics in New Zealand. Its role includes carrying out the five-yearly Census of Population and Dwellings, as well as a number of surveys, including agricultural surveys.

Indicators in this report that use data sourced from Statistics New Zealand are:

- Census data from 1996, 2001 and 2006

- agriculture census and survey data on livestock numbers
- amount of cargo imported into New Zealand
- passenger arrivals to New Zealand.

Ministry of Economic Development

The Ministry of Economic Development has the central aim of fostering economic development and prosperity for all New Zealanders, and it develops and implements policies and services that promote sustainable economic growth. It produces an annual report on economic development indicators.

The indicator in this report that uses data sourced from the Ministry of Economic Development is:

- energy consumption.

Biosecurity New Zealand, Ministry of Agriculture and Forestry

Biosecurity New Zealand, a division of the Ministry of Agriculture and Forestry (MAF BNZ), is responsible for the leadership and co-ordination of the New Zealand biosecurity system. It works to keep out or remove pests and diseases, or effectively manage the harm that they can do to our economy, the environment and our health. The Biosecurity Act 1993 provides the powers that are used to control the flow of risk goods across the border and to respond to and manage new organisms if they arrive in New Zealand.

Indicators in this report that use data sourced from MAF BNZ are:

- number of sea containers imported into New Zealand
- mosquito species in New Zealand.

Ministry of Transport

The Ministry of Transport is the government's principal advisor on transport policy. It manages the interface between the Minister of Transport and the transport Crown entities (such as the New Zealand Transport Agency, Maritime Safety Authority and Civil Aviation Authority), as well as managing the Motor Vehicle Register.

Indicators in this report that use data sourced from the Ministry of Transport are:

- vehicle registrations
- mean age of vehicle fleet.

Other agencies

Data on overseas disease outbreaks were also sourced from the World Health Organization (WHO).

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